SPROUTING SEEDS OF SUSTAINABILITY:

LESSONS IN SCHOOL SUPPORTED AGRICULTURE

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Natalie A. Faris

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Approved by Master's Project Committee:

Dr. Noah Zerbe, Committee Chair	Date
Dr. Corey Lee Lewis, Committee Member	Date
Dr. Llyn Smith, Committee Member	Date
Dr. J. Mark Baker, Graduate Coordinator	Date
Dr. Jená Burges, Vice Provost	Date

ABSTRACT

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Natalie A. Faris

Through this project, I developed and assembled resources to assist high school educators with garden based learning. For the duration of one school year I served as the garden coordinator at the McKinleyville High School Garden. I gained instrumental first-hand experience in community organization and planning, curriculum development and implementation, and a greater understanding of the challenges associated with school supported agriculture. Teachers face many obstacles when providing students with hands-on learning experiences. The resources that I compiled are constructed with this in mind and can be adapted to a wide variety of educational situations. While the materials reflect my experience at the McKinleyville High School Garden, they are comprehensive and include resource references and supplemental materials to support the curriculum. The curriculum provides educators with the necessary tools to implement a garden based learning program that promotes self and collective empowerment and has the potential to encourage action for community change. This paper addresses the lessons learned throughout the process of implementing the curriculum and highlights the outlook for school supported agriculture in the future.

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INTRODUCTION

This project was created in response to the recent resurgence of interest in Garden Based Learning (GBL) programs and curriculum that focus on sustainability education in schools. Many programs and curriculum have been applied in elementary schools (Waliczek, Bradley, Lineberger, & Zajicek, 2001) using popular curricula such as Life Lab K-5 (LifeLab, 2006), GrowLab (National Gardening Association, 2006) and Nutrition to Grow On (California Department of Education, 2005). Consequently literature exists on garden based learning at the elementary level. However, there is a lack of research regarding high school gardens and even fewer collective curricula for high school teachers and high school garden programs.

This project was designed to provide high school teachers with GBL that simultaneously supports curricular efforts that reinforce standards in education. The materials and activities are intended to help students create connections and develop concepts regarding agro-food and sustainability concerns. Students progress to an understanding of sustainability that forms the foundation to a whole-system solution, one that revives once flourishing concepts of local food and alternative agro-food networks (AAFN). As a response to industrial food systems, this knowledge enhances student decisions as individual consumers and improves associations of food and place, while encouraging sustainable practices.

Sustainability can be defined in many ways; the most commonly quoted is that in the Bruntland Commission Report, *Our Common Future*. The report brought sustainability to the forefront of casual conversations as a way to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland 1987, p.43). This notion is the basis for creating alternatives to the present exploitative, agricultural paradigms. AAFN and the movements within, such as GBL, are expressions of both producer and consumer resistance to the global food system of food provision, demonstrate transformations of socio-ecological relations and provide rich learning environments.

The garden based learning presented in this project is constantly evolving. The implementation of GBL, repositions the learning process within particular contexts and establishes a space for continual improvement. This project suggests that each school should support the agricultural education of its students and should focus on present student health and wellbeing rather than on future career paths. School supported agriculture (SSA) is a concept that allows for the school and the community to assist in the development of GBL. For the purpose of this paper school gardening and GBL will remain synonymous with SSA.

Garden-Based Learning is described as "an instructional strategy that utilizes a garden as an instructional resource and teaching tool" (Williams & Brown, 2012, p.22). GBL helps to focus teachers' attention on students as thinkers and to help them grow as writers, mathematicians, and scientists. "It encompasses programs, activities, and projects in which the garden is the foundation for integrated learning, in and across disciplines, through active, engaging, and real-world experiences. In some settings, it is the educational curriculum and in others it supports or enriches the curriculum" (Desmond, Grieshop & Subramaniam, 2002, p.7). School gardens serve as venues for students to experience GBL and generate sustainable practices that shift student consciousness.

I begin with a review of the literature regarding school gardens. There is no single body of literature or much literature, for that matter, that describes what is known about school gardening. Within the limited research, what is widely held is that an increased understanding of the subject matter occurs when hands-on learning is utilized as a tool in the learning process. Within the literature regarding school gardening, there is a small representation of studies regarding garden-based learning and farm-to-school programs and their use and effectiveness in the classroom. However there is little research identifying what learning about food, farming, nutrition, and resource management looks like, who teaches it, or how and why. I conclude the literature review by reviewing the need for comparative international studies on curriculum organization, implementation and the resulting quantifiable student achievement.

In the next section, I present the mixed methods that I employed in the project and demonstrate the use of participant observation, literature analysis and loosely constructed interviews of adult volunteers to inform the content of the materials that make up the substantial appendices. This discussion is followed by a detailed representation of the material presented in the appendices. I outline the McKinleyville High School garden project from conceptualization to implementation. First, I discuss the relevance of the McKinleyville High School Garden Materials (Appendix B) in the development of this project. Second, I give a summary of the project and examine how the materials presented in the McKinleyville High School Garden Activities (Appendix C) can be utilized as tools in garden based learning.

In the final section that follows, I discuss lessons learned from the project and provide suggestions and reflections for the future creation and application of school supported agriculture, garden based learning and school gardens. Throughout this discussion, I tie the supplemental material presented through this project back into the concepts discussed in the literature review. I describe what did and did not work in this project and provide specific examples of solutions employed in similar garden projects. I conclude by offering a positive outlook for SSA and acknowledging the contributions of this project as seeds that may sprout into future collaborations of sustainability.

LITERATURE REVIEW

This review examines a wide range of school garden literature. There is not one comprehensive existing body of literature regarding school gardens. There is however, ample research regarding garden based learning in a variety of literature from horticultural therapy, environmental education, place-based education, youth development, health and nutrition and plant based studies. A limiting factor in this literature is that the effects of GBL are quantified by qualitative evaluations of the programs and the majority of this literature pertains directly to elementary age students. These factors have played a part in the widespread assertion that there is a lack of research regarding the effects of GBL at the high school level. As a result, an overview of literature pertaining to school gardening, the redesign of school grounds, and farm-to-school programs, an emerging component of food and GBL in schools, was gathered from multiple fields of study.

The literature review is organized into three parts. In the first section I review the research regarding the effects of school garden programs on the schools' learning spaces. The second section addresses the observed outcomes of GBL on individuals and I elaborate on this concept with a review of the effects of school gardens on students' knowledge, attitudes and behaviors about and concerning, food, community and the environment. In the last section I conduct a review of GBL and the observed outcomes on the community and sustainability education, which most directly relates to my interest in GBL as a catalyst for community change.

Shifting School Spaces

Experiential learning has been at the forefront of school reform for nearly a century. Most models of reform advocate John Dewey's (1916) hands-on approach to learning that engages students and leads to a fuller understanding of the material presented. Characteristically, hands-on learning in the classroom tends to simulate a life experience, whereas school gardens and GBL provide a real world experience for learning.

Recently Michelle Ratcliffe (2007) theorized that school garden programs have profound effects on the "curricular, physical, and social" learning spaces found in school settings. By encouraging place and project based learning, such as composting, planning, propagating, maintaining and harvesting, the curricular learning space is altered (Barlow, 2000; DeMarco et al., 1998; Eick, 1998). Ratcliffe's (2007) discussions revealed that this shift is not specific to a certain grade level curriculum because gardens provide a space that integrates curriculum from all classes and grade levels. GBL addresses subject matter from all areas including science, math, social science, language arts, environmental studies, nutrition, and agricultural studies (Graham et al., 2005; Desmond et al., 2002), creating a space that integrates all subject matter and allows students to cognitively engage in a variety of learning opportunities (Ratcliffe, 2007).

Ratcliffe continues her hypothesis by describing how school gardens also have the potential to create change in the physical learning spaces on school grounds. School landscapes are contradictory spaces, although teeming with life they are at times devoid of life's essential sustenance - plants. School gardening has emerged to counter this variance and covers a continuum of efforts to increase the horticultural complexity of school landscapes including potted plants, raised beds, containers on asphalt, composting areas, in ground planting, ponds and sunflower houses, indoor vermicomposting, indigenous habitat gardens (Bell & Dyment, 2008; Graham et al., 2005), and a systematic approach to redesign the outdoor spaces around schools into learning landscapes (Brink & Yoast, 2004).

Another notable advocate for school gardens, Dorothy Blair, revealed extremely relevant research in "The Child in the Garden: An evaluative review of the benefits of school gardening". Blair (2009) supports this shift that transfers students' familiarity from open fields, the monocultures of environmental complexity, to understandings of intimate spaces grounded in the natural environment. Blair goes on to the explore the greening of school grounds and how they may readily improve student reflection by providing repetitive access to meanings and associations that serve as reminders of previously learned lessons. In addition to reinforcing learning through continual contact, the creation of gardens and the implementation of GBL improves physical aspects of the school environment such as creating shade, decreasing storm run-off, and improving air quality (Ratcliffe, 2007) while providing more diverse havens for flora and fauna on school grounds beyond crops, flowers, and bushes. Thus, school gardens demonstrate ecosystem complexity wonderfully well. These havens create positive connections of exploration and engagement for students and the community to interact with the environment in which they live.

