What a long, StRaNge trip it's been

IT TOOK A MUNICIPAL COURSE IN CALIFORNIA 20 YEARS TO COME TO FRUITION

BY PETER BLAIS

If a television producer ever comes up with a reality show based on perseverance, the developers of The Crossings at Carlsbad (Calif.) municipal golf course should be booked as part of the cast.

After 20 years of planning, permitting delays, designs and redesigns to satisfy every regulatory board imaginable, with site constraints that left the grading contractor ready to walk off the job after 24 hours, and a plane crash on the third green that killed three people and necessitated the rebuilding of the entire putting surface just days before its unofficial opening, the 18-hole championship course will have its long-anticipated grand opening Sept. 26.

"It's a wonderful feeling to bring it to completion finally," says Skip Hammann, special projects director for the city of Carlsbad. "It has been a long road for a lot of people."

WHY SO LONG?

The city first floated the idea of building a golf course in 1988. A search for an appropriate location led city planners to the 400-acre site with beautiful ocean views. Yet the city already had received permits for an industrial project there. The belief was that obtaining approval for a golf course instead of an industrial park would be a no-brainer. Two years later, voters gave the go-ahead, and the city began the process. It hired architect Greg Nash to design the layout.

"We had more constraints on this site than I've encountered in my entire career," Nash says. "We had endangered plant and bird species, wetland issues, archeological sites, expansive soils and high-power transmission lines. It was a major puzzle putting it all together.

"We tried to get a list of all the constraints by different agencies," he adds. "Every time we put together a plan, we had to negotiate with them. For a while, we dealt mostly with the Army Corps of Engineers. Then we had to deal with U.S. Fish and Wildlife Service. We spent one to two years with each agency. While we were engineering, we discovered things such as part of the property being in a coastal sage area, or we'd come across an endangered black-tailed gnatcatcher habitat. We kept tweaking this and that. Then the Coastal Commission stepped in, and its plans were quite a bit different. They had a zero-tolerance policy when it came to any disturbance. We had to redesign about 40 percent of the course again."

Although the course is 6,850 yards long, the golf course challenges golfers in various ways. One example is the tiered putting surfaces on several holes. Photo: carlsbadimages.com

The difficulty of dealing with various state and federal regulatory agencies, especially in an environmentally conscious state like California, has left developers yearning for a more streamlined permitting process with a clearinghouse where requirements of the various agencies could be listed for developers to see beforehand. Hammann agrees such a clearinghouse for information is appealing. But the reality is that there are so many conflicting regulatory requirements that even if one agency signs off, developers have to meet the new guidelines as new regulations are adopted.

"Because this project went on for so long, things kept coming up," Hammann says. "It's a reiterative process. You keep going through the grind until you finally get there. It's a long, painful process that takes tremendous willpower. Developers hit a roadblock. By the time they got through the problem at hand, all these other things cropped up. You'd think you have everything figured out and try to put a design together so you can go out to bid, but some significant issue comes up that requires another major redesign. You do the redesign, go through the grind again, and something else comes up."

With some environmental studies, developers have to wait until a certain part of the year for a study to be completed before they could start the redesign.

"Starting and stopping makes it difficult to keep momentum going and get a project completed," Hammann says. "Then you have to allocate additional money, and consultants change, which means starting over again in some areas. Greg Nash was one of the few consultants who stayed with this from the beginning. Greg stuck it out. He did a great job and was great to work with."

Nash's final design basically split the 400-acre parcel in half, with 200 acres set aside for the golf course and 200 preserved for habitat to protect multiple endangered species and help tie together more than 1,000 acres of open space in the central part of the city. The Coastal Commission's requirements meant shaving off another 150 yards, which brought the total yardage closer to 6,850 yards rather than the 7,000 yards the city had anticipated.

Winding through coastal terrain and natural canyons, the 400-acre property was home to wetlands, sage brush and other plant, animal and bird life but also had to be infused with massive pines, oaks and sycamore trees.

Bridges – or crossings, thus the course's name – were designed into the layout to meet specific existing environmental and topographic conditions. Five bridges span protected areas and include environmentally sensitive design elements.

