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Usage of plant examples in secondary school biology classes

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USAGE OF PLANT EXAMPLES IN SECONDARY SCHOOL BIOLOGY CLASSES

by
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ABSTRACT

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Botanists have expressed concern over the dwindling recognition and emphasis of plants that currently exists in the fields of education and research. To ascertain if these claims pertain to high schools in the State of New Jersey, a survey on the frequency of using plant examples for teaching 10 biological principles was randomly distributed to secondary school biology teachers. Results from 80 respondents showed that on average, plants are used as examples in teaching 66% of these biological principles. The primary rationale cited by teachers for low or non-usage of plants was that they preferred animals as teaching examples. Underlying factors that explain this lack of plant emphasis include course requirements of teacher certification, the current biology teaching trends in our classrooms, and the recognition and funding opportunities of plant science. Recommendations include requiring a botany course for all college students in biological teaching programs, involving botanical societies in educational collaborations, encouraging a greater awareness of research in plant science, and stressing the importance of plants in secondary biology classrooms.

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INTRODUCTION

The Importance of Plants

Plants play a crucial role in our everyday life and yet "poor awareness of plants seems to be inversely related to their importance" (Lewis 4). They are the primary producers for food consumers and also supply a variety of products such as medication, fiber, fuel, building materials, paper, beverages, and perfumes. They surround us with aesthetic beauty that can be experienced in our homes, parks, and natural settings while offering us numerous forms of recreation. Not only we as humans benefit from the existence of plants but they also offer shelter and habitats for a variety of wildlife. They are crucial to the environment as they filter pollutants from air, recycle large amounts of water through transpiration, control soil erosion, produce oxygen, and may impact the global warming effect. Plants and their byproducts surround every single aspect of society (Lewis 6). Karling, a prominent botanist, summed up the essentialness of plants when he said, "Man and all other animals are in reality guests of plants on this earth" (9).

The Need for Plant Research

Plant research is indispensable in numerous areas. Plant knowledge and experimentation are necessary to address environmental issues such as dwindling natural resources, development of alternative energy sources, and a clear understanding of the ultimate results produced by the destruction of the environment. As medical research continues to address the needs to improve worldwide health, new discoveries continue to provide us with plant-derived pharmaceuticals and research gives us insight on the important impact they have in the human diet. From an agricultural perspective, continued research is essential to develop innovative techniques to feed the world's ever-increasing population. The National Research Council's (NRC) *Commission on Life Sciences* emphasized the importance of plant research with the statement, "Research on plants enriches our intellectual life and adds to our knowledge about other life processes. The results of research on plant systems also can teach us how to approach problems in agriculture, health, and the environment (13)."

The Problem of Plant Neglect in Education

While the significance of plants is irrefutable, botanical societies, educators, and researchers are concerned that the study of plants is somehow getting "left out" of the biological curriculum. While this problem is observed in all levels of education, it can be acutely influential at the high school level. Studies have shown that high school graduates have little knowledge or appreciation for plants, a concept described as "botanical illiteracy." Studies indicate that the numbers of high school graduates who are entering college botany programs and pursuing careers in plant science is continuously declining (Carter 43). The most recent statistics gleaned from the National Science Foundation (NSF) Division of Science Resources' (1985 to 1996) demonstrated that the enrollment in botany programs was declining at a percentage change of – 8.4%, while the total biological graduate enrollment increased by +16.3% (NSF, *Science Indicators* tab. 214). Additional records show that in the total number of degrees granted in the years of 2001-2002, botany accounted for only 3.8% of all biological Ph.Ds, 3.1% of Master's degrees, and.5% of bachelor degrees (tab. 255). Concurrently, there has also been a decline in basic plant research since "an important responsibility of an academic community is education and training that will provide a steady stream of new investigators" (NRC 31). As one scientist remarked, "On the whole, botany has not kept pace with the expansion of other sciences" (Greenfield 1).

Influences Affecting Plant Education

Past Scientific Discoveries

Even a brief overview of historical scientific discoveries, markedly from the 1940-1970's, gives us distinct clues on the diminishing role of plant science. Examining the Nobel Prize winners in biologically oriented categories during this time period illustrates the emphasis of scientific achievements that were recognized and honored. Within these three decades, only four out of sixty awards centered directly or indirectly on plants. These were the (1) elucidation of the Kreb Cycle (1940), (2) nutritional chemistry for livestock (1945), (3) carbon assimilation in plants (1961) and (4), the biosynthesis of carbohydrates from sugar nucleotides (1970) ("Nobel Prize"). Even today, few people are familiar with these concepts as they are of little interest to the public. However, such discoveries as penicillin (1945) and streptomycin (1952), uses of DDT (1948), understanding the growth of the polio virus (1954), heart catherization (1956), the structure of insulin (1958), and polymer synthesis (1963) among many others, were more tangible to the public ("Nobel Prize"). In the same time period, scientific advancements such as the birth of modern genetics, oceanic discoveries, microscopic techniques, controversial finds in human evolution, and an explosion of knowledge and technologies in human health ("Timeline") received greater media attention as the majority of the population could more-readily relate personally to this new knowledge (Hershey, "Historical" 76).

Thus, while some advancements occurred in plant science, they were not treated as discoveries that would radically change the public's perceptions or lifestyles. As science moved forward "with extraordinary developments(s) in biology and medicine...plants lagged behind" (NRC 37).

Historic Changes in College Botany Programs

Concurrently, while less public recognition was being given to plant science, historic educational changes began in the colleges and universities which would effect plant science in education. In the mid-1900's, colleges and universities began to integrate botany and zoology into one "biology" department. In 1956, Ralph Cleland wrote critically that this combining "among the life sciences has already gone too far to allow the hope that all botanical activities can be centered in single strong departments within our universities..."(2), a trend that has continued to today. A 2004 study published by the Botanical Society of America (BSA) reported that botany departments are currently found only in large research universities, where of the 59 research universities originally containing a botany department, only half are now in existence. Even at the time of BSA's publication, Iowa State University had closed its Botany Department (Sundberg, "Where" 3)

In his article, "Historical Perspectives on Problems in Botany Teaching," Hershey outlines the problems that resulted from the past development of general biology departments. He notes that either from the lack of college emphasis in botany or by pure happenstance, there was a shortage of college botany teachers during the transitional years of the merging departments. However, no shortage existed for zoologists who became the majority of the professors in these newly created general biology courses. Since these professors were only trained in animal physiology and had limited knowledge of botany, teaching plant science was problematic within the biology course (341). Hershey aptly describes the essential problem: students in these classes were learning "botany taught by a zoologist" (Hershey, "We Have Met" 81). Wandersee, additionally noted that the problem still exists even when college biologists are properly trained in all biological disciplines, commenting that, "There is a recognized tendency, even for knowledgeable biologists, to overlook, underemphasize, or neglect plants when teaching introductory biology courses"(Wandersee, "Preventing" 84). This plant neglect "is an extremely important problem in biology education because it distorts the reality of biology" (Hershey, "We Have Met" 82).

Changes in High Schools' Biological Emphasis

In examining a history of the past courses offered in high schools, it is evident that the importance of botany that was also predominantly recognized at the college level has also declined. In the early 1900's, botany was a standard curricular offering in the majority of high schools (Coulter 426) in addition to schools' nature and school garden projects that also promoted the study of plants (Bigelow 389-91). Botany textbooks abounded, prestigious journals such as *Science* featured articles on botany teaching, and educational publications presented plant science activities (Ganong). The proliferation of plant science materials began to be a source of criticism, even to the point of complaining at the abundance (Beal 876). Now, similar to colleges, the majority of plant science is taught within the context of the high school's general biology class in which plants are underemphasized.