The community collaborations that fundamentally shift the social space of the school completed Ratcliffe's model. The creation of school gardens is a collective act that pairs students with faculty and other adults from the community. This results in intergenerational partnerships within the community and an increase of community involvement in education, health and environmental awareness. The character of the schools' social space becomes defined by participation, which can serve as a valuable lesson in democracy (Ratcliffe, 2007) and community building; students are directly involved in the community efforts and observe desired behaviors that contribute to a stronger community.

Shifting Student Connections

The bulk of the literature regarding student connection to curricula is concerned with the impact of such school gardens and GBL on two areas: First specialized knowledge and habits such as knowledge of nutrition, preferences for and intake of fruits and vegetables (Morris, Neustadter et al. 2001; Morris and Zidenberg-Cherr 2002; Somerset, Ball et al. 2005). And second, on the capacity to improve knowledge in traditional academic areas, particularly math and science (Graham, Bell et al. 2005; Klemmer, Waliczek et al. 2005; Pigg, Waliczek et al. 2006). Other evaluations have reflected on the potential impact of gardening programs on student's attitudes towards the school environment (Alexander, North et al. 1995; Canaris 1995), interpersonal relationships, self-esteem (Waliczek, Bradley et al. 2001; Somerset, Ball et al. 2005), and environmental attitudes (Skelly and Zajicek 1998; Aguilar, Waliczek et al. 2008).

Past studies of school garden programs have employed various evaluation tools including 24-hour food recall books (Lineberger and Zajicek 2000; McAleese and Rankin 2007), student and/or parent surveys (Morris, Neustadter et al. 2001; Morris and Zidenberg-Cherr 2002), child interviews (Koch, Waliczek et al. 2006), vegetable taste testing (Morris, Neustadter et al. 2001) and lunchroom observation (Parmer, Salisbury-Glennon et al. 2009); with some studies including multiple evaluation tools. However, the study conducted by McAleese ad Rankin (2007) employed only a single evaluation tool.

One of the most successful GBL programs is The Edible Schoolyard (ESY) project in Berkley, California. Founded by celebrated chef Alice Waters and former school principal Neil Smith, the program teaches students about ecology, the origins of food, and respect for living systems. Students plant fruits, vegetables, grains and flowers and tend to them until harvest. Classes continue in the school's kitchen where students prepare and eat delicious meals from the food they've collected. The Edible Schoolyard Project is an excellent model for all schools. Consequently, the ESY has been referenced in many works and used as a point of comparison for many school garden projects.

The evaluation of the ESY project conducted by Murphy (2003) is an important publication showing the students that participated in the ESY exhibited greater gains in science test scores and a better general understanding of garden cycles and sustainable agriculture when compared to a control school; however, the lack of rigorous reporting and quantitative methods may be construed as greatly limiting the interpretation of reported findings. Others have excluded a control school (Cason 1999; Hermann, Parker et al. 2006; Koch, Waliczek et al. 2006; Heim, Stang et al. 2009) or omitted baseline data collection (Graham, Bell et al. 2005), also possibly limiting the usefulness of reported findings. The lack of consistency in evaluation tools used is a factor limiting comparison between various school garden programs and clear findings as different research methods measure different concepts.

The various evaluative studies of Morris and colleagues (Morris, Neustadter et al. 2001; Morris, Koumjian et al. 2002; Morris and Zidenberg-Cherr 2002) have provided much insight into the potential of school gardens, in conjunction with nutrition education, to improve nutrition knowledge, willingness to eat vegetables and vegetable knowledge and preference. However, the lack of consistent findings amongst these evaluative studies indicates a need for further research. More recently, several review papers (Ozer 2007; Blair 2009; Robinson-O'Brien, Story et al. 2008) have attempted to distill existing research on youth-focused gardening programs. These represent an attempt to create a cohesive analysis of the often dis-connected literature currently available. Such reviews indicate that while current findings offer a promising indication of the value of GBL programs there is still a significant need for further research.

Irene Canaris described the impacts of school gardens and concluded that students' receive more benefits than the initial goals to improve nutrition and nutrition education intended (Canaris, 1995). GBL has improved the relevance and importance of learning on a much wider scale; students are not only communicating more effectively about the subjects taught, but are also communicating with members of their communities. Anne Bell (2001) states that students that participate in GBL are more prepared to work with the community that they are a part of. This observed preparedness comes from the real life experiences that make a transition from the learning space to the application space much more tangible.

Shifting Community Sustainability

The activities that take place in GBL are creating shifts in school spaces, placing emphasis on shifts in student learning and engaging students in a wider lesson of sustainability. The engaging, accessible and very current work of Portland State University professor Dilafruz R. Williams and adjunct faculty Jonathan D. Brown (2012), proposes soil as a living metaphor for sustainability education. The principles that contribute to their model are outlined below in Figure 1. The principles that link pedagogy with pedology are the authors' first attempt to create discourse on sustainability in education. Their work has since developed into a book, *Learning Gardens and Sustainability Education* (2012).

The text offers numerous insights and posits that shifts in student consciousness are deeply rooted in community shifts. Redesigning school landscapes is instrumental in the reshaping of community mindscapes. This also localizes the school garden movement and encourages communities to take responsibility for the education of their most important assets, the children and youth of the community.

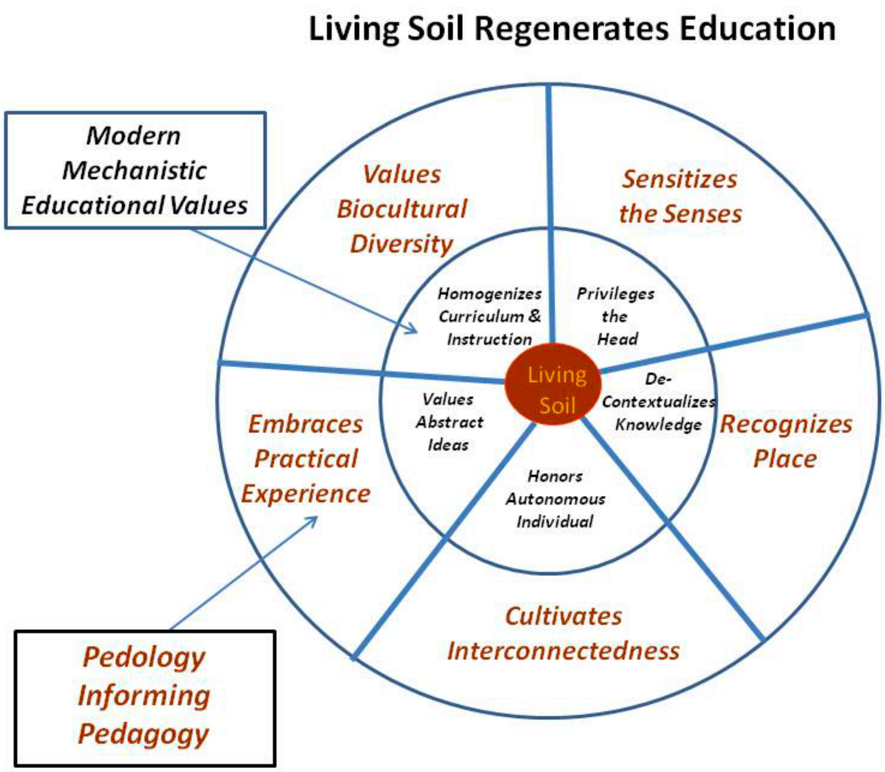

Figure 1. Principles Linking Pedagogy and Pedology (Williams & Brown, 2011)

Students are reminded that they are part of a larger community; their school community is linked with their bioregion, which links nature and culture. One particular framework developed by a colleague of Williams & Brown is discussed in their work and supports the concept that students can discover the way that culture and nature might grow together. The Partnership Model of Sustainability developed by Pramond Parajuli (2002) can be used in garden design, curriculum and teacher training; it informs sustainability education and supports a whole-system, whole-community approach. The principles behind this model describe the partnerships that are created within the generations, species, cultures and economies of the communities in which it is implemented. By using this model in school gardens and GBL, students may learn the paradigms that exist in community sustainability and discern what is and is not sustainable. The students then translate their knowledge into the community, becoming a powerful tool for strengthening community involvement in student learning.

The work done by Ozer (2006) led to the development of a conceptual framework which theorizes that GBL coupled with community involvement has short and long term effects on the students, school and community. Ozer's model describes the students' development as a result of continual interactions with school and community spaces that mutually reinforce one another, demonstrating that changes in one area result in changes in another area. Ozer detailed five different case studies that contributed to her development model and reified GBL and school garden curricula. This research however was not entirely encompassing of the three shifts in school spaces, student consciousness, as well as community sustainability and therefore provides support, but further research on the theoretical model is needed.

While this literature review has addressed GBL in the United States, it is important to note that there are also many settings around the world in which GBL is a part of the school day. The number of students, schools and communities involved in GBL worldwide has not been carefully studied and there is a need for additional comparative, international case studies regarding curriculum organization, implementation and resulting quantifiable student achievement. When GBL is examined in developed or developing economies the outcomes may be quite comparable if the GBL programs have similar specific goals and are implemented with like practices and activities. These factors, as well as the methods of inquiry need to be analogous. In the next section I discuss the methods employed in my project at the McKinleyville High School garden. Although this study pertains to a specific high school in a specific community, the methods of inquiry are not place specific and can be utilized in other GBL research projects. People in all parts of the world are developing amazing projects; the lessons learned and the outcomes discovered need to be shared with one another. In order for GBL practices to grow the connections between and among the many participants need to be cultivated further.