CONSTRUCTION CHALLENGES

Construction finally began in September 2005. SEMA Construction was responsible for the grading and infrastructure, and Wadsworth Golf Construction took over course construction once the site was rough graded. A Wadsworth subcontractor also was responsible for habitat-restoration areas. Jaynes Contracting oversaw building construction including the maintenance center, clubhouse, halfway house and restrooms.

"Often times, we're challenged by soil conditions, but in this case, the issues were primarily man made, apart from the environmentally sensitive areas," says Steve Harrell, president of Wadsworth. "You couldn't simply apply construction techniques to resolve matters. Instead, you had to work within the governmental agency requirements. Usually, we can solve construction problems by simply throwing horsepower at them, but these had to be solved by people meeting and working out the best solutions for both parties."

Nash's design took the 150 yards lost during the Coastal Commission's final changes into consideration. The last few holes on each nine play directly into wind. The variety of holes also helps keep players off balance, while tiered putting surfaces on several holes provide additional challenges.

"People comment about the huge difference between the two nines," Nash says. "One is up on a hillside with long views toward the ocean. The other is along a canyon with wetlands and vegetation."

One permitting requirement forced Nash to design an unusual hole. The California Coastal Commission and Army Corps of Engineers refused to grant permission to develop a crossing near what was going to be the 12th tee. Instead, they insisted developers use an old country road behind the 12th green. To accommodate the requirement, Nash's design leads golfers along a cart path from the 11th green around the adjacent 12th green and then back along the entire length of the 12th hole to the 12th tee. After playing the 12th hole, golfers exit the 12th green along the country road to the 13th tee.


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One nine is up on a hillside with long views toward the ocean. The other nine is along a canyon with wetlands and vegetation. Photo: carlsbadimages.com

"People are going to ask what the heck we were thinking when they play the hole," Nash says. "But it was something we couldn't negotiate or overcome. There was simply no place else we could go."

Revegetation was a big part of the project.

"We spent a lot of money, effort and time to recreate the naturalness of the site," Hammann says. "The result is a great contrast between manicured turf, bunkers, a golf experience and environmentally sensitive areas."

Workers spent as much time revegetating natural areas as they did on course construction in terms of watering and vegetative grow-in, says golf course superintendent Chris Latham.

A requirement to use native soils was challenging. Native soils provide the growing medium for the Tifway 419 Bermudagrass on the tees, roughs, fairways and green surrounds. The only place native soils weren't used is on the 6,500- to 8,000-square-feet greens, which are Dominant bentgrass. The irrigation system provides potable water for the greens and effluent elsewhere.

The builders installed playable and nonplayable rough areas along the edges of the course to serve as buffers, particularly near environmentally sensitive areas. The buffers restrict runoff from pesticides and fertilizers, inputs Latham tries to minimize.

"We've subcontracted with Habitat Restoration Service to take care of the revegetation," Latham says. "They're maintaining the irrigation system devoted to the revegetation for the next five years. After that time, all the irrigation piping will be removed."

Latham works for KemperSports, who the city hired to manage the facility. Kemper will monitor HRS' activities and bridge the gap in those areas to fulfill the permitting requirements and make it hospitable for players.

"For instance, if we're growing-in a coastal area in front of a tee box, we have to make sure the plant life is low enough for players to shoot over," he says.

WHERE DID THE MONEY GO?

In 1988, the city estimated the course would cost $7 million to build. The final figure was $63.3 million.

"That includes permitting, design, everything associated with preparing the course for construction and construction itself," Hammann says. "It includes hard and soft costs."

One has to look at the cost from a different perspective, Harrell says.

"You can't just say it's a $63-million golf course," he says. "It was the development of a difficult site for recreational enjoyment. Without the golf course it would be vacant property with a bunch of power lines on it. Some people might say that's fine. Other people wanted something different. It's not like the money was spent on greens, tees, bunker sand, storm drains and a fancy irrigation system. It was spent on a number of things unique to that site."

The project required two separate irrigation systems, one for the manicured turf areas of the golf course and a second for the natural revegetated areas, which cost about $2 million apiece. Then there are several million dollars worth of bridges. Add to that almost 20 years of consultant and permitting costs.

"An untrained eye might ask why it cost so much, but there were many things you wouldn't encounter on most courses," Nash says. "The average guy might ask where they spent all that money, but it can add up quickly."