A parallel downward trend of plant science in colleges and secondary schools is now attributed to high school teachers who are being influenced by their college teaching programs (Hershey, "We Have Met" 91). Many of these biological teaching programs have been criticized for requiring few biological courses, biology classes with little botany, or not mandating a botany course in graduation requirements. The vast majority of high school biology teachers have not taken a single botany course and have no plant science knowledge other than what was presented in their own college general biology course (Hershey, "Historical" 341). As one study demonstrated, a college general biology course only presents, at very best, half of what would be encountered in an Introductory Botany course. For example, only a fourth of the surveyed general biology classes included a lab on photosynthesis (Sundberg, "What Are" 78-9). "This neglect of plants in biology is self-perpetuating; teachers get little training in botany, and so they teach little plant botany in their courses" (Hershey "Plant Neglect" 418).

This unfamiliarity with plants results in secondary biology teachers spending as little time as possible on plants and teaching them in an uninteresting or irrelevant manner. One study demonstrated that biology teachers "use plants as example organisms less than 20% of the time (Reinsvold 3)." Replicating the college level curriculum, the void left by plants has been replaced with animals, ushering in a whole new era of zoocentrism, which stresses that animals are the primary life form and command central focus in the study of life. This viewpoint also neglects the important role that plants have in the interaction between animals and their physical environment. Plants are relegated to being a negligible part of the environment that animals live in (Wandersee, "Preventing" 84) and not readily noticed (Wandersee, "Toward" 3). The editor of *American Biology Teacher* even wrote, "We are all more interested in animals: They react, they move, they even think… they are more like us" (Flannery 306). Zoocentrism is exhibited in the classroom when plants are only presented within their corresponding unit, as one section of the course. Yet in contrast, animals are not only taught in their unit but extensively woven through the teaching of other biological topics. For example, animals are used to explain such concepts as extinction (dodo bird, dinosaurs), evolutionary change (Darwin's finches, horse), and community populations (lynx and hare).

The neglect of plant study is likewise observable in high school elective courses, such as ecology. In teaching environmental conservation, plants should receive a sizable amount of attention, but zoocentrism occurs here as well. For example, students might learn about old growth forests only through the knowledge of the spotted owl's plight. Overall, the focus remains on endangered animals and rarely are endangered plants mentioned (James). Yet the threat of extinction looms for one of every eight plant species in the world and nearly one of three in the United States, according to the worldwide assessment of plant endangerment by the World Conservation Union (Stevens A1). Unfortunately, there lingers an unstated "message that plants are not important enough to study as essential components of the world they live in" (Fail 4).

It is probable that this lack of plant emphasis and zoocentric teaching is a probable determining factor in the development of our students' interest. A cross-age study done by Wandersee in 1999 noted students were approximately twice as interested in studying animals as compared to plants. When questioned further, only 7% of the 274 respondents showed a scientific interest in plants (Wandersee, "Plants or Animals").

Where there is a lack of teaching and interest, lack of knowledge is likely to follow. An study was published in United Kingdom's *Journal of Biological Education* in 2005. While this study did not involve United States students, it similarly emphasizes the lack of students' plant background. In an Honors Biology class, 812 high school students were asked to identify pictures of ten common wildflowers. Spelling was not a factor, the students could identify plants by familiar names, and the flower examples ranged in the difficulty level of … daisy, clover, violet, buttercup, thistle… and thyme. Findings demonstrated that 86% could name no more than three of the ten plants; only one student, with the highest score, could name seven (Bebbington 63). In contrast, younger children in grade school are able to recite the scientific names of extinct dinosaurs and give animal examples from almost every Phylum. To assess the likely influence of teachers, Hershey noted that it would be interesting to conduct a nationwide survey comparing student and teacher knowledge of plants versus animals ("We Have Met" 79).

High School Biology Textbooks

Textbooks contribute to the problems of plant neglect in secondary biology classrooms as they are not only used to guide instruction, but also to develop the curriculum content (Haury 2). The American Association for the Advancement of Science reviewed the top high school biology textbooks and found them deficient in overall content. "At their best, the textbooks are a collection of missed opportunities"

(Koppal 2). In assessing the plant content in secondary biology textbooks, one researcher noted that it rarely exceeds 15-20% of the total content (Bozniak 42). In another study by Uno, he analyzed six of the most popular, best-selling high school biology textbooks and reported that the material therein included 37% devoted to general biological principles, 42% to humans and animals, 14% to plants, and 7% to other organisms. On average, only six of forty-three chapters were specifically about or included plants and plants were used infrequently as examples in general biological principles. Animal concepts also permeated the labs with the distribution of 20% on plants and 32% on animals. The suggested plant labs were passive, uninteresting and not experimental in nature. Some of the examples included drawing and labeling monocots and dicots or focusing on preserved specimens or slides. Uno concludes that what is presented in the textbook is of great importance because 75% of classroom activity and 90% of homework is directly related to the text (264-5).

National Science Standards

Not only have our textbooks influenced our plant education opportunities, but also the National Research Center's (NRC) National Science Educational Standards (NSES) whose curriculum is adopted and modified by the majority of states. While the "NSES provide(s) a framework for teaching precollege science… it does not stress the fundamental importance of plants in teaching" (Hershey, "Plant Content" 1). The actual standards are quite short and concise for "Life Science Standards, Levels 9-12": "Students should develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, organization in living things, and the behavior of organisms" (NRC 106-7). However, in "The State of Precollege Botanical Education", Uno identifies three main problems within the explanatory guidelines of the standards. First, throughout this supporting text, biological principles are either limited or not always applied to plants. For example, NSES includes the statement that, "All animals depend on plants. Some animals eat plants for food" (NRC 129). This diminishes the many other important roles of plants such as providing shelter, energy sources, and oxygen. Second, similar to textbooks, the suggested plant activities and labs tend to be static and non-challenging for both students and teachers (Uno 263). And third, if the guidelines were followed explicitly, there are certain situations that would actually exclude discussion about plants. (Uno 263). For example, the NSES focuses solely upon animal behaviors that help survival (NRC 128-129). Overall, the national science standards show an animal bias in its content recommendations (Hershey, "Plant Content" 3).

State Science Standards

The *New Jersey State Science Standards* are described in "*The State of State Science Standards – 2005*" as a "mammoth document" and criticized for its "sheer size and complexity of text (Gross 51)." With the magnitude of scope and attention to detail, it would be expected to provide ample opportunity for plants to be represented proportionally to animals. Of the twelve science standards adopted by New Jersey in 2002, only standards six and seven refer to biological sciences. Standard six states, "All students will gain a basic understanding of the structure, characteristics, and basic needs of organisms." Standard seven states, "All students will investigate the diversity of life."

These standards are accompanied by two correlating documents: "Framework- Content" and "Framework-Process." Each framework is comprised of "cumulative progressive indicators" based on the particular science standard, which are specific statements of what the student should know or be able to do in each K-12 grade and are listed in Appendix A. To assess the role of plants and yet avoid a distorted view, the 9-12 framework needs to be considered within the context of the entire K-12 since prior knowledge is emphasized and expanded. Standards six and seven have 17 and 13 correlating indicators respectively in their Framework-Content. It is noteworthy that two of these indicators directly deal with plants: "Explain how plants convert light energy into chemical energy"; "Describe how plants produce substances high in energy content that become the primary source of energy for life" (NJ 6.7). All indicators use the word "species" when stating principles of diversity, biological evolution, and genetics that can apply to either plants or animals. In its framework-content document, the *New Jersey State Science Standards* display an unbiased approach to all species and exceed the National Standards by noting the significance of functions that are specific to plants.