METHODS

In this project I applied a mixed methods approach in order to use a range of ways of collecting information and measuring change to ensure that the most meaningful data was collected to reveal the full impact of the project. This approach utilized and included field notes and flexibly structured interviews that are principal to my participant observations as well as information from the literature and other secondary data sources. An analysis of the data was conducted using different methods to clarify and explore similarities and contradictory results and a comparison with the existing literature. This provided an understanding of what worked and what didn't, how it was experienced, and how it was valued.

This mixed method approach is supported by Creswell (2003) in that methods are progressive and successive, the discoveries of one method advances the discoveries of another method. This method acknowledges the data and subjects as an integral part of the research and allows the experience to guide the research without the constraints of detailed, theoretical framework. By incorporating this method and expanding on the ever-growing literature on gardening, schools, education and learning, a rich source of information and experience was gathered.

By placing importance on Participatory Action Research (PAR) and participant observation, I recognize the embedded nature of my situation. By understanding that I am a graduate student within the community that the project was conducted in, I remain independent and unbiased about the project. Although I examine the community involvement to the project and compare these observations to overall participation of communities with similar GBL projects throughout the nation, I am committed to the development of the community to support GBL and school gardens. It is essential to encourage community involvement and facilitate a lasting collective effort. It has been a regrettable pattern in many individual school gardens that the concept, content, and implementation are the product of a few individuals and they do not have the support of the larger community. PAR enabled the establishment of a cooperative community endeavor and helped to blur the line between researchers and researched as well as the knowledge created for academic purposes. PAR allowed me to conduct research on an element of the community that is of great concern to me and advocate for collaboration among community members.

Grounded Theory has been an essential element of my methodological structure. Kathy Charmaz (2005) explains that Constructivist Grounded Theory offers accessible inductive methods for qualitative research. It incorporates an active attempt to construct meaning in the world around us by reflecting on personal experiences and new knowledge, further encouraging self-reflexivity, while recognizing the mutual creation of knowledge by the "viewer" and the "viewed' and also aiming at interpretive understandings of meanings. This helped to clarify my role as the school garden coordinator while conducting research on the project.

Another methodology that encourages self-reflexivity, employed throughout my research is the concept of lived research described by bell hooks (1994). Lived research encourages the researcher to conduct the study through day-to-day life rather than coming into the study as an outside onlooker. I employed lived research in the project as a teacher, coordinator, student and member of the community. I became intimately involved instead of approaching to the project as an outside observer. Witnessing as explained by Fernandes (2003) supports this concept. Witnessing allowed me as a researcher to observe and create findings without emotion of the participants involved. I was personally invested in the project and the success of the students involved in the project, but by embracing lived research and witnessing I was continually comparing the progress of the project to the guidance that I provided for the project while being objective to the literature regarding other projects. As questions or concerns evolved about the project or the curriculum, I was able to assess my approach to the project and conceptualize changes to the curriculum to better assist the teacher and students.

Asset-Based Community Development is yet another aspect of my methodology. Since education is at the core of community concerns, focusing on education as an asset drives the development process of community involvement and places importance on the strength of the community, critical for sustainable development. Equally important in the process of releasing power to the citizenry is identifying associations and social networks that can be strengthened through collaboration. Communities are then empowered by "locally based solutions" that "are seen as essential for people to improve the conditions that will enable them to become food secure" (Allen, 1999:119). One such local solution is school gardening. This is a form of community gardening that provides new settings for interactions among members of the school community and potentially promoting the social networks, sense of connectedness, and skills of the community (Twiss et al., 2003).

ABCD advocates for responsibility to the land and the people that inhabit the land. ABCD is contextual, in that different communities will use these practices in different ways according to their own communities. This generates greater local control over food. The ultimate control over food production is on the micro level. Gardens are specific microenvironments that work in cooperation with nature. Gardens ground students in growth and decay, predator-prey relations, pollination, carbon cycles, soil morphology, and microbial life. Gardens are intensely local. In turn, local organizations such as farmer's markets, community garden collectives, and food councils are concerned with sustainable agriculture and strengthening the local foodscape. These organizations may bring communities together and serve as podiums for promoting school stewardship.

MCKINLEYVILLE HIGH SCHOOL GARDEN PROJECT

This project is separated into two main sections: McKinleyville High School Garden Materials (Appendix B) and McKinleyville High School Garden Activities (Appendix C). The information provided in the MHS Garden Materials section in intended to help outline the steps that were taken in the process of creating a GBL program at MHS. The MHS Garden Activities are meant to provide educators with activities that can be adapted to their own GBL programs. The activity section is not meant to stand alone but to support existing curriculum. Both sections of the project were constructed as a result of my involvement as the MHS Garden Coordinator; while limited to the scope of the MHS school garden and GBL learning program, the sections can also inform broad scale sustainability learning in many diverse places.

From its beginnings, the community supported the McKinleyville High School garden project. A non-profit group from the area, Locally Delicious, got word through one of my committee members, that I was interested in coordinating a school garden revitalization at the McKinleyville High School. This group eagerly assisted me in organizing other community members and forming a garden committee for the project. The collaborations of the committee will be discussed throughout and can be observed in the MHS Garden Materials section (Appendix B). The committee consisted of a wide range of people from the community to ensure a broad base of support and vital to sustaining the project for many years. This committee met several times a month to discuss various aspects of school gardens and GBL programs. We brainstormed concepts that were applicable to the project prior to approaching the teacher of the MHS agriculture class and the administrators at MHS. After decisions had been made and a plan formulated as to the direction and purpose of the project, I asked the MHS agriculture teacher to join the garden committee and attend meetings. The addition of the agriculture teacher provided instrumental information necessary for the implementation of the project, insight regarding the site and resources on hand, as well as an understanding of her needs and the needs of the school. A proposal was created for the school and district administration and approval for the project was received.

This planning stage also helped to focus the project and manage community involvement and contributions. An example of a meeting agenda can be found in Appendix B.1. This meeting was intended to help organize donations and create a timeline for the garden workday that had been planned in previous meetings. It is important to note that this agenda focused on assigning tasks for the volunteers in order to meet the deadlines of the workday and ensure its success. Allocating tasks within school garden projects is crucial and encourages community participation. At meetings prior to those detailed in Appendix B.1, a volunteer and I had spearheaded several tasks that facilitated the creation of promotional materials for the workday (see Appendix B.2 and B.3). Another volunteer, representing a local group, the North Coast Community Garden Collective (NCCGC), assisted by writing donation letters for local businesses and farmers (see Appendix B.4 and B.5). By working with the NCCGC, the value of a community gardening network that shares resources and supports local projects became apparent. Such a network helps to gain access and develop relationships within the community. With this assistance, the MHS garden project was able to receive donations that included irrigation materials, compost, manure, mulch, cover crop seeds, and vegetable starts.

Before the garden workday a site inventory was taken to document the physical features and patterns of use at the site. This helped to successfully choose beneficial activities and prevent future problems. This step offers an opportunity to involve a community resource person such as a landscape architect, biologist, ecologist, forester, conservationist, cartographer or master gardener. It is important to note built in features, such as benches, work sheds, and existing soil; natural features, which include hills, slopes and wind areas; patterns of use, such as entrances and exits, shaded areas, routes for fire drills, and maintenance challenges; utilities like water, sewer, storm drains, and electrical; as well as the history and culture of the site, wildlife, surrounding ecosystems, and native species. At the MHS site garden beds containing degraded soil, work sheds, a greenhouse and an orchard existed as built in features. Many sites however will be blank slates. There exists a wide variety of resources available on-line and in literature outlining site planning for such sites (see resources in Appendix D). In other sites school gardens may not be possible due to lack of land, time or funding. At these sites, creative small-scale techniques can be sought to familiarize students with sustainability education (see resources in Appendix D).

The activities selected for the MHS workday included weeding existing beds, moving and mixing compost, preparing one quarter of the beds for transplants, cover cropping another quarter of the beds to increase soil fertility, sheet mulching the remaining beds to add organic matter over the fall and winter, building a compost bin, and transplanting donated starts. The activities conducted were appropriate given the three-hour time frame allocated for the workday. Figure 1 is a record of the weed burdened garden site prior to the workday and a photograph of the garden site during the workday when the weeds had been removed. The workday also brought about transformations to the MHS garden beds, orchard and newly constructed composting area, seen in Figure 2. While Figure 3 documents the garden site several weeks after the workday, a well-planned and organized maintenance strategy helped to establish deep-rooted and productive vegetables observed in the photograph.

Figure 2. MHS garden before the workday and after weed removal at the workday

Figure 3. MHS garden beds, orchard and composting area before and after the workday

Figure 4. MHS garden several weeks after the workday

Over time the need for maintenance decreased, but establishing planning for maintenance in the beginning allowed for less work later. Assessing the maintenance needs is an on-going process and changing conditions may result in changing maintenance strategies. Good tools, attention to compaction, utilizing resources to protect from pests, rodents or birds, as well as an adequate watering schedule, on-going manual weed control, and mulching helped the maintenance of the MHS garden. Another factor to the ease of maintenance in the MHS garden was the schedule of speakers and the associated projects that were conducted in the garden.