The course meshes well with the area's economic base, which consists largely of golf-equipment manufactures, such as Callaway, Cobra and Titleist, and tourism. Two hotels are planned – one, the Sheraton Carlsbad Resort & Spa, is scheduled to open in January. The city also is encouraging the development of two manufacturing parks in the immediate area that will generate significant tax revenue.

"It's a good addition to the San Diego North area," Nash says. "The city of Carlsbad is in this for the long haul."

Voters approved this project years ago, and despite the hefty price tag, the city believes it's getting something more than just a golf course.

"We're getting an amenity in the middle of the city that provides linkage for our open space and trails and a 28,000-square-foot clubhouse that's a gathering place for the community," Hammann says. "The city is looking long term rather than short term and believes this will be a tremendous asset to the city, the golf industries in this area, the folks who live in and around Carlsbad, and the tourism industry that comes through here. The long-term goal for the city is that the revenue generated from the course will repay the general fund. The repayment is estimated at 30 years."

DAILY MAINTENANCE

The steepness of the site, distances from hole to hole, and the fact the course is spread out over 400 acres (counting the revegetated area), means additional maintenance considerations.

"The challenge is traversing the property and getting from place to place," Latham says. "The front nine has quite a few elevation changes. The back nine has more canyons."

Latham plans to use manpower studies, process mapping and multitasking to allocate resources and control costs as best he can. Changeovers from employee to employee and job to job will occur during lunch hours as frequently as possible to avoid unnecessary trips back and forth from the course to the maintenance center. For instance, workers will bring a mechanized blower and trimmer along with them when mowing greens. As they move around the course, they'll also trim curbs, tee-box surrounds, greens and banks rather than simply mowing the greens and then going back to the maintenance center to pick up tools to perform the other functions.

Latham's crew also will maintain a lighted driving range. That job will be somewhat easier thanks to an artificial turf-teeing area that aligns golfers with five target greens. The artificial surface looks and feels like real grass and allows golfers to tee their balls.

"We have a modern maintenance facility and a central-service system similar to a Jiffy Lube," he says. "We'll probably carry 20-plus workers on the crew. In addition to an assistant superintendent, we'll have a second assistant whose job is strictly to monitor the habitat-restoration area."

And the crew will be responsible for maintaining three water features – one on the 18th hole that also will be used for irrigation and two on the seventh hole, an upper one that feeds into a lower one via a waterfall.

PLAYING CHALLENGES

The Crossings' unofficial opening was August 11. Feedback from players has been that the course's dramatic elevation changes on the front nine and canyon setting on the back make it look much harder to play than it actually is, says general manager Jeff Perry. Golfers are encouraged to select an appropriate set of tees to match their abilities and take what the course offers them rather than imposing a certain style of play on the layout.

Slow play was an initial concern because of the elevation changes and long distances from some greens to tees. But foursomes generally have played the course between four hours and 15 minutes and five hours.

Nash did a nice job of working with the land and making a dramatic but playable course, says Steve Skinner, president of KemperSports.

"We hope it will be playable for all levels of players," Skinner says. "We will know better when the everyday golfer begins getting out there. It's in a great market with great weather. The course could host as many as 60,000 rounds annually."

By area standards, The Crossings should be affordable for most everyday golfers in the San Diego market, where green fees at some facilities exceed $200. The cost to play will be $90 Mondays through Thursdays, $95 Fridays and $110 Saturdays and Sundays. Carlsbad residents will pay $30 less and San Diego County residents $15 less.

"Time will tell how successful and well received the project will be," Hammann says. "It has created a lot of buzz and excitement. It will be a success." GCI

Peter Blais is a freelance writer based in North Yarmouth, Maine. He can be reached at pblais@maine.rr.com.

AT A GLANCE
The Crossings at Carlsbad

Location: Carlsbad, Calif.
Web site: www.thecrossingatcarlsbad.com
Type of project: New construction of a municipal course
Architect: Greg Nash
Builder: Wadsworth Golf Construction
Superintendent: Chris Latham
Owner: City of Carlsbad
Project started: Conception 1988; construction 2005
Project completed: August 2007
Cost: $63.3 million, which includes all hard and soft costs
Notable: Conception to construction took almost 20 years because of the coastal location and California's complex regulatory climate. Builders installed a separate irrigation system for the out-of-play revegetated area that will be removed in five years.