Another correlating section in the New Jersey Standards is labeled "Framework-Process" and accompanies the standards' "Framework-Content" and outlines projects and lab exercises that would help in teaching the combined 30 cumulative progressive indicators of standards six and seven. This is where the State science standards minimize the importance of plants – in the actual implementation. Again, considering the entire K-12 framework, standard six contains 76 activities and standard seven contains 22 activities. Without reproach, it is observed that not all activities are restricted to plants or animals, such as the modeling of organic compounds or genetic probability labs while other activities equally include animals and plants in the instructions and set-ups. However, of 98 activities, 33 specifically focus on animals, excluding humans, while only 10 activities specifically focus on plants. Other problems include, the creation of cell models in which plant organelles are not included, creating a mini-ecosystem narrowly restricted to researching the kind of food needed by each animal, and the serious lack of any plant-based labs or projects in the entire areas of genetics and evolution. It might be encouraging to plant advocates observing "species" in the indicators; but animals are primarily used in activities.

Summary of the Problem

Thus, while it is easy to point to key social and institutional changes affecting the role of plants in education, it is much more difficult to ascertain how to correct the problem. The past scientific discoveries, merging of college departments, textbooks and science standards are not readily adaptable to change. The teachers, however, are an ideal starting point to promote the importance and essentialness of plants.

Purpose of Thesis

This thesis seeks to explore three questions: First, apart from teaching a chapter or unit specifically on plants, I will ascertain how often New Jersey's secondary biology teachers are incorporating plant examples when teaching general biological principles. Second, if they are not, what are the reasons? Third, I will explore possible strategies and recommendations to increase plant education, with the ultimate goal of a botanically literate society.

METHODOLOGY

Construction of Survey

A survey was used to address two primary questions. The first question asked for the frequency that secondary biology teachers use plants to teach core biological principles that were developed using the framework-content of standards six and seven of the New Jersey Science State Standards. Appendix A lists the indicators of the framework-content and Appendix B correlates these with the principles used in the survey. The survey contained a forced-choice, numerical scale of 1-5, where 5 is "always" and 1 is "never". If a teacher recorded a 3 or lower, the second part of the survey asked that (s)he record possible reasons for the infrequent use of plants. Should none of the given reasons suffice, an additional column of "other" was available with additional space for corresponding comments. The survey was intentionally made uncomplicated to complete in order to encourage a high response rate. Teachers were asked to provide their answers by using a check mark in the appropriate column to record their responses. The participating teachers had the option of remaining anonymous and the purpose of the study was not stated on the survey.

Distribution of Survey

Seventy-five randomly selected high schools were contacted, representing all of New Jersey's counties. Each school's mailing contained three surveys (Appendix C) with self-addressed stamped envelopes and a cover letter (Appendix D) to the school's science supervisor explaining the intent of the study.

Interpretation of Results

When respondents marked 5 or 4, these values were summed and plant usage was considered "frequent". Likewise, when respondents marked 1 or 2, these values were summed and plant usage was considered "infrequent". Column 3, being the middle point, was omitted to maintain a buffer between the two sides.

Chi-Square analysis with Excel was performed to test for significance and demonstrate that teachers use plants to illustrate some principles more often than others. Standard deviations were obtained for each averaged grouping of data.

Some teachers answering 3 or less did not check a column indicating the reason for low plant usage, while others checked more than one reason. This resulted in a mismatch in the total number of those answering 3 or less when compared to the number of reasons given. It also should be noted that the majority of respondents who checked "other" provided comments concerning their use of animal examples. It was uncertain why they did not just check the "other species" box. Regardless, "other" was still entered as the given data.

Additionally, 26 of the 80 responding teachers also wrote additional comments and explanations of their answers. These were informative and occasionally quoted within the discussion and conclusion and the majority are listed in Appendix E.

Limitations

There were three limitations in the use of this survey. First, the survey relied upon self-reported data. Even though respondents had the option of remaining anonymous, it is possible that teachers answering "always" in describing their use of plant examples, exaggerated the positive aspects of their teaching. Possibly for the same reason, few teachers checked the box indicating that they were "unfamiliar with any (plant) example" as this could make them appear unqualified/uneducated.

Second, reasons for low plant usage were provided and teachers could mark as many as applied. While there was an option to add additional reasons, teachers may have found it easier to check a given box rather than write out an explanation for their low usage. Thus, other reasons for not including plants in biological education may not have been given by the teachers.

Third, while all the listed biological principles were developed from the New Jersey science standards, a particular teacher may choose not to teach all ten principles. It might have be easier to report low usage of plants for a particular principle than to admit an entire principle is lacking in his/her teaching.

RESULTS AND DISCUSSION

Return Rate

Of the 75 schools receiving the survey, 60 participated. Eighty-three of the distributed 225 surveys were returned within the response period. Of these, three were completed incorrectly and were not included in the statistics. Thus, the return rate was 37% with a usable return rate of 36%.

Significance of Data

There is a statistically significant difference between the levels of plant usage by respondents when teaching all the biological principles as determined by Chi-square analysis [X^2 (36, N = 80) = 211.2, p < .005].

Survey Results

Raw Data from each of the ten principles are shown in Table 1, while Table 2 shows this data in a percentage form. Figure 1 shows that some principles were taught using plant examples more frequently than others. Table 3 addresses the second question of rationales for plant disuse. As illustrated by Figure 2, the principle reason for plant disuse was "other organisms are better examples" and the least cited reason was "not relevant to principle."

Table 1. Usage of Plants in Teaching Biological Principles

total respondents = 80

Biological Principle	usage 5 (always)	4	3	2	1 (Never)
Adaptation	23	19	21	13	4
Extinction	6	10	13	22	29
Speciation	8	17	18	20	17
Taxonomic Classification	21	28	13	13	5
Growth and Development	14	33	14	5	14
Mitosis	42	24	6	2	6
Inheritance of Genetic Traits	47	16	5	4	8
Population Growth	7	22	15	12	24
Nutritional Requirements	25	23	17	7	8
Competition	13	25	17	16	9

Table 2. Percentage of Teachers Using Plants in Teaching Biological Principles

total respondents = 80

Biological Principle	usage 5 (always) (high:100%)	4 (high: 80%)	3 (mid: 60%)	2 (low: 40%)	1 (Never) (low: <20%)
Adaptation	29	24	26	16	5.0
Extinction	7.5	13	16	28	36
Speciation	10	21	23	25	21
Taxonomic Classification	26	35	16	16	8
Growth and Development	18	41	18	6.3	18
Mitosis	53	30	7.5	2.5	7.5
Inheritance of Genetic Traits	59	20	6.3	5.0	10
Population Growth	8.8	28	19	15	30
Nutritional Requirements	31	29	21	8.8	10
Competition	16	31	21	20	11