Speakers and activities were scheduled (see Appendix B.6) throughout the semester to enrich the curriculum and satisfy state standards, as well as assisting in the maintenance of the garden. I met with the teacher prior to the start of the semester to outline where specific speakers from the community might fit into the current curricula (see Appendix B.6). The speaker schedule was also structured with the seasons in mind. Seasonality is a topic that students are less familiar with and serves as a grounding principle throughout the activities. The first topic (Appendix C.1) was intended to introduce students to the local food systems within their communities. The game highlights the interconnectedness of the diverse participants within the community and leads to the broad understanding that all participants are mutually supported by one another's behaviors, decisions, and actions. By using specific community examples for the game, a comprehensive and transformative experience for each student is created and can further enhance this activity. This contributes to the students creating a grounded sense of place. This sense of place is elaborated in the following activity (Appendix C.2) as students learn about specific alternative food markets and how to create marketable products by fitting plants into their own plan for a garden bed. The weekly speaker conducted the garden bed activity, and lesson plans for this activity can be found in the additional resource reference section (Appendix D).

An activity on soil is presented in Appendix C.3 and helps to illustrate the correlation between healthy soil and vigorous, productive plant growth. This connection contributes to increasing gardening knowledge and also awakening curiosity and wonder. Students begin to question what is under the asphalt that characterizes most schoolyards and start to develop an appreciation for the foundation of life, "living soil" (Williams & Brown, 2012). Soil building activities such as composting (Appendix C.4) and vermicomposting (Appendix C.5) introduces microbial communities to the students and further links the soil food web with life cycles such as growth and decay. These activities also contribute to the understanding of humus building and the use of natural processes to form the foundation for healthy soil. This activity showed that the creation of compost is a profound experience, one that teaches students about reducing food waste in landfills and closes the cycle of food production, consumption, and waste disposal. Ultimately, these activities speak to the use of natural fertilizers as a resistance to the industrial chemical fertilizer regime. It is truly evident that the process of sprouting seeds of sustainability begins with an understanding of soil and its' relationship to the creation of place in which flora, fauna and food may thrive for generations to come.

Bringing speakers from the community into the school garden and classroom instantly instilled a sense of community cooperation and collective efforts. Both of these may lead to change within the community. The students are part of the community and it is a great asset to the community to have knowledgeable youth. A speaker from the local Food Co-op volunteered to come into the class and present concepts of nutrition in a program called Harvest of the Month. Many Co-ops throughout the United States also teach this program in schools. Harvesting and tasting are activities (Appendix C.11) that complement such discussions regarding nutrition and attach meaning to such a visceral experience. Students began to appreciate the farmers and the places that support food production and it was observed that they wanted to share in that creation of knowledge. The activities that encompass deciphering plant parts for food (Appendix C.7) and planting seeds to produce those plants (Appendix C.8) reified the desire for mutual understanding.

Another aspect of school gardens that is reinforced through the activities is that gardens serve as a place for ecosystem lessons. The activities regarding integrated pest management (Appendix C.9) and appropriate technology (Appendix C.10) allowed for diverse lessons that incorporated abstract concepts. Gardens bring realism to those concepts. Students interacted with the companion planting process and observed the insects that moved into the neighborhood that they created. This creative concept supports the inquiry regarding appropriate technology. The act of integrating plants to provide an ecosystem for beneficial insects is basic to the ecological process, similarly appropriate technology emphasized the use of simplistic, accessible techniques in school gardens, communities, as well as throughout the world. Students established an understanding of a worldview that was then translated to their knowledge of hunger within communities locally and globally. The Hunger 101 game presented in Appendix C.12 instills the necessity for cooperation in securing food for all people.

The final feature that was explored in this project was the need for community involvement in the maintenance of the garden during the summer months when school was not in session. I proposed a collaborative approach to the problem and presented the potential of a scaled down CSA on school grounds. This could be considered school-supported agriculture (SSA). I created flyers (Appendix B.7) for the teacher to post and distribute. The concept included the incorporation of school faculty, school families, and community members as shareholders. They would provide the small funding needed to run the garden during the summer months and in exchange they would receive food from the garden. The response to this proposal was significant. However, we experienced many difficulties in trying to come up with a viable organizational strategy for the SSA. This demonstrated that future attempts at SSA development are needed in order to help create a successful model for schools to implement into their GBL programs. This was just one of the many lessons that was learned during the course of the MHS garden project. In the next section I discuss this and other lessons in depth and provide suggestions for the future.

DISCUSSION AND CONCLUSIONS

In this section I will discuss the lessons learned and tie the project back into the concepts presented in the literature review; and also provide suggestions for the future of this project, garden based learning and school supported agriculture. The substantial appendices were the primary outcome of my research. The activities presented in Appendix C offer a concise strategy for assimilating GBL/SSA into high school settings. In virtually any setting GBL can be viewed as a tool of multiple uses: one that supports core academic training, standards based education and the enrichment of core curriculum (Graham et al., 2005); develops the mental, emotional, and physical realms of a person through improved nutrition and increased exposure (Blair, 2009); teaches social and moral development through sustainability education and ecological literacy (Canaris, 1995; Aguilar, Waliczek et al., 2008); communicates basic vocational competencies about food commodities for subsistence consumption and trade; imparts life skills that are tangible through participation in the activities and with the community (Ratcliffe, 2007); and encourages personal leadership and individual decision making (Desmond et al., 2002).

As specified by the literature, I learned that GBL is certainly a broad field that encompasses much more than educational learning; it can be used as instrument in community development and organization for action, it can address food security, introduce sustainable development, develop economies, and transform mindscapes and landscapes (Desmond et al., 2002; Ratcliffe, 2007; Williams & Brown 2012). It seems appropriate to suggest that GBL when applied to a larger context, outside the classroom, makes contributions beyond those to basic education. The contributions outside formal education are equally important to the growth and development of a healthy environment and community.

This project recognizes the strength of a cooperative community approach to learning. By creating the speaker schedule I strived to incorporate multiple community members that represented a wide range of community development projects. This technique was a useful tool meant to attach meaning to the activities. Community members either assisted in the activities or enhanced the activities through their own presentations. From conversations with the primary teacher at MHS involved in this project, there were two main shortcomings within the project. One, the speaker schedule was designed early in the school year and was intended to be adjustable based on speaker availability. There were several last minute changes made by the teacher and the speakers, this lead to multiple speakers in some weeks. Fortunately the flexibility of the schedule allowed for these variances; however a more consistent schedule in the future is desirable. Second, the teacher communicated that the speaker schedule was too condensed and suggested that it be organized into a full school year instead of one semester. This was a valuable lesson learned and aided in the reconstruction and organization of the activities (Appendix C) post project. I was able to adapt the activities and add elements that allowed for various settings and time frames to the activities.

The expansion of the activities for this project was greatly assisted by *The Sustainable Agriculture Activities Guide* developed by The Student Experimental Farm and the University of California, Davis. This publication is one of the most comprehensive collections of on-farm experiential learning for high school and college students. The collection was published in cooperation with the Center for Land-Based Learning (CLBL). The FARMS Leadership Program, run by CLBL "introduces high school students to the importance of environmentally-sound farming practices that preserve land and its resources for future generations" (CLBL, 2011). The FARMS Program is carried out in several regions in California. The CLBL is working to develop a 'train the trainer' program to increase the regions throughout the state that are involved in the FARMS program. This train the trainer program will be of great use in projects like the one conducted at MHS in the future.

Another lesson learned involves the attempt at a summer maintenance strategy. I suggested that a SSA be formed to assist in the summer maintenance of the garden. Interest for such an approach was apparent, however the additional workload of an experimental SSA was not suitable for this situation. A more extensive survey of community interest is suggested for future attempts at SSA implementation. One concept, divergent from the SSA approach to summer maintenance but still relying heavily on community collaboration, is the involvement of Master Gardeners in the summer maintenance strategy. This approach can be observed at the high school garden in Crested Butte, Colorado. In a collective community effort, the Master Gardeners contribute to the maintenance of the school gardens just as they contribute to the maintenance of the community plots. School gardens then become more the focus of the communities and less the focus of the schools.

While school supported agriculture can generate outcomes that represent challenges for the schools and the teachers, those problems eventually offer solutions and contribute to a greater understanding of GBL. This project, its activities, and the lessons learned from school supported agriculture are intended to assist in furthering the practice of GBL. This project is not a formula or a blueprint for creating a GBL program. Such an objective is beyond the purpose and scope of this study. It is my hope that teachers, organizers, policy makers and community members can utilize the material presented throughout to develop schools of sustainability in thought and practice. This project is not just a single school in a single place; it describes a deep connection to place itself. This reflects peoples desire to live near their roots, or establish those roots and sustain them.

The outlook for school supported agriculture is bright. School supported agriculture has been integrated into alternative agro food networks. The movement towards schools of sustainability enables the exchange of knowledge and information about food and regarding food issues among people and among movements within AAFNs. The concept of knowledge creation then serves as the basis for the formation of spaces in which alternatives can be enacted. School gardens are such spaces. They are places where seeds of sustainability can be sprouted, where students can learn to become responsible members of the citizenry and where communities can shape collaborative efforts that offer generations of students, community members, and non-community members an opportunity to observe how concepts of food can be shared with one another.