BY JEFF HAAG

Grow playable, healthy turf

A look at factors that damage chloroplasts and the defenses that protect them

The goal of every turfgrass manager is to provide a playable surface and aesthetically pleasing green turfgrass. Achieving the latter involves a reciprocal balance between soil, fertility, moisture, temperature, humidity, grass species, mowing techniques, cultural practices and cooperation from Mother Nature. All these aspects have to be working in sync for turfgrass to perform properly and be appealing colorwise.

Protecting and strengthening chloroplasts would seem like the logical action to take because this is where chlorophyll, a pigment that gives turfgrass its green appearance, is developed.

The most important characteristic of plants is their ability to photosynthesis – to make their own food by connecting light energy into chemical energy. This process is carried out in specialized organelles called chloroplasts. A photosynthetic cell contains anywhere from one to several thousand chloroplasts. The electrons from chlorophyll molecules in photosystem II replace the electrons that leave chlorophyll molecules in photosystem I.

Located inside the chloroplast are thylakoid membranes where light reactions take place. This is where chlorophyll is found, therefore, there's a synergistic relationship between keeping the chloroplasts and the thylakoid membranes as healthy as possible.

There are events that can be harmful to chloroplasts and thylakoid membranes, as well as necessary components that can prevent damage to them.

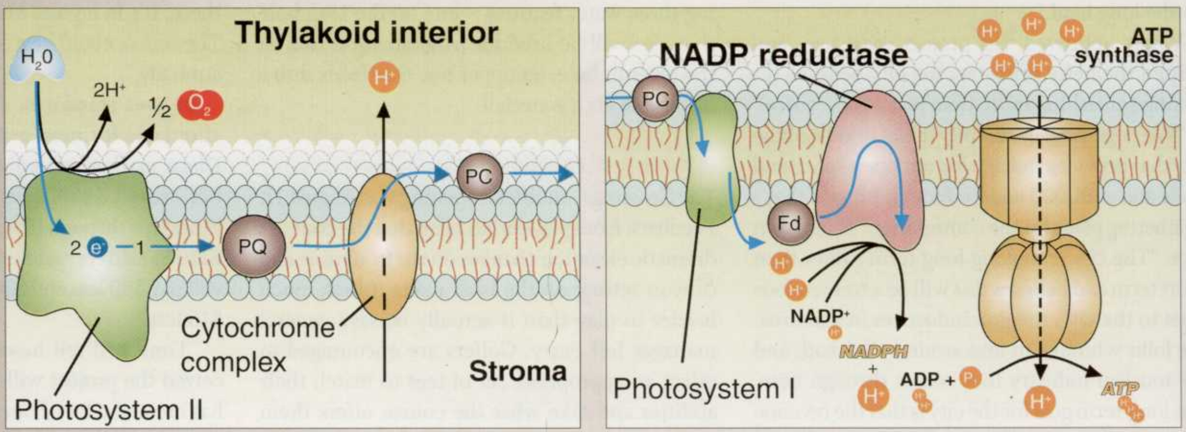
FREE RADICALS

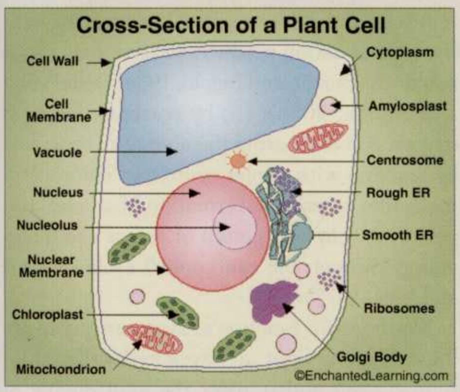
One event that can damage chloroplasts is the development of free radicals. The medical profession has shown that free radicals can cause diseases in the human body. Likewise, turfgrass managers know that research throughout the past several years has shown free radicals can damage lipids, proteins and DNA inside cells of turfgrass plants, including chloroplasts.