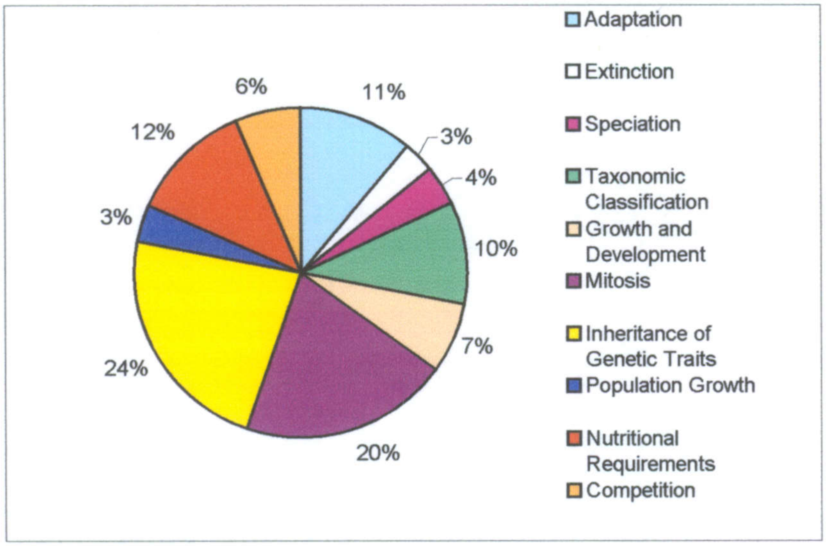

Figure 1. Percentage of teachers always using plants when teaching biological principles.

Table 3. Reasons for Disuse of Plants in Teaching Biological Principles

	Not Relevant to principle	Other organisms are better examples	Not adopted in educational resources	Not required in standards	Not familiar with any example	other
%	2.0	70	11	5.0	6.0	7.0

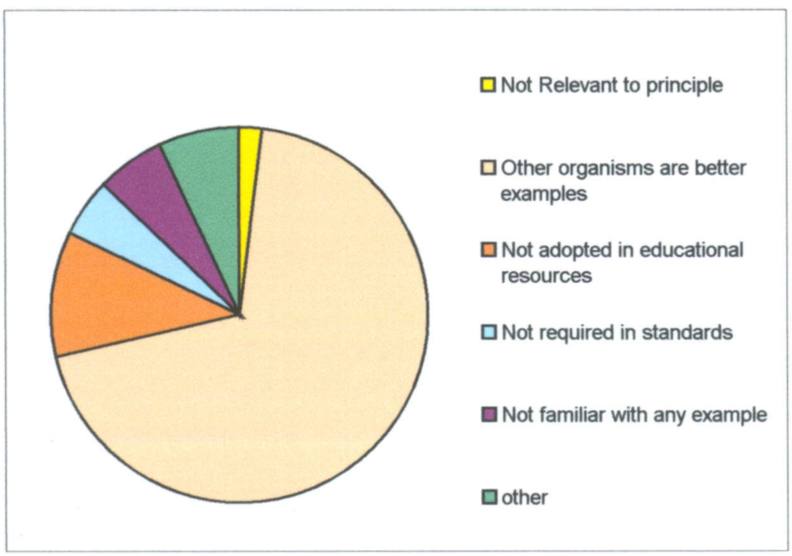

Figure 2. Reasons for disuse of plants in teaching biological principles.

Comparisons of Plant Usage

Table 4 shows the overall level of plant use in teaching each biological principle and the means can be comparatively viewed in Figure 3. In Figure 4, the percentage values of high, mid, and low plant usage are shown together for a comprehensive view.

Table 4: Statistical Comparisons of Plant Usage by Teachers

	mean	median	mode	stand. dev.
Adaptation	3.6	4	5	1.21
Extinction	2.3	2	1	1.28
Speciation	2.7	3	2	1.29
Taxonomic Classification	3.6	4	4	1.46
Growth and Development	3.4	4	4	1.33
Mitosis	4.2	5	5	1.67
Inheritance of Genetic Traits	4.1	5	5	1.32
Population Growth	2.7	3	1	1.38
Nutritional Requirements	3.6	4	5	1.29
Competition	3.2	3	4	1.26

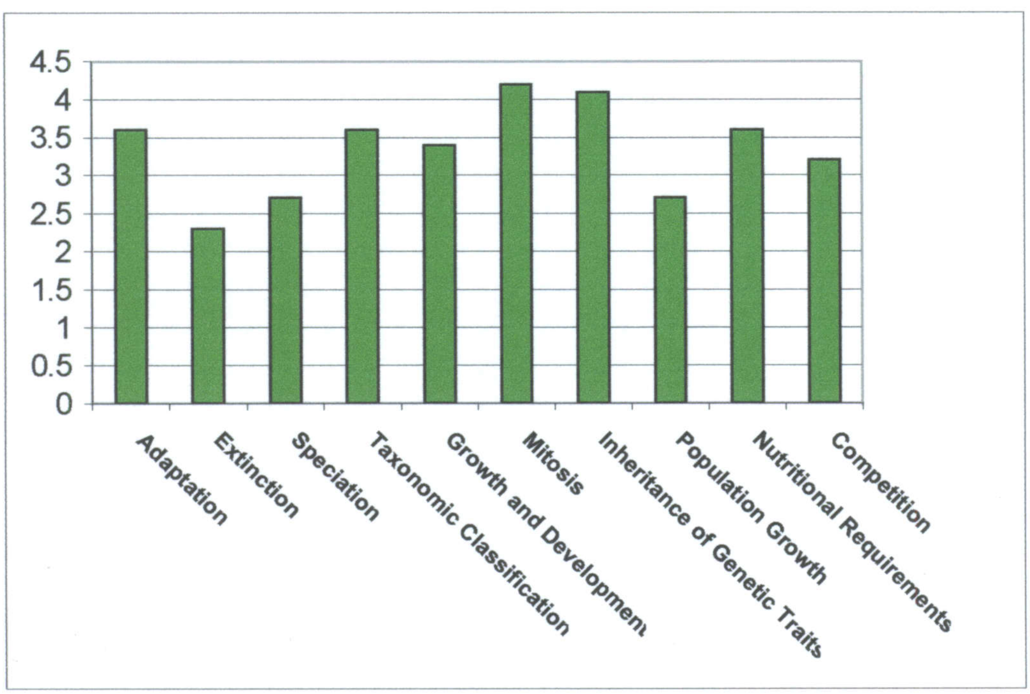

Figure 3. Comparative use of plants by teachers.