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APPENDIX A

LIST OF ACRONYMS USED

AAFN	Alternative Agro-Food Network
CLBL	Center for Land Based Learning
CSA	Community Supported Agriculture
ESY	Edible Schoolyard
FFA	Future Farmers of America
GBL	Garden Based Learning
IPM	Integrated Pest Management
MHS	McKinleyville High School
NCCGC	North Coast Community Garden Collective
SSA	School Supported Agriculture
USDA	United States Department of Agriculture

APPENDIX B

MHS GARDEN MATERIALS

Appendix B.1 MHS Garden Committee Meeting Agenda

AGENDA
McKinleyville High School Garden Committee Meeting
Tuesday, September 7, 2010, 5:00 p.m. to 6:15 p.m.

Natalie	5 min	Intro and Review of Speaker Schedule
Natalie	15 min	Donation Organization • Compost/Soil - Discuss pick up/drop off Wed • Worm Box/Compost Bin Material - Obtain pallets • Cardboard/Straw for Sheet Mulching - Obtain cardboard • Chicken Manure - Discuss pick up/drop off Wed • Starts - Discuss pick up
Natalie	45 min	Workday Beds • 9 weed and cultivate • 10 weed for cover cropping later • 20 sheet mulch Organization and Leadership of Tasks • Weeding • Building Compost Bin • Moving and Mixing Compost/Soil • Sheet Mulching Needs • Irrigation Discuss arrival time on Saturday
Natalie Stacy	5 min	Workday Organization 5 min Welcome/Sign In/Picture Disclaimer Moment of Silence for 9/11

55 min	Weed 19 of 39 beds
	Build Worm Box/Compost Bin
60 min	Move and Mix Compost into 9 beds
	Sheet Mulch 20 beds
60 min	Transplant Starts
	Mulch Beds

Appendix B.2 Press Release

McKINLEYVILLE HIGH SCHOOL AGRICULTURE WORKDAY

For Immediate Release

On Saturday, September 11th from 9 am to Noon students, parents, teachers, and community members will be coming together to help revitalize the McKinleyville High School Garden. Volunteers will be moving compost into existing beds, weeding, raking, planting fall crop transplants, building compost bins, and setting up irrigation.

More volunteers are needed. Please come out and support your community. This garden workday is an excellent chance to network with local gardeners or get your hands dirty for the first time. Please bring work gloves, water, sunscreen, and appropriate clothing. The workday will be held rain or shine.

Thank you to the following businesses for donating to the project: Fox Farm Company for soil, Royal Gold Products for compost, Dripworks for irrigation materials, A&L Feed for cover crops, and numerous local farmers for extra crop transplants.

Please direct questions to McKinleyville High School 707-839-6400.

This promises to be a great work day that will help to foster a sense of community and create an environment for students to learn about soil, compost, fruits, vegetables, nutrition, marketing local food, and much more.

The garden is located on McKinleyville Ave. just south of Murray Rd.
Hope to see you there!

Appendix B.3 Workday Flyer

McKinleyville High School Agriculture Workday

Please come help our project!

Saturday, September 11th
9 am—Noon
McKinleyville High School Garden

All Students, Parents, Community members!
Please come help us revitalize the garden beds.

Bring: work gloves, water bottles, snacks if you wish, sunscreen. What will we be doing? Moving top soil into boxes, digging, weeding, raking, planting fall crop transplants, sprucing up the area. There are many tools at the school, but if you have your favorite shovel or wheelbarrow, please bring it.

Enjoy a sense of community! Meet other high school families. Help your students get excited about the garden project where they will be learning about soil, compost, vegetables, nutrition, marketing local food, and much more!

Questions? Call Natalie, HSU graduate student 970-556-8358
or Mrs. Kastler 441-9875 voice mail box.

Appendix B.4 General Donation Letter

[Date]

Dear [business name],

Engaging students in agricultural education is an important factor in encouraging interest in agricultural careers and gardening fields.

School gardens help to educate students about agricultural practices and careers. The McKinleyville High School Garden in McKinleyville, CA is getting a 'facelift' so that it may better serve its' students and the community.

The McKinleyville High School Garden is conducting a workday on September 11, 2010. In order to make this day a success we are asking for donations from local businesses. Currently we are in need of [list material needed] for approximately 10 garden beds.

If you are able to make a donation or have further questions, please get in touch with the garden organizer at your earliest convenience:

Natalie Faris
naf17@humboldt.edu

Thank you very much for your time and consideration. We appreciate your business in the community and we are grateful for your efforts to build a stronger and more sustainable local food system!

Sincerely,
The Mckinleyville High School Garden

Appendix B.5 Farmer Donation Letter

Dear Farmer,

Thank you for the work you do to provide delicious and nutritious food for our community. We are grateful for your efforts to build a stronger and more sustainable local food system.

To that end, the North Coast Community Garden Collaborative supports community gardens as a way to increase access to fresh and healthful foods, educate people about how their food grows, teach sustainable growing techniques, and to promote the importance of local food from a health, environmental, cultural and economic standpoint. Community gardens include neighborhood gardens, school gardens, food pantry gardens, and gardens for homeless youth, among many others. We aim to make gardening accessible to all people, particularly those without land to cultivate and those who face barriers to accessing healthy foods.

As many community gardeners have little money for starts, and most lack adequate places to nurture seeds, we are currently seeking donations of vegetable starts for the fall season. Any donations received will be distributed to local community gardens in Humboldt County, such as the McKinleyville High School Garden. This particular garden educates students about agricultural practices and careers, and is getting a 'facelift' so that it may serve as a demonstration garden for other schools. The agriculture department at McKinleyville High is heavily involved, and provides volunteer opportunities and internships for students. They are hosting a work and planting day for students and their families on Saturday September 11, 2010.

If you have any excess plant starts for donation, please get in touch with us at your earliest convenience:

Debbie Perticara	Chris Lohoefener	Deborah Giraud
(707) 269-2071	(707) 269-2064	(707) 445-7351
debbiep@nrsrcaa.org	lohoefener@nrsrcaa.org	ddgiraud@ucdavis.edu

We would be happy to pick them up or make other appropriate arrangements. Your donation will be acknowledged in a newsletter of the North Coast Community Garden Collaborative and on our website, as well as local school publications. Your donation is also tax deductible should you request it.

Thank you very much for your time and consideration. We appreciate your work in nourishing our community!

Sincerely,

The North Coast Community Garden Collaborative

Appendix B.6 McKinleyville High School Speaker Schedule

AG 1 SPEAKER SCHEDULE - FALL 2010

Week / Date	**Topics**	**Speaker**	**Suggested Activity**
2 / Sept 1, 2010	Food Systems /Commodities	Natalie Faris, HSU	Food Systems Game
3 / Sept 8, 2010	The Business of Growing Things	Portia Boni Bramble, NCGA	Tasting / Plan Garden Beds
4 / Sept 15, 2010	Irrigation/ Integrated Pest Management	Stan Schmidt, Grace Good Shepard	Garden Tour
5 / Sept 22, 2010	Crop Science: Vegetables	Deb Giraud, UC Extension	Cover Crop
6/ Sept 29, 2010	Healthy Soil/ Compost/ Vermicompost	Erin Derden Little, CAFF	Compost / Construct Worm Box
8/ Oct 14, 2010	Vocational Education	Steve Salzman, Greenway Partners	Research Appropriate Technology
8/ Oct 15, 2010	Food and Nutrition	Brenda Harper, North Coast Co-op	Harvest and Taste
12/ Nov 8, 2010	Crop Science: Fruits	Jim Polly, Fieldbrook Nursery	Taste
12/ Nov 10, 2010	Hunger Issues	Mike Canning, Food For People	Hunger 101
15/ Dec 2, 2010	GMO	Noah Zerbe, HSU	Research GMO
16/ Dec 10, 2010	Greenhouse/ Container Gardens	Natalie Faris, HSU	Seed Starting

ADDITIONAL SPEAKER SUGGESTIONS

Spring Semester	CSA	College of the Redwoods	Tour

Appendix B.7 School Supported Agriculture Flyer

LOOKING FOR INTERESTED SHAREHOLDERS

We are exploring School Supported Agriculture as a viable option for the care of the McKinleyville High School garden this summer. What this means is that you could have the chance to buy a small share at the cost of $40-50 dollars. This contribution would help to pay a volunteer to tend the garden for the summer. In turn you, the shareholder, would be able to pick your own vegetables from the garden once a week for the duration of 8 weeks. This is a new concept that is just beginning to take root at schools, if you think that you would like to participate as a shareholder this summer please let us know. This is an exciting opportunity to help the garden continue to flourish throughout the summer and into next school year! Thank you for your support.

QUESTIONS AND INTEREST SHOULD BE DIRECTED TO:

STACY KASTLER (707) 845-8254

APPENDIX C

MHS GARDEN ACTIVITIES

Appendix C.1 Local Food Systems Game

Grade Level: Adaptable for all grade levels.

Overview: This game should be incorporated into a lesson about commodities and food economies. Students will participate as consumers, producers, and distributers within the local food system. This game serves as an example of how the food system is affected by all members of the community.

