Toward a Theory of Plant Blindness

Introduction to the Problem

We are two botanists and biology educators who are committed to exploring and investigating why people in the US tend to be less interested in plants than in animals, and why they often fail to notice the plants that are present in their own environment (Wandersee & Schussler, 1999a). We think such knowledge, once gained, may be useful in a variety of settings—from teaching an introductory biology course, to planning a public education program at a botanic garden, to writing a children's book about plants, to pursuing new botanical research. We also hope that the answers to these questions will ultimately lead to improvement of the nation's scientific literacy level, and to greater public understanding of plants (Flannery, 1999). The future of US research in the plant sciences depends, to a large extent, on the support of a botanically literate citizenry (Niklas, 1995).

Acknowledging Prior Work

Across the years, others, of much greater stature in the botany community than we, have pondered these same questions. Much of what they have observed and concluded has been both stimulating and helpful to us in beginning our own quest—and we have great respect for the work that they have done (cf. Bernhardt, 1999; Kramer, 1999; Sundberg, 2000). For example, prior explanations for US students' disinterest and inattention to plants have posited such underlying sources as zoochauvinistic introductory biology instructors, zoocentric examples used to teach basic biological concepts and principles, hypertechnical and uninteresting botany lessons, and underemphasis (or utter neglect) of plants in students' biological laboratory and field experiences (e.g., Darley 1990; Hershey, 1993, 1996; Nichols, 1919; Uno, 1994).

The Quest for a New Theory

However, the findings of our own research studies,including two recent nationwide studies on public perception of plants (Wandersee & Schussler,2000a), coupled with the general findings of other biology education and visual cognition researchers, suggest to us that the aforementioned sources may well be secondary factors, but the primary factor for explaining why people in the US often have a greater interest in animals than plants, and why they tend to pay little attention to the plants around them, is the way that humans perceive plants—due to the inherent constraints of their visual information processing systems. Theories are logical and principled systems that describe, predict, and explain. What follows represents the current state of our progress toward constructing a theory of plant blindness.

The Pathway Leading to the Introduction of a New Term

Following several years of preliminary discussions, library searches, small-scale investigations, and a fair amount of trepidation, in 1998 we decided to introduce a new term, *plant blindness*, to the US biology education literature (1998a). We did this because we thought the current state of inattention to and under-representation of plants—not just in biology instruction, but in US society in general—might be better explained by using research-based principles of human perception and visual cognition than by earlier, instructional-bias/deficiency-related-hypotheses—such as zoocentrism, zoo-chauvinism, and plant neglect. We also wanted the new term to be free of accumulated and inappropriate connotations, and to serve as a precursor term for use in explaining some of the resultant learning-related problems (cf. the secondary terms mentioned previously).

Delimiting the New Term

We coined the term *plant blindness* by reasoning that most people were already linguistically familiar with the use of the word *blind* as a metaphorical adjective suggesting missing visual information (e.g., blind date, blind seam, blind chance, blind alley, blind spot, snow blindness, need-blind admission). As for the limits of the word *plant* within our new term, our work thus far has been focused on the US public's inattention to and disinterest in understanding most angiosperms. So the term is most appropriately used in reference to the flowering plants.

Defining the New Term

Subsequently, we defined *plant blindness* as: the inability to see or notice the plants in one's own environment—leading to: (a) the inability to recognize the importance of plants in the biosphere, and in human affairs; (b) the inability to appreciate the aesthetic and unique biological features of the life forms belonging to the Plant Kingdom; and (c) the misguided, anthropocentric ranking of plants as inferior to animals, leading to the erroneous conclusion that they are unworthy of human consideration (Wandersee & Schussler, 1998a).