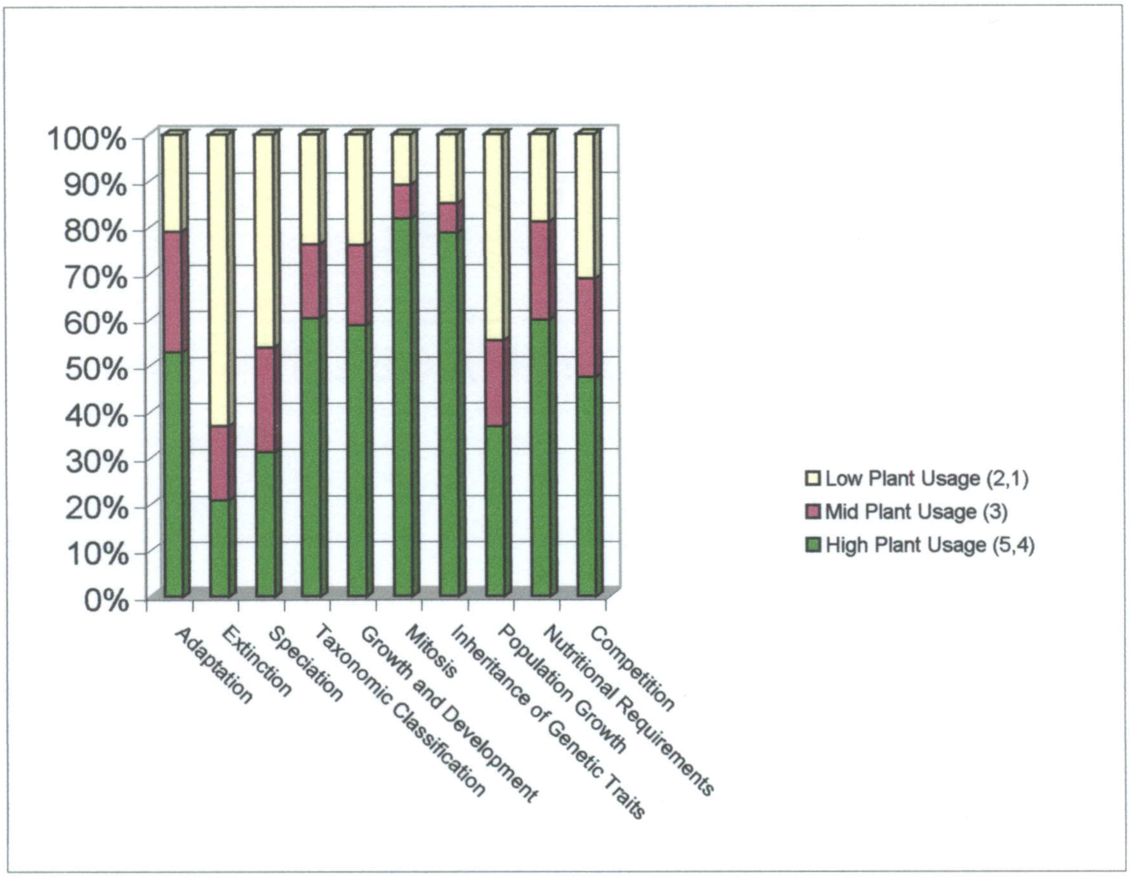

Figure 4. Plant usage percentages.

Plant Usage in Individual Biological Principles

Adaptation. While the mean of the results demonstrated a 72% overall usage, only 53% of teachers used plant examples frequently. A higher value was expected since various plant traits are easy examples of adaptation. It is possible that plant adaptations were only addressed in the specific plant unit and not revisited in the evolution unit. Should this be the case, teachers are losing an opportunity to build on and refer to prior learning. Five teachers who demonstrated low usage in this area reported that plant adaptation was not adopted in their resources. Regardless, the topic of adaptation is a required biology standard and plant examples can be added. Twenty-four teachers indicating low usage, preferred other organisms as better examples.

Extinction. Plant examples are used by teachers an average of 46% of the time, but only 20% of teachers use plant examples frequently. When compared with the data from other principles, extinction was observed to have the lowest results for the utilization of plants. In this category, 58% of teachers never used a plant as an extinction example and over half, responded that "other species are better examples." Nine responding teachers admitted that they were not familiar with any examples of extinct plants, and seven noted that this was not in their educational resources. In checking with three of the current textbooks used in New Jersey's biology classes, no examples are given of extinct plants (Standafer, Raven, Miller). One comment given under the "other" column for disuse stated, "extinct plants don't draw interest like animal examples."

Speciation. This closely followed the trends observed in "extinction" with a slightly increased usage. Overall use was 54%, but only 31% of teachers used plants frequently. Twenty-one percent never used a plant example for speciation and four teachers noted that they were not familiar with any examples. Several comments noted that, "animals are easier to relate to."

Taxonomic Classification. The overall use of plants in this principle was 72%. Recognizing that the systematic classification of all life can not be considered complete without a plant example, they were never used 7.5% of the time when teaching this principle. One person commented, "We focus more on other kingdoms."

Growth and Development. This biological principle was used by 68% of the sample study. The disparity between the two extreme is notable: The highest column of use was marked by 17.5% teachers and lowest column of use was also 17.5%. Ten percent of the teachers noted that their adopted educational resources did not contain plant growth and development, even though this information was present within the plant unit in all three surveyed popular high school life science textbooks (Standafer, Raven, Miller). As before mentioned, other organisms are considered better examples.

Mitosis. This principle showed a high level of usage for the teachers. There was an 84% overall usage, with 82% of teachers using plant examples frequently. This was most likely due to the traditional usage of the onion root tip to view the varying stages of mitosis. Surveyed textbooks also had an equal presentation of animals and plant mitosis (Standafer, Raven, Miller).

Inheritance of Genetic Traits. Similarly, this principle had a 79% frequency rate. Inheritance is usually introduced with Mendel's pea plant experiments. Thus, it is surprising that 10% of respondents used plants infrequently. It would be interesting to look at these teachers' curriculums and observe how genetics is introduced. Perhaps, as one of the respondents had commented, "We focus on humans."

Population Growth. When developing the survey, the choice of this principle involved some uncertainty. I did not know if it was routinely covered in a general biology class, even though it is alluded to in the New Jersey science standards. The response demonstrated that only five teachers checked that it was not in their educational resources and only four teachers claimed it was not required in the State standards. Results indicated that plants were used 54% of the time. Again, "other species" were overwhelmingly noted as better or as one teacher commented, "we concentrate on human populations." Thus, only 36% of teachers teach this principle frequently using plants, and

30% never cite plants. While plant populations are important to study singularly, even within a zoocentric curriculum, plant populations should still be noted as a crucial variable that directly or indirectly support animal populations.

Nutritional Requirements. Judging from the extra comments teachers gave, many interpreted "nutritional requirements" as teaching photosynthesis, rather than soil or mineral nutrients involved in plant nutrition. Thus, while 60% reported that they taught this concept frequently using plant examples, many of the respondents were answering to photosynthesis and thus inflated the usage percentage. Since this principle was misinterpreted by some of the teachers, it would be advisable to clarify the definition of "nutritional requirements" for future surveys involving this topic.

Competition. There was an 64% overall usage, with 48% using plant examples frequently. Of those who used plants infrequently or never, 60% noted that other organisms are better examples. Even from the perspective of using animal examples, their competition over plant resources should have been an important topic of discussion.

Survey Conclusions

Four major conclusions can be drawn from this study. First, when plant examples were not used frequently, the most frequent reason is that "other organisms are better examples." Judging from additional comments, animals were considered "better examples." Teachers wrote comments such as, "My students relate better with animal examples," and "I am more comfortable using animal examples." This perpetuates the continued absence of students discovering the value of plants and developing a future interest in botany. Biology is "the study of life" and its study should not be restricted to particular life forms merely because it interests students or makes teachers feel more comfortable in their presentation.

Second, it can be inferred that plant examples are used more frequently when they were part of the curriculum and textbook. Three current high school biology textbooks (Standafer, Raven, Miller), all contained plant cell mitosis and Mendel's study introducing genetics. These were the two principles that scored the highest for usage and generated a substantial "always" use response as seen in Figure 1. Nevertheless, the textbooks contained limited plant examples for the other eight principles that might influence the low usage of plant examples.

Third, the lowest plant usage occurs when teaching particular principles. Plants are left out of evolution, which is unfortunate since many concepts such as co-evolution, adaptation, and survival of the fittest can utilize plant examples and plant-based lab experiments can demonstrate these principles. Low plant usage also occurred in teaching the principles of extinction, speciation, and population growth, topics that have great relevancy in environmental and conservation issues since, by some estimates, 20% of all plants are nearing extinction (Allen 926) and agricultural output needs to keep pace with the ever-expanding population.