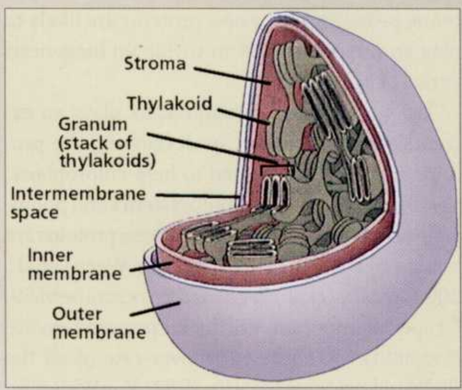
Typically, free radicals are stable molecules that contain pairs of electrons. When a chemical reaction breaks the bonds that hold the paired electrons together, free radicals are produced. They contain an odd number of electrons, which make them unstable, short-lived and highly reactive. As they combine with other atoms that contain unpaired electrons, new radicals are created, and a chain reaction begins (Droge, 2002; Haag, 2005).

This chain reaction, or accumulation of reactive oxygen species, in plants is generally ascribed to several possible sources (Klessig and Malamy, 1994; Corpas et al.,2001; Desikan et al., 2001; Blokuna et al., 2003): cell-wall-bound perxidases, membrane-located NADPH oxidases, amine oxidases, xanthine oxidase, chloroplastic electron transport chains, mitochondrial electron transport chains, and peroxisomal fatty acid B-oxidation, which includes the H_20_2-generating argyl-coenzyme A oxidase steps (Couee et al., 2006). These sources can be attributed to environmental causes such as

The electrons from chlorophyll molecules in photosystem II replace the electrons that leave chlorophyll molecules in photosystem I. Images: Sinauer Associates and WH Freeman







There is a synergistic relationship between keeping chloroplasts and thylakoid membranes as healthy as possible. Images: Sinauer Associates and WH Freeman.

drought, heat, and ultraviolet light, or chemicals such as herbicides (Haag, 2005).

Accumulation of reactive oxygen species is central to plant response to several pathogens. One of the sources of reactive oxygen species is the chloroplast because of the photoactive nature of the chlorophylls (Kariola et al.,2005). The free radicals, or reactive oxygen species, are singlet, hydroxyl, superoxide and hydrogen peroxide.

LIGHT

There's a catch-22 with light. Light is necessary for photosynthesis to occur; however, it also can play a part in the degradation of chlorophyll.

When photosynthetic organisms are exposed to ultraviolet radiation, significant, irreversible damage to important metabolic processes within the cell might occur (such as lesions in DNA and inhibition of photosynthesis). Through these reactions and others, radical forms of oxygen are often created. Many reports suggest this damage is because of oxidative stress resulting from UV-A, (Dring et al., 1996, Jeffrey and Mitchell, 1997, Turcsanyi and Vass, 2000) UV-B (Teramura and Ziska, 1996, Gotz et al., 1999, Mazza et al., 1999, hideg et al., 2000, Estevez et al., 2001) or both (Krause et al., 1999, Muela et al., 2000, Vega and Pizzaro, 2000, Laloi et al., 2006).

Photosynthetic light absorption and energy usage must be kept in balance to prevent formation of reactive oxygen species in the chloroplasts. Drought causes stomatal closure, which limits the diffusion of carbon dioxide to chloroplasts and thereby causes a decrease of carbon dioxide assimilation in favor of photorespiration that produces large amounts of hydrogen peroxide (Noctor et al., 2002). Under these conditions, the probability of singlet oxygen production at phtosystem II and superoxide production of photosystem I is increased (Niyogi, 1999; Foyer et al., 2005). These can cause direct damage or induce a cell suicide program (Tambussi et al., 2000).

It has been known for a long time wavelengths in the ultraviolet-B region of the spectrum are effective in inactivating photosynthesis, and the molecular target is photosystem II (Jones and Kok, 1966., Chen and Gallie, 2005). An excess of light brings about the inactivation of oxygenic photosynthesis, a phenomenon known as photoinhibition (Powles, 1984), and the molecular target of photoinhibition is photosystem II, a thylakoid multisubunit pigment-protein complex (Bergo et al., 2003). The major effect of ultraviolet-B light on the thylakoid proteins is the breakdown of the reaction centre D1 protein (Trebst and Depka, 1990; Friso et al., 1994; Barbato et al., 1995).

One must question whether ultraviolet-B radiation will become an even more serious factor in the future. The depletion of the stratospheric ozone is causing renewed concern about the increased level of ultraviolet-B radiation reaching the earth's surface (Smith et al., 1995). It's also known exposure to environmental ozone can cause significant damage to turfgrass by imposing conditions of oxidative stress (Chen and Gallie, 2005; Grimes et al., 1983; Schraudner et al., 1998). This might be the case because we're seeing a gradual increase in yearly temperatures throughout the world and an increase in skin cancers in humans. How it affects crops and turfgrass plants in the future remains to be seen.