Possible "Symptoms" of Plant Blindness

We have proposed that persons afflicted with the condition known as *plant blindness* may exhibit symptoms such as the following: (a) failing to see, take notice of, or focus attention on the plants in one's daily life; (b) thinking that plants are merely the backdrop for animal life; (c) misunderstanding what kinds of matter and energy plants require to stay alive; (d) overlooking the importance of plants to one's daily affairs (Balick & Cox, 1996); (e) failing to distinguish between the differing time scales of plant and animal activity (Attenborough, 1995); (f) lacking hands-on experiences in growing, observing, and identifying plants in one's own geographic region; (g) failing to explain the basic plant science underlying nearby plant communities—including plant growth, nutrition, reproduction, and relevant ecological considerations; (h) lacking awareness that plants are central to a key biogeochemical cycle—the carbon cycle; and (i) being insensitive to the aesthetic qualities of plants and their structures—especially with respect to their adaptations, coevolution, colors, dispersal, diversity, growth habits, scents, sizes, sounds, spacing, strength, symmetry, tactility, tastes, and textures (Wandersee & Schussler, 1999a).

Angiosperms, Flowers, and Visual Signal Values

Raven, Evert, and Eichhorn (1986) have pointed out that "the angiosperms make up much of the *visible world of modern plants*" (emphasis added; p. 584). Ghillean Prance, past Director of Royal Botanic Gardens—Kew, has said that his institution's research findings suggest that the earth is home to approximately 320,000 flowering plant species (Tangley, 1998). The key characteristic that sets the angiosperms apart from other plants is the *flower* (Bernhardt, 1999). Unlike animals, flowering plants cannot move from place to place to seek a mate; however, they have transcended their rooted condition via a set of features embodied in their flowers. Pollination by insects is basic in the angiosperms, and the first pollinating agents were probably beetles. The more *attractive* the plants' flowers were to the beetles, the more often they would be visited, and thus, the more seeds they would produce. Any changes in the floral phenotype that made such visits more frequent or more efficient offered an immediate selective advantage. Flower-visiting animals are drawn there by *visual* and/or olfactory attraction. Thus, plants were able to control their relationships with their pollinators, in part, by modifying their *visual signal value* through coevolution. To avoid or minimize herbivory, it is advantageous for the plants in a population to blend together visually. So, it could be said that, in effect, plants modify their *visual signal values* in accordance with the survival values conferred.

Seeing Involves More Than Meets the Eye

Why do many people tend to overlook the plants in their own environment? There is no simple scientific answer. First of all, most of us think that we see all of our surroundings simply by opening our eyelids and looking outward. Alas, there is much scientific evidence to reject that view (Catell, 1895; Nickerson & Adams, 1979). "No matter how hard we look, we see very little of what we look at," concludes Elkins (1996, p.11). Norretranders (1998, p. 126) has calculated that during visual perception, the human eye generates in excess of 10 million bits of data per second as input for visual processing, yet our brain ultimately extracts about 40 bits of data per second from that immense data stream for our conscious vision to consider—of which about 16 bits per second is ultimately fully processed. This means that our sensory bandwidth "…is far lower than the bandwidth of our sensory perceptors." Only .0000016 of the data our eyes produce are actually considered consciously; it is assumed that the rest must somehow subliminally affect our thoughts, feelings, and actions, and this means that most of our mental life must take place subconsciously. It seems that visual consciousness is like a spotlight, not a floodlight. And if that is not shocking enough, we do not see events in real time (Norretranders, p. 210). The computation time involved in processing the visual data we receive has been shown by experiment to take approximately .5 second, making *the present* a self-delusion. Perhaps the most important take-home message we have gleaned from Norretranders' (p. 242) analysis is that, although large amounts of visual data are discarded, "…what is presented [to our conscious attention] is precisely that which is relevant."

Factors That Affect People's Visual Attention

"We [humans] …tend to be surprisingly bad at recalling details of objects we see or use daily," writes acclaimed memory researcher Alan Baddeley (1982). For example, just because we have looked at a lot of pennies during the course of our life doesn't mean we can draw an accurate picture of one. Psychologist Stephen Kosslyn of Harvard University cautions us in the very title of his article that "the mind is not a camera, the brain is not a VCR." Rugg (1998, p. 1151) emphasizes that "all events are not equal; they differ in how they are initially encoded into memory." He claims that two critical factors determine whether or not we will remember an event: the degree of attention we pay to it, and the meaning or importance we assign to it. We think that appropriate botanical education and plant-growing experiences can enhance the quality of both.