Fourth, even when teachers report a low use of plants in teaching, it is rarely attributed to a lack of relevancy. Teachers understand that plants are possible examples of biological principles, even if they are unfamiliar with them. With effort, teachers can familiarize themselves with plant examples to create a complete view of biology.

Recommendations for Improving Plant Education

Biology teachers in New Jersey use plant examples 66% of the time when teaching a variety of biological principles, a figure that straddles the line of failure in many grading systems. Improvement and reform in biology are not just necessary, but crucial to continued plant research as well as ensuring a plant literate society. Is there any hope for change? One teacher, perhaps unknowingly, responded to this question by writing on her questionnaire, that "This little survey has heightened my awareness." If a sampling study can impact one teacher, surely there is a myriad of other ways to potentially impact education to promote plant science.

Not only New Jersey, but the entire nation can implement steps to improve the inclusion of plants in education. The solutions to the problem of plant neglect rests with college teaching programs, botanical societies, governmental granting agencies and educational programs, secondary education systems, and elementary schools. As many problems in botany education are interrelated (Hershey, "Historical" 340), there is hope that a concerted change in one area would promote change in another, starting a motivational domino effect.

College Biology Departments

The damage done when colleges combined zoology and botany into a single biology department is irreparable. Botany departments that are currently separate from other biology departments should not be merged into a single biology department (Bozniak 45). As one botany professor stated, "Dismantling botany courses is not a step in the direction of ensuring the long-term survival of future generations of humans as species" (Fail 4). Where departments have already merged, remedy rests with three potential courses of action that botany instructors can implement.

First, college botany instructors need to be actively engaged in the curriculum development and teaching of the college biology courses; this will correctly "define biology, especially for those who think it is a synonym for zoology" (Greenfield 2). This under representation of plants can be observed in the biology curricula of our State's colleges and universities. For example, the 2005 - 2006 course offerings of the nine New Jersey State colleges and universities have an overall ratio of four animal courses (excluding human) to one plant course. Even in college classes such as Evolution and Developmental Biology, which should include all species, the course descriptions show a bias for animals ("Undergraduate"). Another example can be viewed in the curriculum overview for the Physiology and Behavioral Ecology course offered at the College of New Jersey which states, "A detailed investigation into…interactions among organisms and between organisms and their environment. Emphasis is placed upon… adaptations of animals to adverse conditions…" ("Undergraduate"). The article, "Developing a Curriculum for the Teaching of Botany," even strongly suggests that general biology courses should be constructed around plants "because without the world's flora very few animals will persist" (Carter 44).

Second, biology and education departments need to cooperate by promoting the need to require a semester of botany as a prerequisite to graduation (Uno 266), recognizing that their profession will be influencing students in their study of life, of which plants are crucial. The 1998 National Science Board's report study noted the importance of biology teachers being familiar with the topics they teach. The report stated that when teachers taught concepts they were unfamiliar to them, they discouraged student participation, presented the topics in a less coherent fashion, and spent more time on unrelated issues and tangential topics such as study skills or cooperative effort (NSB 1:1).

Third and lastly, incoming students interested in science need be aware of career options in plant science. Currently, "students coming to college simply do not know that botany is a possible and legitimate career choice for them" (Boznaik 42). The Botanical Society of America's survey in 2003 reported that the entry salary for a plant biologist was $33,000 and increased to 103,000 for those with 30+ years of experience ("Salaries"). Thus, college students should not overlook the many avenues of opportunity afforded to plant biologists at educational institutions, government agencies, and industries. This could be accomplished by a small presentation in a general biology class, through personal contact, public displays, or open forums.

Botanical Societies

Change is also needed in botanical and horticultural societies. As a member of the Botanical Society of America (BSA), Uno stated that, "It is foolish for botanists to believe that simply proclaiming the importance of teaching about plants will have any long-term benefits to BSA, the study of plants in general, or the number of students interested in the plant sciences" (265). While few societies have begun to address the problems of plant science in education, the majority do not actively participate in educational reform, a self-defeating option since the vast majority of members in these societies are plant researchers. If students are not exposed to plant science or motivated to enter the field, the society memberships will decrease and ultimately weaken. Dr. Ehlele, associate director of BSA noted the lack of influential involvement by the Society's members when he quipped, "Plants are important, there is no argument on that. It remains to be seen whether botanists will be" (7).

Botanical societies should also be more supportive of teaching as a primary profession for college botany professors. These societies emphasize research while minimizing the importance of teaching botany. (Mlot, Forword). For example, the American Society for Horticultural Science relegates the publication of teaching articles to its less popular journals and gives four awards for outstanding research, while providing no recognition in the area of education (Hershey-Historical 343). Research is given a priority over teaching as shown in a recent study conducted by the National Center for Education Statistics, which demonstrated that, the higher the academic rank of the professor, the less time is spent in the classroom and the greater amount of time is spent conducting research. Allotting for all duties, full professors spent an average 48% of their time on research, but only 21% in teaching. Conversely, full-time instructors/lecturers spent only 22% of their time doing research and 50% in the classrooms teaching (app.8); thus, the most experienced college botanists are spending less time teaching botany. *Botany for the Next Millennium* summarizes the problem well: "Teaching students about plant biology is as critical to the future of the field as is research and must take its proper place as an equally laudatory endeavor for botanists" (Mlot).

Botanical societies should also be supportive of our high school biology teachers, as well as professors teaching botany courses. One method of aiding secondary education is through the use of their publishing power. While BSA already publishes *Plant Science Bulletin* which presents new ideas for K-12 teachers, more botanical groups need to be enlisted in publishing teaching materials. Plant societies can help by critically reviewing biology textbooks and endorsing those with substantial plant content as well as creating guidelines that explain core concepts to help "botanically challenged" teachers already assigned to the classroom. Uno suggested an especially helpful task whereby the societies can provide plant examples for the biological concepts in state and national standards (266).

Secondary biology teachers should be invited to attend plant societies' symposiums or have societies fund workshops centering on high school botanical teaching (Uno 266). When the ABS holds its yearly botany conference, one day is dedicated to the Educational Forum. For decades, ABS did not encourage the attendance of K-12 teachers by stating that, "The principle focus of the Forum will be undergraduate education" ("Botany 2004"). Only this past year did ABS make serious strides to include K-12 teachers ("Botany 2005"). More emphasis is needed on forums that uniquely incorporate the use of plants in our high school biology's courses.

Governmental Granting Agencies

Change is needed in the government's funding of basic research to encourage scientists to explore the complexities and applications of plants. The largest amount of competitive grant funding is distributed through two major governmental agencies, the National Institute of Health (NIH) and The National Science Foundation (NSF). Focusing on human health, NIH received a larger funding at $27.9 billion for the 2006 fiscal year

(“About NIH”). NSF provides grants to basic research in a wide range of science disciplines and received a budget of $5.58 billion for the current fiscal year (“NSF and Congress”). Of the total research studies supported by the $5.58 billion budget, only a fraction supports plant studies. As one botanist noted, there is a disparity in the amount of funding designated to basic plant research (Carter 43). This bias can be viewed on the NSF website which currently showcases recent studies funded by NSF. While four studies are plant-based, sixteen studies deal directly with animals. Three studies were inappropriately titled to indicate they included all species, when in reality animals were the focus. Another study documenting the decrease of native species proportionally to the increase of human dwellings in Asia, only recorded the decrease in panda bear populations. The obvious decrease of plant bamboo did not figure into the article.