SENESCENCE

Senescence results in massive levels of cell death, but the purpose of senescence isn't cell death; rather death only occurs when senescence has been completed. Senescence occurs in two stages. The first stage is reversible, and the cells remain viable throughout. The second stage results in cell death (Buchanan-Wollston et al., 2003; McGlaughlin and Smith, 1995; Mothes et al., 1960; Riefler et al., 2006; Venkatrayappa et al., 1984).

The key enzyme in the pathway to chlorophyll degradation during senescence appears to be pheophorbide *a* oxygenase. The activity of pheophorbide *a* oxygenase increases dramatically during senescence, implicating this enzyme as a control point in the process (Buchanan-Wollston et al., 2003; Hortensteiner et al., 1998). Light absorption by pheophorbide *a* oxygenase also is believed to cause the production of singlet oxygen (Pruzinska et al., 2005), which is a free radical.

Because senescence is reversible, it suggests that fully developed chloroplasts retain enough genetic information to support regreening and chloroplast reassembly.

CALCIUM AND POTASSIUM

From a nutritional standpoint, there are various nutrients and compounds that can be applied in the process of strengthening and defending chloroplast damage.

Because the chloroplasts and thylakoid membrane are located inside the plant cell, the first line of defense would seem to be to strengthen the plant cell by keeping calcium and potassium at optimal levels. Calcium plays a key role in strengthening the cell walls of the turfgrass plant, while potassium helps strengthen cell walls inside the turfgrass plant, which makes it harder for physiological problems to occur inside the cell wall (Haag and Serrato, 2006).

With regard to calcium applications, add a light amount of zinc along with the calcium because zinc helps calcium to translocate to the cell walls (Haag and Serrato, 2006).

AMINO ACIDS

Amino acids are the building blocks of proteins. Under optimal conditions, proteins are able to perform the normal physiological function to synthesize amino acids, but intensively manicured turfgrass, such as golf courses and athletic fields, are rarely operating under optimal conditions because of stress caused by low mowing heights and traffic (Haag and Serrato, 2006).

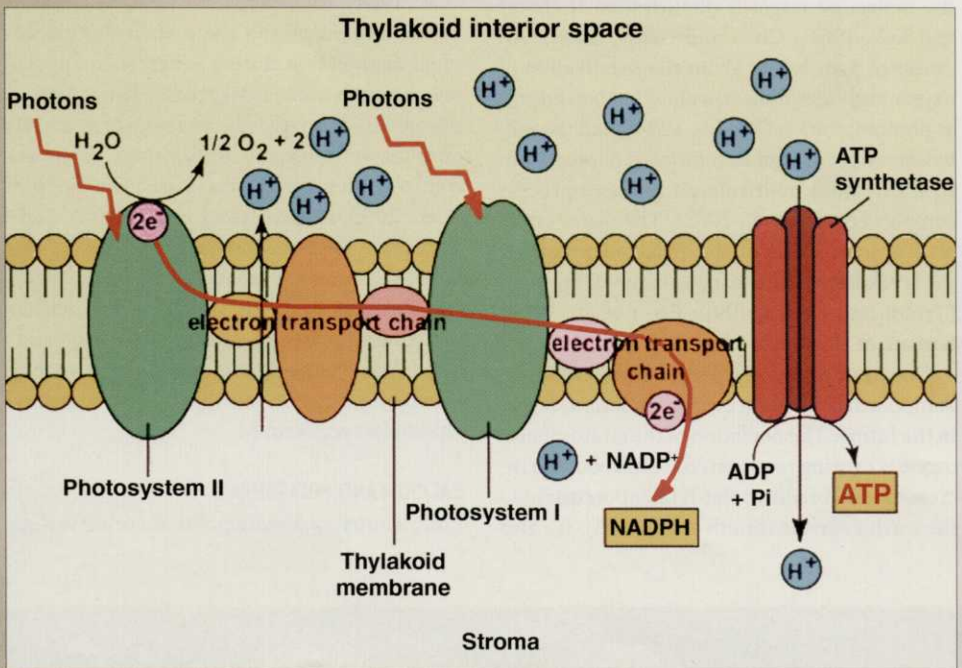
To date, 154 proteins in the turfgrass plant have been identified – 76 (49 percent) are integral membrane proteins. Twenty-seven new proteins without known functions, but with predicted chloroplast transit peptides, have been identified – 17 (63 percent) are integral membrane proteins. These new proteins are likely to play an important part in thylakoid biogenesis (Friso et al., 2004).