Vision as Explained by Gibson's Ecological Optics

Ware (2000, p. 35) urges us to think of the world as an "information display." Human visual perception is about interpreting and understanding patterns of light—light between 400-700 nanometers in wavelength—as absorbed, reflected, refracted, diffracted, scattered, or transmitted within the environment we occupy. Applying J. J. Gibson's (1986) framework for describing our visual environment—a field he called ecological optics—it is the *surfaces* within our environment that are the keys to understanding human visual perception. Light + the environmental surfaces which present themselves yields the *ambient optical array*—a term he coined to represent all the light rays that are arriving from all directions at a particular point in the environment, as structured in space and time. Gibson argues that *surface texture* is one of the fundamental visual properties of an object and it produces *texture gradients* that are very important, along with *surface boundaries* and *cast shadows*, to our judging of space and distance (Ware, 2000, p. 40).

The Surfaces of Plants Affect How We See Them

Plant surfaces are amazingly varied and complex: leaf microtextures, for example, can yield irregular patterns of reflection—causing both the amount and color of light to vary with ambient and source illumination angles, and with viewing angle. Illumination level variations, such as when the sun temporarily goes behind a cloud and then emerges, further complicates visual information processing. Digital images of plants contain much less information than is present in the ambient optical array, but they can be very useful when linked in a meaningful way with actual laboratory and field experiences (Wandersee & Schussler, 1999b). We think it prudent to note that, when viewing works of art, experts recommend limiting one's viewing of the images to no more than 1 hour per session, and to no more than 150 images in a single session to avoid visual processing fatigue (Berman, 2000).

Some Visual Principles That May Help Explain Plant Blindness

We continue to search the research literature to answer the question of why humans often overlook plants, as opposed to animals, and why they are often less interested in learning about and understanding plants than animals. In seeking a better explanation for *plant blindness* than biased learning approaches and gaps, we have compiled the following list of relevant principles of human visual perception and visual cognition (Wandersee & Schussler, 1999a).

1. People typically tend to know less about plants than animals. Less than 2.5% of the US population is directly involved in raising farm crops (Koning, 1994, p.7). Our research has shown us that persons who have had few meaningful and mindful educational and cultural experiences involving plants demonstrate little basis beyond popular culture for plant recognition. Humans can only recognize (visually) what they already know. Psychologists would say that plants have *low signal value* for many US citizens today. Mack and Rock (1998) have proposed what they call *inattentional blindness,* and they have found that once objects have acquired meaning for an observer, they are more likely to be consciously perceived. Inattention can become attention once an object or event has meaning. We often see what we expect to see, not what's actually there—because seeing involves not just the eye, but the eye-brain system (Solso, 1994, p. 31).

2. When flowering plants are not flowering or possess inconspicuous flowers, the chromatic homogeneity, the spatial homogeneity, and the overlap of their green leaves makes edge-detection difficult. When the azaleas of the Deep South are not in bloom, they are perceived as quite non-descript bushes. When they are covered with red, pink, and white blossoms, no one can ignore them. Gopnik, Meltzof, and Kuhl (1999, p. 65) claim that: "Paying attention to edges is the best way of dividing a static picture into separate objects." Because green plants are typically static objects in the observer's field of view, seeing them and noticing them may pose much greater problems of visual detection than dynamic objects do. In addition, humans tend to get bored and habituate if they look at a relatively constant scene for too long a time (p. 27). If the members of a set of objects are not sufficiently distinct from their surroundings, they blend-in, and nothing is consciously perceived. We cannot visually label them and they do not "pop out" chromatically from their background. The visual cortex continuously filters out more of the data it receives from the retina of the eye than it retains for conscious analysis. Without our conscious intention, attention, and effort to preserve it, most of the visual data our brain receives about plants is likely to be discarded.