Goal: Illustrate the interconnectedness of the local food system, and highlight the importance of locality and seasonality over durability and distance.

Objective:

1. Students will understand the local food chain and the relationship between collaborative efforts and a self-reliant food economy.
2. Students will explore the meaning of local in the food that we eat.
3. Students will describe their individual participation in the food system.

Time: 40 minutes

Materials:

1. Local Food System Game
2. Consumer, Producer, Distributer Cards
3. 3 Game Pieces

Advanced Preparation:

1. Create Local Food System Game board (see enclosed material examples)
2. Create Consumer, Producer, Distributer cards (see enclosed material examples)
3. Create game pieces to correspond to the card colors

Background: This activity links the work of producing agricultural products with concepts about local distributing and the consequences for producers, distributors and consumers. Many people in today's society are far removed in both space and time from the source of their food. This distancing of people from their food source has lead to an increase in certain consumer choices and decrease in others. We may be able to buy many new types of exotic fruit or variations of breakfast cereals in super markets, but we are offered fewer in-season locally grown agricultural products.

This activity helps students to observe within their own community the importance of the local food system as an alternative to the corporate grocery store model in which producers and consumers are separated through a chain of processors, manufacturers, shippers and retailers. A local food system strives to reduce the number of hands that food is exchanged through before it reaches the consumer. For example CSA farm shares, U-Pick, roadside stands, and farmer's markets, are all direct markets to the consumer.

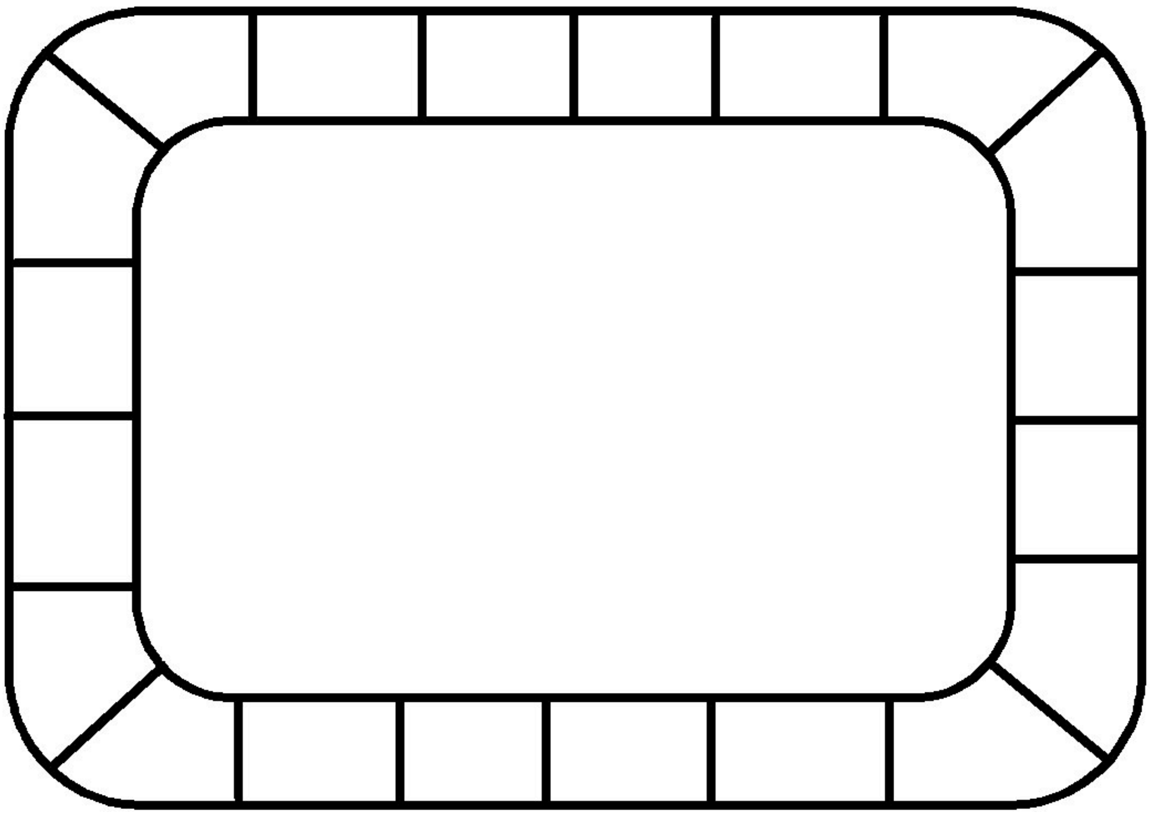
Local food systems are collaborative efforts to build a more locally based, self-reliant food economy. A system that recognizes the importance of the small farmer as the backbone of the community. Consumers have the power to choose what system they support. By participating in alternative activities such as growing food in a school garden or raising animals for FFA, students are exercising the right to education themselves about the diverse options within food systems. These systems are complex, this activity helps to illuminate the interconnectedness of the system in your community.

Procedure:

1. Explain that you are going to play a game called Local Food Systems and ask the students to define that term. Discuss the three major steps in the food system: producer, consumer and distributor.
2. Ask students to list members of the community for each step. For example consumers are individuals, families, students, etc.
3. Divide the students into three groups and distribute one card to each student according to their group.
4. Explain that one card will be read from the producers, consumers, and distributors and the playing pieces on game board will be adjusted accordingly each time a card is read.
5. Start the game and continue reading cards until all the cards have been read.
6. Wrap the game up by explaining that the point of the game was not to see who finished first or last. It was to demonstrate that everyone in the community moves ahead together.
7. Encourage students to investigate where they can purchase fresh, locally grown produce. Ask the students to find out where there might be a CSA, farmers' market, roadside stand or U Pick operation in their community.
8. Ask them if the know people who garden in their yards or in the community gardens where they live.
9. If possible have the students visit a local farmers' market, nearby community garden, or diversified farm in the area. Have the students make a list or create a poster with the places they can find affordable fresh produce in their neighborhood.

Material Examples:

1. Game board can reproduced onto an overhead, projected through a computer, or redrawn on a poster board. It may be helpful to add images of local consumers, producers, and distributors.



2. Local consumer, producer, and distributor cards. It may be helpful to print or write each group on different color card in association with each groups' game piece. Each card can be individualized to specific farms, towns, and restaurants in your area. Below is an example of a producer, consumer and distributer card.

Producer	Consumer	Distributor
• Grace Good Shepard Church, McKinleyville • This garden provides food for the church food pantry • Producers move ahead one space • Consumers move ahead one space	• Arcata Single Parent • You harvest lettuce from your garden and use it on your child's sandwhich for their school lunch • Consumers move ahead two spaces	• Rita's Mexican Restaurant • Your salsa is made locally in Humboldt County with local produce and is on the shelf at many grocery stores in the area • All move ahead one space

Appendix C.2 Alternative Food Markets

Grade Level: Appropriate for middle and high school students

Overview: Alternative food markets have emerged in response to conventional food "super" markets. Farmers markets, CSA (Community Supported Agriculture) and farm based outlets such as U-Pick and farm stands are a way to be directly connected to local farmers, the food they raise and the land on which it is grown.

Goal: Explore emerging alternative food markets and understand the importance of direct marketing in the business of growing food.

Objective:

1. Students will understand the importance of alternative food markets in local food systems.
2. Students will become familiar with farmers markets, CSA, and farm based outlets.
3. Through inquiry students will explore alternative food markets and describe direct marketing strategies.

Time: 20 minutes for explanation and discussion, several lessons may incorporate student research

Materials:

1. Images of alternative food markets
2. Documents that support alternative food markets, such as vendor requirements and CSA share contracts

Advance Preparation:

4. Gather images of alternative food markets, if possible markets that are available locally or regionally
5. Gather farmers market vendor requirements and CSA share contracts

Background: In the early 1900s, nearly 40% of Americans lived on farms and much of their food was produced at home or locally. As cities grew, more and more people left the farms, and the food had to be brought to them. Today, 80% of our population lives in urban areas and less than 2% lives on farms; therefore we have been almost completely cut off from the sources of our food.

American consumers are becoming aware of this disconnect and regaining control over their food. Farmers markets not only give people access to good food, they are becoming the new public square and developing into lively meeting places. At farmers markets, farmers sell their produce at a designated public place. Farmers markets are great business incubators for small farmers and food processors. Farmers who sell through farmers markets generally try their hands at additional entrepreneurial activities by expanding product lines; venturing into value-added product development (manufactured, prepared and processed foods); and sharpening customer relations, merchandising, and pricing skills. Depending on the size and sophistication of the farmers market operational structure, the market can provide marketing, infrastructure, and sales support as producers experiment with new products.

The trend towards alternative food market has increased significantly. In 1970 there were only 340 farmers markets; in 2011 there were nearly 7,200 markets listed on the USDA directory of farmers markets. That doesn't take into consideration informal markets that haven't made it into the directory. More than 137,000 farmers sell $1.2 billion worth of products direct to consumers, through farmers markets, CSA (Community Supported Agriculture) subscriptions and memberships, and other direct channels. Local spending in alternative food markets benefits both the farmer and the community. Farmers can take in up to seven times greater net revenue on a per unit basis from selling locally than selling to the conventional food distribution system.