The application of amino acids plays an extremely important part in developing the proteins specifically designed to help chloroplasts, thylakoid membranes, photosystem I and photosystem II to function properly. These proteins are known as D1, D2 CP43, CP47 (de Weerd et al., 2002, Zheleva et al., 1998) and cytochrome b559. Of special importance is the D1 protein because it exhibits the highest turnover rate of all the thylakoid proteins (Matto, 1984; VonWettstein et al., 1995; Prasis et al., 1992; Aro et al., 1993; Schuster et al., 1988) and is highly vulnerable to singlet oxygen (Barber, 1984), a free radical.

ANTIOXIDANTS

The antioxidants a-tocopherol (vitamin E), ascorbic acid (vitamin C), carotenoids (B-carotene), vitamin B6 and mannitol in some biostimulants play a vital role in scavenging free radicals (Barna et al., 2003) and helping protect chloroplasts, thylakoid membranes inside the chloroplasts, photosystem I and photosystem II.

The best biostimulant that I've encountered to date is the N.O.G. product.



The image to the left depicts how the electron transport chain moves through the thylakoid interior. Image: Gary E. Kaiser, Ph.D.

CAROTENOIDS (B-CAROTENE)

In terms of its antioxidant properties, carotenoids can protect photosystem I and photosystem II in one of four ways: (i) by reacting with lipid peroxidation products to terminate chain reactions (Burton and Ingold, 1984; DellaPenna and Pogson, 2006); (ii) by scavenging singlet oxygen and dissipating the energy as heat; (iii) by reacting with triplet or excited chlorophyll molecules to prevent formation of singlet oxygen, or (iv) by dissipation of excess excitation energy through the xanthophyll cycle (Mathis and Kleo, 1973).

Xanthophylls function as accessory pigments for harvesting light at wavelengths that chlorophyll can't and transfer the light energy to chlorophyll. But, they also absorb excess light energy and dissipate it to avoid damage in the xanthophyll cycle.

A-TOCOPHEROL (VITAMIN E)

A-tocopherol (vitamin E) is considered a major antioxidant in chloroplasts in at least two different but related roles. It protects photosystem II from photoinhibition and thylakoid membranes from photooxidative damage (Havaux et al., 2002; Havaux et al., 2005; Delong and Steffen, 2002, Flohe and Traber, 1999). The antioxidant properties of vitamin E are the result of its ability to quench singlet oxygen and peroxides (Fryer, 1992; Sattler et al., 2006).

Although vitamin E is a less efficient scavenger of singlet oxygen than B-carotene, it might function in the thylakoid membrane to break carbon radical chain reactions by trapping peroxyl radicals (Fryer, 1992; Burton and Ingold, 1984; Mathis and Kleo, 1973).

ASCORBIC ACID (VITAMIN C)

It's generally believed maintaining a high ratio of ascorbic acid is essential for the scavenging of free radicals (Mitler, 2002) and are needed in high concentrations in the chloroplasts to be effective in defending the turfgrass against oxidative stress (Noctor and Foyer, 1998).

Although ascorbic acid can directly scavenge the free radicals superoxide and singlet oxygen, the main benefit ascorbic acid plays in the prevention of free radicals is that it's an excellent scavenger of the hydroxyl radical (Blokhina et al., 2002; Yoshida et al., 2006). The hydroxyl radical is dangerous to turfgrass because it can inhibit carbon dioxide assimilation by inhibiting several Calvin cycle enzymes (Asada, 1996).

VITAMIN B6

Apart from its function as a cofactor, vitamin B6 is also thought to act as a protective agent against reactive oxygen species, such as singlet oxygen (Bilski et al.,2000; Chen and Xiong, 2005; Ehrenshaft et al.,1999; Drewke and Leistner, 2001). Vitamin B6 is also the master vitamin in processing amino acids and plays an important role in developing proteins specifically designed to help chloroplasts, thylakoid membranes, photosystem I, and photosystem II to function properly.