3. The members of plant populations typically grow in close proximity to each other, whether cultivated or natural, and they rarely move (except in wind or rain). Static proximity is a visual cue that humans use to group objects into bulk visual categories (Zakia, 1997). Thus, individual plants may tend to be de-emphasized, with the totality being labeled simply as "plants." If there are animals, especially large ones, moving on this living environmental canvas, the animals may become the focus of our attention. This helps to explain the "plants as backdrop" phenomenon. When we watch a game of football, for example, we rarely think about the huge population of grass plants the players are moving upon.

4. In most people's minds, plants are typically rather non-threatening elements of an ecosystem and incidental contact with them can usually be ignored without dire consequences. Visual habit and general familiarity diminish the conscious attention we give to such objects. If our vision operates to minimize expended energy, then low-priority-level attributes may be discarded to make visual processing easier. Human-eating plants do not exist, and we all know it. However, if we are warned that poison ivy may be present in the woods where we are walking, we are quick to develop and employ a template-like search image for compound leaves containing three leaflets in order to screen incoming visual data. In this case, the threat of bodily harm posed by its secondary plant substance, pentadecanedienyl catachol, makes the possible presence of this species in our path intensify our visual vigilance.

5. The brain uses patterns of space, time, and color to structure visual experience (Zakia, 1997). Because they are immobile autotrophs, plants generally offer fewer spacing-based, time-based, or color-based visual cues for humans to observe than animals do—except, for example, during periods of pollination and dispersal (cf. Wandersee & Schussler, 2000b). The brain is fundamentally a difference detector, and when it finds none, the perceptual field is not perturbed. For example, invasive plants, such as kudzu, capture our visual attention and interest because they grow with great vigor in places where we don't expect or want to see them.

We have argued that, instead of invoking zoological biases as the root cause, there may well be a visual-cognitive-societal basis for why plants (and thus, the plant sciences) are frequently ignored or undervalued by the US public, under-represented in American biology courses, and considered less interesting than animals. Our research suggests that a keen interest in animals does not necessarily preclude an equal interest in plants, and vice versa. In fact, many botanists, including us, are pet owners. In querying students about the reasons they were more interested in learning about animals than plants, they responded that animals: (a) can move quickly via appendages; (b) have to eat regularly just as we do; (c) have human-like eyes for vision, (d) have human-like faces, (e) exhibit many interesting behaviors, (f) have dramatic and easily observable life cycles; (g) mate, give birth, and raise their offspring; and, (g) can interact with, and sometimes even play with, people (Wandersee, 1986).

Plants Versus Animals

Our own research studies (Wandersee, 1986; Wandersee & Schussler, 1998b) and that of other biology educators (Baird, Lazarowitz, & Allman, 1984) have found that, for the groups of school students that were studied, the majority of students (both girls and boys) preferred to study animals over plants. Our 1998 study of 274 US students drawn from grades 4-7 in a major metropolitan area indicated that: (a) student interest in animals led plants by approximately a 2:1 margin; (b) girls were more likely than boys to express an interest in learning about plants; and (c) of the nearly 300 students we queried, only about 7% spontaneously expressed a scientific interest in plants—and of *that* 7%, about two-thirds were *girls*.

The Dominance of Interest in Animals

Paradoxically, plants form the basis of most animal habitats and all life on earth (Abbott, 1998). Although animals frequently steal the spotlight when the specter of extinction is raised, one in eight plant species is currently threatened by extinction. Intellectually, we may know that you can't sustain pandas without bamboo for them to eat, but culturally, facts like this are often forgotten (Abbott, 1998). Few American children's cartoon characters, shaped candies, stuffed toys, team mascots, songs, or games pay homage to plants rather than animals. Children in the US seem to be primarily "animal-socialized."