In Alen Bement’s (NSF Director) 2007 budget address, he lists twenty areas that will receive priority attention and funds. The list includes plant genome research, originally funded at $101 million with a projected $2.5 million budget increase. Although the recognized importance of plant genome study should be welcomed news for both plant science and educators, the amount offered needs to be scrutinized against other proposed NSF spending and budget increases. While the plant genome research funding will increase by 2.5%, every other current NSF priority project will have a greater percentage increase. Additionally, the plant genome project is the lowest funded of all priority research areas. For example, cyberinfrastructure research is supported with $597 million and will increase by 15%. Homeland security is supported with $384 million and will increase by 12%. Networking and Information Technology Research and Development is supported with $904 million and will increase 11.5%. Even the Climate

Change Science Program is supported at $205 million with an increase of 4.0% ("Remarks"). Of all the priority areas, plant genome research appears to be the lowest priority.

NSF's list of priority projects also includes a new initiative bolstering K-12 science education programs funded at $104 million ("Remarks"). This modest amount of funding and could potentially be used partially to fund plant science education, yet the development of these programs should be monitored closely for plant science content and development. In the past NSF has used funding for plant science education to support nonscience organizations, such as the National Gardening Association, instead of actual plant science societies (Hershey, "We Have Met," 84).

Governmental Educational Agencies

Change is needed in the government's educational reforms affecting biological sciences. Current science standards demonstrate plant neglect. Future standards and supporting materials should reflect the importance of plants and not over-emphasize animals in their examples and activities. Another government reform plan, "No Child Left Behind" mandates to "rally every sector of society to work with schools to improve math and science excellence"; this can also be applied to improving the quality of plant science excellence. This legislation encourages partnerships between schools and community organizations, museums, science centers, colleges, and universities. Therefore, various botanical groups, college departments, and plant science facilities are encouraged to partner with the secondary schools to influence and educate students on the importance of plant science.

Secondary Schools

Of twenty randomly selected New Jersey high schools, it was observed that not one listed a plant science or botany course within the curriculum choices, although the majority offered vertebrate anatomy and physiology. Some biology electives in high schools were as original as marine biology, forensic science, and microbiology; enrollment in these science electives would meet the student's science requirements. Four high schools had horticultural classes as electives, but these could not be used toward the school's science requirement. High school biology programs need to be aware of the animal-bias in their course offerings and take the initiative in offering a plant science course.

While biology course offerings are important, the strongest influence on students is within the biology classroom. If college teaching programs include plant science and botanical societies increase their contributions to teaching resources, high school biology teachers would be more likely to promote the importance of plants and notice the zoochauvinism in their supporting materials and tendencies in their own teaching. Not only the content, but the attitude that accompanies the instruction is important in influencing students' perception of plants.

Because biology textbooks have shortcomings and may be zoocentric, teachers should not use them as their sole source for teaching and should be supplemented with additional resources (Haury 4). Additionally, pressure from educators can influence publishing companies to avoid animal bias in their textbooks. In the meantime, there are some collaborative efforts to compile information on botanical pedagogy for all levels of teaching. These are found on web sites such as Scott's Botanical Links (http://www.ou.edu/cas/botany-micro/bot-linx/) and Partnership for Plant-Based Education (http://ppbe.org/) and are an invaluable pedagogical resource.

The biology principles to be taught, currently dictated by national and state standards, are fairly inflexible. However, there is flexibility in the examples and activities that can be used to facilitate the awareness of plants. Instead of singularly presenting animal examples in lecturing, plants can be just as readily used (Reinvold 3). For example, the leaves of plants in various` climates can be used to illustrate adaptation. Nutrition or even organism systems can be contrasted between animals and plants and protein synthesis or the role of enzymes can be taught from a plant perspective. Discussions on competition and population growth from an animal perspective can include the important role of plants as a limiting factor as well as noting that plants themselves can also be viewed as a distinct population with their own unique set of limiting factors. Recombinant genetics can not only introduce gene manipulation techniques, but also their plant applications in agriculture and drug production. Each of these recommendations can be implemented without disrupting the biology curriculum or affecting time restraints.

The use of plants needs to be augmented in laboratory exercises and activities. It has been suggested that the most important approach to plant labs is to include direct, hands-on, personal experience with plants (Richards 175). For example, plants can easily serve as control and test subjects while subjected to multiple variables in open-ended investigations to understand the scientific method. Plants can be utilized in the teaching of "survival of the fittest" by changing the environmental conditions of their growth.

Another author notes that these inexpensive organisms can be used to teach complex concepts such as osmosis, cell differentiation, adaptation, and ecological interactions (Reinsvold 5). Additionally, they "provide at least a partial solution to the animals dissection controversy because… plants can demonstrate many biological principles" (Hershey, "Plant Neglect," 418). Unfortunately, plant labs have been criticized for the prolonged period they require to gather data, which results in waning student interest, but there are two alternatives that would address this issue. The first is to use "activities related to pollen germination, imbibition of water by seeds, and fruit and seed dispersal experiments" that can be accomplished in less than 45 minutes and thus be completed in a single class period (Uno 265). The second is to emphasize to students that scientific research does not happen in a 45-minute time slot; plant labs are more realistic. Biology teachers may also opt to use rapidly developing species such *Brassica rapa* as developed by Wisconsin Fast Plants which can reduce the time necessary in many experiments.

Furthermore, teachers need to realize teaching plants can be uniquely interesting. One college professor posted her opinions on line, aptly describing why students are not interested in botany at the college level:

> I see a huge animal bias in my college level students. To some of them, trees are merely something you sit in to hunt from. I think this is because most of them have had the interest beaten/bored out of them in prior classes. Instead of starting with, "This is a plant--it can make its own food, it can make oxygen, it can skip sex altogether, you can reproduce it from a single leaf, it mimics a bee to achieve pollination, this one can eat bugs, etc. Isn't it cool?" they were given, "This is a plant cell--here are the chloroplasts... Memorize all the parts of the cell and the

photosynthetic pathway." Snore... If you hit them with the "gee whiz" factor up front, more of them stay awake for the hard science later on. I realize that, in a way, that is catering to the "entertain me" mentality, but you do need to find the hook that draws them in. We need to have students at all levels poking in terraria, lying belly-down in patches of bluets, tasting odd crops, and mucking about in wet ditches. (Reed)

Elementary Schools

Zoocentrism in elementary schools is highly over-emphasized. In most cases, the first school trip kindergartners take is to the zoo; the first report of school age children is usually on an animal. As you walk through any elementary school the preponderance of student artwork that depicts animals, books characterizing animals, and decorations and learning aids with animals becomes vividly evident. Plants are seldom displayed and a discovery trips to gardens or natural forests with the intent to learn about plants are scarce, possibly because of the teacher's lack of plant knowledge. The Botanical Society of America published a 2006 study that included the plant misconceptions held by college students enrolled in elementary teaching programs. Some of these future teachers carried the misconceptions that plants do not contain DNA and do not respond to stimuli (Krantz 94). "If children get misconceptions of botany early, it is more difficult to reteach and unteach during later years" (Mlot, III).

While a study by Wandersee and Schussler showed that the majority of cross-aged students prefer to study animals as opposed to plants ("Plants or Animals"). In another study also conducted by them, it was demonstrated that this preference could be influenced. Early childhood experiences with plants coupled with a friendly and knowledgeable "plant mentor" was found to be a good predictor of a student's later interest in plants (*National Survey*). Elementary school teachers are in a unique position to guide children's first interactions with plants.