MANNITOL

The antioxidant mannitol has the ability to protect and quench two damaging free radicals: singlet oxygen and hydroxyl. Singlet oxygen is damaging because it can react with proteins, pigments and lipids and is thought to be the most important species for light-induced loss of photosystem II activity, as well as the degradation of the D1 protein (Krieger-Liszkay, 2004). It has been demonstrated that when mannitol is present in the chloroplasts, it can protect plants against oxidative damage by the hydroxyl radicals (Senn, 1987; Shen, 1997).

MANGANESE AND MAGNESIUM

Both of these nutrients are attached to the chlorophyll molecule that's located inside the chloroplasts. These two nutrients play a part in making turfgrass greener by helping develop chlorophyll. They also transport other vital nutrients and are responsible for many enzymatic functions and help prevent chlorophyll degradation in the cells (Haag and Serrâto, 2006).

CARBON

There's new evidence carbon plays a role in the development of the turfgrass plant leaf, and that a reduction in carbon reduces photosynthetic activity, which reduces carbohydrate availability to the turfgrass plant. There's also new evidence to suggest proper development of the turfgrass plant can't occur without proper amounts of carbon in the chloroplast (Raines and Paul, 2006). There's more evidence to suggest that, if there's an abundant source of carbon in the thylakoid membranes inside the chloroplasts, it can be mobilized for use as an energy source during senescence (Graham and Eastmond, 2002).

HUMIC ACIDS

Humic acids are another compound that contain antioxidant properties that promote the scavenging of free radicals. The added benefits of humic acid are that they increase the availability of micronutrients, phosphate and potassium to the plant and enhance the chlorophyll content of turfgrass.

Humic acids also stimulates root initiation because of the auxin-like activity they contain, which is most likely because of their ability to inhibit indoleacetic acid oxidase breakdown (Haag, 2005; Haag and Serrato, 2006). **GCI**

Jeff Haag is golf course superintendent at Bowling Green (Ohio) State University. He can be reached at jhaag@bgnet.bgsu.edu.

Editor's note: Literature cited in this article can be found on GCI's Web site, www.golfcourseindustry.com, posted with this article.

IMPACT ON THE BUSINESS

The plant health dilemma

BY PAT JONES

The evolution of turfgrass science is, in many ways, similar to the evolution of human medical science. In less than a century, we've gone from the most rudimentary forms of nutrition and treatment (manure and heavy metal fungicides like cadmium and mercury) to feeding plants with key elements and treating pathogens that cause disease with highly specific and environmentally benign inoculants. It's not too different than medical science moving from leeches and bleeding to lasers and non-invasive surgery in the same time frame.

BACK TO BASICS

One of the bigger trends during the past decade has been the "back to basics" approach of combining traditional granular fertilization with liquid/foliar nutrition programs that are tailored to meet the needs of the turf and soil. The article above focuses on a core aspect of this trend – finding the right combination of nutrient elements to feed the plant what it needs to thrive.

By identifying the key aspects of photosynthesis and making sure your program meets those needs, you can make an excellent start toward creating a customized "diet" that fits your turf's photosynthetic requirements. More importantly, by understanding the basic nature of plant self-feeding, you can think about your nutrition program at its most fundamental level.

IT'S ELEMENTAL, WATSON

The author effectively points out how a variety of elements and proteins help build up turf health from the inside out. Calcium, potassium, amino acids and various vitamins are all photosynthetic enhancers. The question is, how do you know which to use and in what combination?

The answer lies in a combination of soil and tissue testing and trial and error. By establishing a baseline and working with your local university, consultants and colleagues, you can determine the best mix of supplements. It's no different than getting a physical exam or blood test from you doctor to determine the best combination of diet, exercise, nutrition and preventative medicines for your own health.

RETURN ON INVESTMENT

Many of the articles that we run in GCI's research section offer immediate opportunities for cost-savings or instant improvement in turf quality or health. This is a different approach. The payback here is that, by understanding the building blocks of healthy plants, a superintendent can look at his nutrition program with a new set of eyes and develop a long-term approach.

In the long run, healthy turf is the best defense against pathogens and pests. **GCI**