Perhaps it's not just an American phenomenon, however. Visitors using the main entrance of the world's most famous botanic garden, the Royal Botanic Gardens—Kew (located near London) are greeted by *The Kew Mural*, a great and stunningly beautiful, intricately carved, wall-mounted, wood-relief sculpture depicting the Kew Gardens being assaulted by the powerful wind storm that struck down or damaged over 1,000 trees on 16 October 1987. The many kinds of wood used to make the sculpture came from actual timbers felled by the tempest; the interplay of natural colors, polished wood grains, flowing shapes, and visually palpable textures leave its viewer breathless. Yet, inexplicably, about two-thirds of the sculpture's surface area is devoted to images of *animals* being displaced by the storm. The plants depicted in it are rendered as either fragile or marginalized; the animals are central to the mural, and appear as either forceful opponents or agile survivors. Plants are clearly the backdrop of the visual tale being told.

The Importance of Having a Plant Mentor

In our two national studies covering 27 states (the first, looking at US "Generation Y" youth, and the second, at US mothers of young children) focusing on each demographic group's attention to, interest in, and understanding of plants—one of many interesting findings was that having early experiences in growing plants under the guidance of a knowledgeable and friendly adult was a good predictor of later attention to, interest in, and scientific understanding of plants, as well as of the kinds of plant experiences a young mother will provide for her children (Wandersee & Schussler, 2000a).

Describing Plant Mentorship

But the adult who serves as a *plant mentor* need not necessarily be the child's mother. Lewis (1996, p. xviii) writes: "I bonded with plants at an early age. As a small, curious boy, I once watched my grandmother crush a dried zinnia flower in her hand, then gently blow on the mixed pile of fragments. Petals and other chaff flew off, leaving tiny brown daggers on her palm. `Seeds to grow next year,' she said…I was awed and excited by the chance to practice this magic, and, *with her guidance* [emphasis added], soon started my own tiny garden." Your authors remember similar "magic moments" as budding plant scientists—one of us recalls an exciting, mentored, personal experiment during her 6^{th} grade year, comparing the germination rates of pea seeds that she placed in a freezer for various intervals to pea seeds that were not frozen; the other recalls using a small vial of gibberellic acid, obtained from a local greenhouse by his father, in a supervised, personal attempt to grow giant bean plants (ala' Jack and the Beanstalk) for a school science project during his 5^{th} grade year.

A Possible Long-Term Solution to the Plant Blindness Problem

Based on the evidence we have gathered to date, we hypothesize that early and iterative, well-planned, meaningful and mindful education (both scientific and social) about plants —coupled with a variety of personal, guided, direct experiences with growing plants—may be the best way to overcome what we currently see as the human "default condition"—*plant blindness*.

Plants, Culture, and Plant Blindness

We also postulate that the greater the degree of value a culture ascribes to plants, and the greater number of members within it who work directly with plants or plant products, the more likely the prevalence of plant blindness in that culture will be lower (cf.

Balick & Cox, 1996). As Charles Lewis (1996, p. 22) contends, "Those who live by hunting or gathering, fishing or farming, must observe nature's signs….Changes in foliage color would be a strong indication that preparation for surviving the long winter should begin."

In addition, Lewis (1996, p. 20) asks: "If dwellers in the savanna [of Africa] did use tree shapes and the visual appearance of the terrain for swift assessment of its potential as a habitat, could they not have evolved innate preferences for particular landscape characteristics (preferences that resonate within us today)? Investigators have found that Americans like park settings that might be characterized as `savannas'…." Research by Balling (a psychologist) and Falk (an ecologist) found that younger school children (ages 8-11) who were shown slides of five different biomes expressed a significant preference for savanna-like settings, and later found that only after people grow older do they begin to select more varied landscapes—usually of the type familiar to them (1982).