The culmination of all these potential changes could result in a balanced view of biology, as well as a botanically literate society, ready to meet the challenges of tomorrow.

CONCLUSION

This research identifies our progressive deterioration of plant science in education while demonstrating our zoocentric tendencies at the expense of expanding our knowledge of plants and the discoveries they provide. Recommendations for colleges, botanical societies, research and governmental agencies, and schools provide possible solutions to improve the status of plants in the classroom. Regardless of our educational emphases, plants are important whether or not we recognize them as such. However, the sooner we accept their relevance in our world, the greater the benefit will be derived for generations to come.

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Appendix A: New Jersey Science Standards: Curriculum Framework for Standards Six and Seven (NJ 84-5, 110-1)

Cumulative Progressive Indicators for Standard Six

By the end of Grade 4

6.1 Compare and contrast living things
6.2 Determine the basic needs of organisms.
6.3 Show that living things have different levels of organization.
6.4 Show that plants and animals are composed of different parts serving different purposes and working together for the well being of organisms.
6.5 Describe the life cycles of organisms.
6.6 Group organisms according to the functions they serve in a food chain.
6.7 Identify the major systems of the human body and explain how their functions are interrelated.

By the end of Grade 8

6.8 Describe and give examples of the major categories of living organisms and of the characteristics shared by organisms.
6.9 Recognize that complex multicellular organisms are interacting systems of cells, tissues, and organs.
6.10 Identify and describe the structure and function of cell parts.
6.11 Explain how organisms are affected by different components of an ecosystem and the flow of energy through it.
6.12 Illustrate and explain the life cycles of organisms.

By the end of Grade12

6.13 Identify and describe organisms that possess characteristics of living and non-living things.
6.14 Identify and explain the structure and function of molecules that control cellular activities.
6.15 Explain how plants convert light energy to chemical energy.
6.16 Describe how plants produce substances high in energy content that become the primary source for energy for animal life.
6.17 Compare and contrast the life cycles of things as they interact with ecosystems.

Cumulative Progressive Indicators for Standard Seven

By the end of Grade 4

7.1 Recognize the diversity of plants and animals on Earth.
7.2 Develop a simple classification scheme for grouping organisms.
7.3 Recognize that individuals vary within a group.
7.4 Identify and describe external features of plants and animals that help then survive in varied habitats.

Appendix A continued

By the end of Grade 8

7.5 Illustrate how the sorting and recombining of genetic material results in the potential for variation among offspring.

7.6 Compare and contrast acquired and inherited characteristics.

7.7 Classify organisms by their internal and external characteristics.

7.8 Discuss how changing environmental conditions can result in evolution of a species.

7.9 Recognize that individual organisms with certain traits are more likely to survive and have offspring.

7.10 Describe how information is encoded in genetic material.

By the end of Grade12

7.11 Explain how DNA can be altered by natural or artificial means to produce permanent changes in a species.

7.12 Explain that through evolution that Earth's present species developed from earlier distinctly different species.

7.13 Explain how the theory of natural selection accounts for an increase in the proportion of individuals with advantageous characteristics within a species.

Appendix B: Survey's Biological Principles Corresponding Curriculum Framework Progressive Indicators

1. Adaptation: 7.4, 7.8, 7.9, 7.12, 7.13
2. Extinction: 7.8, 7.12
3. Speciation: 7.5, 7.8, 7.11, 7.12, 7.13
4. Taxonomic Classification: 6.8, 7.1, 7.2, 7.7
5. Growth and Development: 6.4, 6.5, 6.9
6. Mitosis: 6.10, 7.10
7. Inheritance of Genetic Traits: 7.10
8. Population Growth: 6.11
9. Nutritional Requirements: 6.2, 6.16
10. Competition: 6.6, 6.17, 7.13

Appendix C

Usage of Plants in the Biology Curriculum of Secondary Schools in New Jersey

When teaching the following biological principles, please circle in column (b) the number that best describes your use of plants as examples, with 5 representing always and 1 never. If you answered 1, 2 or 3 regarding your usage of plants, in the remaining columns check one or more of the reasons you do not use plants more frequently,

Biological Principle	Usage (b)	Not relevant to principle (c)	Other organisms are better examples (d)	Not in adopted educational resources (e)	Not required in standards (f)	Not familiar with any example (g)	Other (please explain below) (h)
Adaptation (structure and function)	5 4 3 2 1						
Extinction	5 4 3 2 1						
Speciation	5 4 3 2 1						
Taxonomic Classification	5 4 3 2 1						
Growth and Development	5 4 3 2 1						
Mitosis	5 4 3 2 1						
Inheritance of Genetic Traits	5 4 3 2 1						
Population Growth	5 4 3 2 1						
Nutritional Requirements	5 4 3 2 1						
Competition	5 4 3 2 1						

Other

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Appendix D

1/26/06

Dear Science Department Supervisor,

I am presently working on my Master's degree at Rowan University. In my thesis, I am determining the usage of plant examples when teaching biological principles. As part of my paper, I need completed surveys from your school's Biology teachers in order to compile data on this topic. Enclosed are several copies of the survey as well as self-addressed stamped envelopes. It is my hope that you will assist me in furthering my educational goals and I will be grateful for your help in this endeavor.

Sincerely,

Tamara Egner

Appendix E: Examples of Comments Given on Survey

Comments on Using "Other Organisms" as Examples:

"My students respond to examples involving animals better."

"Students usually find it easier to understand animals in many areas of biology. I've also found more movies that deal with topics that are about animals."

"We do a unit on plants, but use animals as examples (for the rest of the course)."

"(I) use animal examples that students are more familiar with."

"I truly try to balance plant and animals examples. However, I am more comfortable with non-plant examples."

"I try to split examples (animals and plant); students seem more comfortable with animals but plants are more useful in some instances."

"Animal examples are more powerful to students."

"Plants are in the plant unit, tend to use animals as examples."

"Better to use examples they can relate to like humans, chimps, birds."

"Just don't use plant examples."

"I don't know if other organisms are 'better examples.' It may be that the students are just more familiar with other examples."

"I also teach Anatomy and Physiology and use that information for examples in General Biology."

Appendix E continued.

Comments on Time and Space Restraints:

"Plant content is deleted with increase in biochemistry and technology."

"No time for plant labs."

"Can't even get to the Plant Kingdom."

"With everything that needs to be covered in the curriculum, plants are last."

"Plants are not discussed in detail because of the strict requirements we must meet to prepare the students for the HSPA (High School Proficiency Assessment)."

"With five classes of 30 students there is no room to do plant labs… plants are not discussed."

Comments on Limited Plant Use:

"Plants are covered in Environmental Science (not general biology).

"I do mention plants in terms of agriculture outside the unit."

"We try to include plants in general discussions."

Positive Comments on Plant Use:

"In my biology class, I'm in the process of infusing hydroponics in the curriculum."

"Plants are incorporated whenever possible."

"We do a bean project and follow our plants through their growth and development. We compare our plants to ourselves throughout the course."

"I tend to use plants whenever possible."

“I have a background in botany and use plants as examples frequently.”

Appendix E continued.

Other Comments:

“I just hadn’t thought of using plants but I just as easily could.”

“This is an excellent project. Textbooks should infuse more plants to remind us.”

“ This little survey has heightened my awareness.”