In just a few decades, CSA operations have grown dramatically throughout America. The government does not track CSAs, so there is no official count of how many CSAs there are in the U.S.. Local Harvest has the most comprehensive directory of CSA farms, with over 4,000 listed in the grassroots database. On these farms a farmer offers a certain number of "shares" to the public. Typically these shares consist of a box of seasonal vegetables and fruits, but might also include other farm products. Interested consumers purchase a share and in return receive a box each week throughout the farming season. This arrangement works symbiotically for the farmer and the consumer: farmers get to spend time marketing earlier in the year prior to the farming season, farmers also receive payment early in the season, farmer and consumer share the costs and risks of the farm and together farmer and consumer reap the benefits creating mutual bond, consumers also receive extremely fresh produce, get exposed to new produce, and usually have the opportunity to visit the farm. It is a simple idea that has had profound results. Tens of thousands of shares have been contracted and in some areas there are not enough CSA shares to fill the demand.

Other direct food markets include U-Pick and farm stands. A U-Pick is a farm that opens its fields to the public during harvest season. U-Pick farms offer fruits such as strawberries, blueberries, and pumpkins in the summer and early fall months. Farm stands are places where a single farm sells its produce, either from the back of a truck parked on the side of the road or from a roadside stand near the farm. Farm stands are generally only open during warm weather and some may be "self serve". Farm stands allow direct market sales without off-farm transportation costs, although some stands are located off the farm to get closer to traffic volume or population centers. Generally, marketing costs depend on the size of the retail outlet. As volume, traffic, and product selection increase, so too will stand size, operating costs, and management time.

Procedure:

1. Discuss alternative food markets as a response to conventional "super" markets. Ask students to describe the differences between the two markets. List the benefits of alternative food markets.
2. Discuss farmers markets. Explain the requirements of farmers and show documents that farmers must adhere to in order to vend at farmers markets. Integrate farmer-consumer relations into this discussion. As an option ask students to attend a local farmers' market or experience one on the Internet.
3. Transition into discussion of CSA. Use the class as an example. Each student is a shareholder and contributes a specific dollar amount to the farm. Have the students fill out shareholder contracts. Ask the students to figure out what the shares contribute financially to the farm. Incorporate the farmer-consumer relationship in this discussion and explain that the two are also sharing risks such as weather, drought or storms destroying crops. As an option visit a local CSA or tour one virtually on the Internet.
4. Discuss U-Pick and farm stands. Incorporate direct marketing into this discussion and explain the importance of this marketing strategy in the success of farm-based operations.
5. Assign an inquiry project in which students will research a farm and report to the class the direct marketing strategies that the farm employs to reach consumers. Each student will need to write a one page summary and present the research verbally in a five minute presentation.

Resource References:

Market Forces – Creating Jobs Through Public Investment in Local and Regional Food Systems, Union of Concerned Scientists, August 2011

Appendix C.3 Identifying and Improving Soil Texture and Type

Grade Level: Appropriate for middle and high school students

Overview: Soils are generally described according to the predominant type of soil particle present: sand, silt or clay. By conducting a simple soil test, you can easily see what kind of soil you're dealing with.

Goal: Determine the texture and type of soil and identify how soil can be improved. Plants are more vigorous and more productive in healthy soil.

Objective:

1. Students will examine soil samples and be able to identify the different materials, including sand, silt, clay, gravel, and humus.
2. Through their observations students will be able to infer that one soil formed in a dry environment with little vegetation and the other formed in a wet environment with abundant vegetation.
3. Also from their observations, students will be able to conclude that the sample containing more humus and about equal amounts of sand, silt, and clay would be best for plant growth.
4. Students will also understand how to improve soil structure.

Time: 20 minutes for explanation and testing, 20 minutes for discussion, 2 days for observations

Materials:

1. Soil samples: sandy, silty, and clay in marked containers
2. Quart jars with lids
3. White piece of paper for each student

Advance Preparation:

1. Obtain three different soil samples from a commercial source or collect them yourself and place in three different containers.
2. Mark the sandy soil container with the letter "A", the silty soil container with the letter "B", and the clay soil container with the letter "C".
3. An alternative to using classified soil samples is to make two different types of soil by mixing sand, silt, clay, and humus in different proportions to create the correct soil proportion (see #5).
4. Fill a different quart jar about one-third full with the appropriate proportions (see #5).
5. Proportions (see below drawing).

Background: Soil texture can range from very fine particles to coarse. You don't have to be a scientist to determine the texture of the soil. Every soil has unique physical characteristics, which are determined by how it was formed. The silty soil found in an old floodplain is inherently different from stony mountain soil; the clay soil that lay under a glacier for millions of years is unlike the sandy soil near an ocean. Some of these basic qualities can be improved with proper management, or made worse by abuse.

Soils are generally described according to the predominant type of soil particle present: sand, silt or clay. By conducting a simple soil test, you can easily see what kind of soil you're dealing with. You may want to repeat this test with several different soil samples.

Procedure:

1. To get a rough idea of soil texture, have students select one soil sample from a marked container. Have them note what letter sample they took. Place some soil in the palm of their hands and wet it slightly, have them run the mixture between their fingers. If it feels gritty, your soil is sandy; if it feels smooth, like moist talcum powder, your soil is silty; if it feels harsh when dry, sticky or slippery when wet, or rubbery when moist, it is high in clay.
2. Have the students examine the rest of the sample on the paper at their desk. Have them take notes about what they see in their sample.
3. Now fill each of the quart jars to the top with water. Screw on the lid and shake vigorously, until all the clumps of soil have dissolved.
4. Then set the jars against a solid background or on a windowsill and have the students watch as the larger particles sink to the bottom
5. After a minute or two the sand portion of the soil will have settled to the bottom of the jar (see drawing in advance preparation #5). Mark the level of sand on the side of the jar.
6. Explain that you will leave the jar undisturbed for several hours. The finer silt

particles will gradually settle onto the sand. You will find the layers are slightly different colors, indicating various types of particles.

7. Explain to the students that you will leave the jar overnight. The next layer above the silt will be clay. Mark the thickness of that layer. On top of the clay will be a thin layer of organic matter. Some of this organic matter may still be floating in the water. In fact, the jar should be murky and full of floating organic sediments. If not, you probably need to add organic matter to improve the soil's fertility and structure.
8. Conclude with discussion about the each students soil sample and transition into a discussion about how to improve soil structure.

Discussion: Even very poor soil can be dramatically improved. With their roots in healthy soil, plants will be more vigorous and more productive.

In sandy soil, sand particles are large, irregularly shaped bits of rock. In a sandy soil, large air spaces between the sand particles allow water to drain very quickly. Nutrients tend to drain away with the water, often before plants have a chance to absorb them. For this reason, sandy soils are usually nutrient-poor.

A sandy soil also has so much air in it that microbes consume organic matter very quickly. Because sandy soils usually contain very little clay or organic matter, they don't have much of a crumb structure. The soil particles don't stick together, even when they're wet.

To improve sandy soil, work in 3 to 4 inches of organic matter such as well-rotted manure or finished compost. Mulch can be used around your plants with leaves, wood chips, bark and hay or straw. Mulch retains moisture and cools the soil. Add at least 2 inches of organic matter each year. Grow cover crops or green manures.

In clay soil, clay particles are small and flat. They tend to pack together so tightly that there is hardly any pore space at all. When clay soils are wet, they are sticky and practically unworkable. They drain slowly and can stay waterlogged well into the spring. Once they finally dry out, they often become hard, and the surface cracks into flat plates.

Lack of pore space means that clay soils are generally low in both organic matter and microbial activity. Plant roots are stunted because it is too hard for them to push their way through the soil. Foot traffic and garden equipment can cause compaction problems. Fortunately, most clay soils are rich in minerals, which will become available to your plants once you improve the texture of the soil.

To improve clay soil work 2 to 3 inches of organic matter into the surface of the soil. Then add at least 1 inch more each year after that. Add the organic matter in the fall, if possible. Use permanent raised beds to improve drainage and keep foot traffic out of the growing area. Minimize tilling and spading.

Silt soil contains small irregularly shaped particles of weathered rock, which means they are usually quite dense and have relatively small pore spaces and poor drainage. They tend to be more fertile than either sandy or clay soils.

To improve silt soil add at least 1 inch of organic matter each year. Concentrate on the top few inches of soil to avoid surface crusting. Avoid soil compaction by avoiding unnecessary tilling and walking on garden beds. Consider constructing raised beds.

Appendix C.4 Composting

Grade Level: Experimental design appropriate for middle and high school students

Overview: Composting is the oldest form of recycling and is controlled decomposition. It provides an opportunity for students to observe the decomposition process and energy cycle at work; produces a valuable soil supplement; and reduces the amount of organic material requiring landfill or incineration.

Goal: Demonstrate how soil organisms recycle organic wastes through composting.

Objective: Students will fill a compost bin with organic wastes and observe the decomposition of the organic wastes into humus during the school year.

Time: 40 minutes for discussion and set up, several months for observations.