A Botanical "Sense of Place"

Hollingsworth (2001) writes about the value of capturing one's *sense of place* photographically—via a close-up, a detail, a panorama, or a landscape scene that approximates a still- life painting of an importance site in one's personal history. At the beginning of a graduate seminar in botanical education, we also explored this idea, by asking the participating science instructors to prepare and then give brief, 5- to 10-minute talks describing their own *botanical sense of place*—reflecting upon salient memories drawn from childhood days, and specifying several kinds of plants which grew in their yard or neighborhood that played a role in their life while they were growing up—and situating their hometown in its ecological and economic botany settings. It seemed to be a worthwhile exercise in self-discovery for them—realizing who their plant mentor was (if they had one); which plants they often used for play, for shelter, for scent, or for taste; what kind of bioregion they lived in; what kinds of area cash crops became familiar to them; and so forth. More importantly, it brought prior knowledge about and experiences with plants to the fore, and it provided accessible, conceptual anchor points for linking the new botanical knowledge they were learning to their existing knowledge structure about plants (Fisher, Wandersee, & Moody, 2000; Mintzes, Wandersee, & Novak, 1998, 2000).

Some Activist Approaches We Are Trying

"Prevent Plant Blindness." Those three simple words are emblazoned diagonally across our 20" x 30", bulletin-board-sized, full-color, classroom poster which is being distributed to more than 22,000 US science teachers and botany instructors as part of our national campaign to increase students' awareness of and interest in plants. We designed the poster to be initially puzzling, and to elicit inferences about its meaning. This aligns with Solso's (1994, p. 26) tenet drawn from visual cognition research which says "…we gaze longer at interesting or puzzling things…." The poster shows a tree-lined, riverine landscape. Hovering, Magritte-like, in the sky above is a large pair of dark-red-tinted glasses. The implication is that someone wearing those red glasses would not be able to see any of the green plants shown in the scene below—that if one's vision is "filtered," either physically or conceptually, one may actually miss seeing the plants that are present in one's environment. The back of the poster provides a complete definition of plant blindness, lists its symptoms, and offers directions for 20 simple, plant-science-related activities. This poster was subsequently endorsed by BSA's Education Committee.

Besides the plant poster project, we have also written, illustrated, and published a 40-page children's science picture book which presents a plant mystery to children between the ages of 4 and 8 (Schussler & Wandersee, 1999). It is intended to be the first of a series of mystery books involving the two main children's characters, who are portrayed as being best friends, namely—Abby and Tate. The first book subtly introduces its "readers" to some basic principles of plant care and encourages them to try raising an African Violet plant. We have introduced the book to a fair number of elementary teachers, parents, and grandparents, and have made it available at cost on Amazon.com. It has just been translated into Spanish by plant ecologist Sandra M. Guzman, and a Spanish version will be available in about six months.

In addition, in 1998, we founded a science book award, now recognized by children's literature libraries and authors worldwide, called the Giverny Award. It is given each year to the author and illustrator of the book selected by the Award Committee as the best children's science picture book in our selection pool—with preference given to storybooks that teach plant science concepts and principles in an indirect and engaging way. Each year's winning book is described on our research group's web site (http://www.15degreelab.com) We hope that our annual book award, children's plant mystery books, classroom poster design and distribution, research publications, and regular presentations at selected, science teachers' and scientific society meetings will, at least in a small way, help increase the US public's awareness and interest in plants.

Brief Closing Remarks

If we are to liberate American students from the intellectual, perceptual, and visual processing traps that can lead to *plant blindness,* those of us who teach introductory biology and botany courses must work to expand our students' botanical horizons. While biological science departments may be currently reorganizing themselves along the lines of common research themes rather than taxa of organisms studied, plants stand as distinctively different life forms from humans, life forms that have, historically, rewarded our focused study, observation, and investigation. We think there are sound scientific reasons why botany, like the plants it studies, needs to maintain its own visibility and identity (Greenfield, [1955] 1999).

In BSA's strategic plan, *Botany for the Next Millennium* (Niklas 1995, p. 11) we read that, "Functionally, plants are the primary mediators between the physical and biological world." That is no minor feat; that role alone calls out to those who teach biology and botany to help "Prevent Plant Blindness."