Materials:

6. Compost bin (should be built prior to lesson, see appendix D.4A)
7. 3-4 large bags of wet leaves, straw, sawdust, cardboard, or newspaper. If the leaves are not wet they will need to be dampened thoroughly during bin set up. If a hose is not available it is effective to dampen the leaves ahead of time. The leaves need to be thoroughly dampened or they will not compost properly through out the school year. These are considered brown materials, high in carbon.
8. 1-2 bags of grass clippings, weeds that have not seeded, and food waste. These are considered green materials, high in nitrogen. The optimal ratio of material is 30:1, C:N.
9. Finished compost or soil.
10. Garden tools: gloves, hoe, shovel, and rake.
11. Compost thermometer, optional.

Background: In nature, soil organisms called decomposers digest organic material such as leaves, dead plants and animals. The digestion process converts the fresh material into humus, a dark brown component of soil rich in plant nutrients. Composting is simply a matter of managing the decomposition process, and the end product is called compost. A compost pile is a teeming microbial farm. Bacteria start the process of decaying organic matter. They are the most numerous of the decomposer organisms; one tablespoon of soil contains billions of bacteria! Fungi and protozoans soon join the bacteria and, somewhat later in the cycle, earthworms, centipedes, millipedes and beetles do their parts. Each organism has a role in the food web of the compost pile. Successful composting is simply a matter of providing the conditions in which the decomposer organisms will flourish. Like us, they need food, air, water and a habitable temperature.

First level decomposers, bacteria do the majority of the work and are the primary decomposer organisms of a compost pile. There are three types of aerobic (oxygen-requiring) bacteria.

1) Psychrophilic bacteria (thrive in lowest temperature range, 55 degrees F or less) give off a small amount of heat as a by-product, causing a rise in the pile's air temperature.
2) Mesophilic bacteria (thrive at 70-90 degrees F) do most of the work and also generate heat as a by-product, raising the pile temperature even more.
3) Thermophiles (thrive at 104-200 degrees F) work fast and last only 3-5 days. Actinomycetes (higher form of bacteria similar to fungi and molds) liberate carbon, nitrogen and ammonia, making nutrients available for plants. They take over during the final stages of decomposition, often producing antibiotics that destroy bacterial growth.
   Fungi also take over during the final stages of composting when the organic material has been changed to a more digestible form.

Second level decomposers include protozoa, rotifera, nematodes (roundworms), earthworms, millipedes, sow bugs, land snails and slugs, springtails, feather-winged beetles, mold mites and beetle mites. They consume the first level decomposers. Some second level decomposers, such as earthworms, also consume the organic residue, so they can also be considered first level decomposers.

Third level decomposers include ground beetles, centipedes, pseudoscorpions and ants (ants are usually not found in a compost pile that contains adequate moisture - they are a sign that the pile is too dry). They feed upon first and second level decomposers. Some may also consume organic residue.

Health Considerations: If you are aware of any students in the class with allergies or asthma, those students should not handle compost without gloves, and should not stir the compost or put their face into the compost bin. Observing from the side of the bin should not present any problem. They can add material, but another should do the burying or stirring. Observing the compost samples without smelling or touching them should not present any problem. Students with compromised immune systems should not participate in this activity without their doctor's approval.

Students must always wash their hands with soap after adding material, stirring or handling the compost. The majorities of soil organisms are harmless to humans and cannot survive our body temperature, but prevention is the best medicine. In general, working with compost does not present any more of a health concern than gardening, but it is important to wash hands after working with soil.

Procedure:

1. Show the students the materials that make up the recipe for the compost.

2. Discuss other items that might be used in a home compost, coffee grounds, egg shells, egg cartons, food scraps (banana peels, apple cores, pasta, etc.), and weeds that have not seeded. Ask what else might be good ingredients and go over a list of materials that cannot be composted such as dog and cat feces, meat, etc.
3. Discuss the layering of compost and the appropriate 30:1, C:N ratio.
4. Have students divide into teams of 2-3. Have them put on gloves and add materials to the bin, discuss these materials and their role in the compost. Each team will take a turn adding a layer of material to the bin until the bin is full. Layer the materials in the bin 2”-8”. Sprinkle soil or finished compost between the layers. Dampen leaves and other materials with a garden hose. A hoe is very useful for stirring the leaves; show the students how to use the tool.
5. Discuss how this is the first stage of compost. For compost to reach its optimum condition and be most effective to the soil it must receive proper care. Water is necessary for compost to reach completion, but not too much because then it will turn anaerobic and begin to smell foul. If it is wet outside it might be helpful to cover the compost or layer straw on top. Compost must be turned in order to allow oxygen to assist in the decomposition process. Heat is also important. A compost pile actually produces its own heat. Explain that the inside of the pile is very hot due to the weight of the material. This is where a compost thermometer can be used to track the temperature changes through out the year.
6. Elaborate on the decomposition process by explaining that various microorganisms such as bacteria and fungi are the workhorses that decompose the organic materials during this very active, hot phase of composting. Continue the discussion by including examples of first, second and third level decomposers. Have students look at the finished compost to try and identify fungus, insects and earthworms. Draw attention to how the pile will get smaller as it ages to become the finished compost. Ask the students why they think this happens. Ask the students to handle the finished compost and recognize how it looks and smells like rich soil.
7. Commence with hand washing.

Maintenance and Use:

1. Turning the pile refers to mixing a pile, usually with a pitchfork. If using the wooden pallet compost bin, open the front and turn the pile. In multi-bin systems, when one bin is emptied, the contents of the next are forked into it. Turning accomplishes two primary purposes: it aerates a pile and it moves material from the relatively cool, inactive periphery to the active center.
2. Timing of the turning depends on how wet the pile was to begin with and how quickly it dries out, which depends at least in part on how humid it happens to be. The rule of thumb for an active, hot pile is turn every three days until it stops heating up.

3. Turning too often (every day) disrupts the formation of the fungi and actinomycetes that do much of the composting work and may prevent the pile from heating up completely. For the fastest, most efficient decomposition, a pile should be left essentially alone to "cook" until it starts to cool. Then it should be aerated at once and left again.
4. To get a reading of how the pile is doing, wait at least two days after assembling it, then pull away some of the surface material. Six inches down, the pile should be noticeably warm if not downright hot. Check the pile each day, covering the hole after each test. When the material is clearly cooling down, it's time to turn it.
5. A compost thermometer thrust into the center of a pile makes it even easier to figure out what's going on in there. It can also give startling evidence of how hot a hot pile gets. A good, hot pile will reach at least 130°F (54°C) and stay there for two to four days. When the temperature drops back down to about 100°, turn the pile.
6. Temperatures, CO_2, moisture percentage of the pile can be tracked through out the year as well as turning maintenance or the addition of water and materials to the pile (see Appendix D.4B).
7. Large quantities of new material can also be incorporated into a working pile when it is turned. The most thorough mixing will be accomplished on a tarp outside the bin, but interspersing thin layers of new and old material will also mix them sufficiently. Fork six inches or so of the old pile into its new bin, then add several inches of new material, and continue until the bin is full. If your active pile was good and hot, it should heat back up again within a day or two.
8. Even when the hot pile has stopped heating up, it still needs to cure for a couple of weeks before it is ready for use. Heat can become such a focus of quick composting that gardeners forget that several important degradation processes go on only at cooler temperatures.
9. As the heat-loving thermophilic bacteria die off, mesophilic bacteria that thrive at temperatures between 70 and 100°F (21-38°C) re-establish themselves and continue the composting process. Fungi and actinomycetes, which can be suppressed at high thermophilic temperatures, also flourish at this time. Both play important roles in breaking down tough lignin and cellulose, much of which can withstand even the high temperatures of hot composting.
10. Fungi and actinomycetes are not the only organisms that return to the pile as it cools. Most of the larger organisms -- beetles and the precious garden worm -- can't withstand the temperatures in a hot pile, so they migrate elsewhere as the temperature rises. But as its heat moderates, they move back in. These migrations ensure that when the compost is spread, it will contain the full range of organisms that make compost so vital and so valuable. If compost is not left to cure, these macro-organisms do not have time to re-populate the pile.

Resource References:

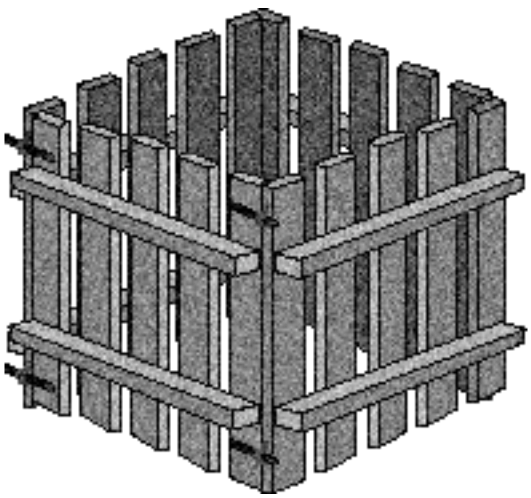
Campbell, Stu. Let it Rot, The Gardener's Guide to Composting. Vermont: Storey Publishing, 1990.

Cornell Composting. Cornell University Waste Management Institute www.compost.css.cornell.edu/Composting_homepage.html

Martin, Deborah L. & Grace Gershuny. The Rodale Book of Composting. Emmausm Pennsylvania: Rodale Press, 1992.

Appendix C.4A Wooden Pallet Compost Bin Plan

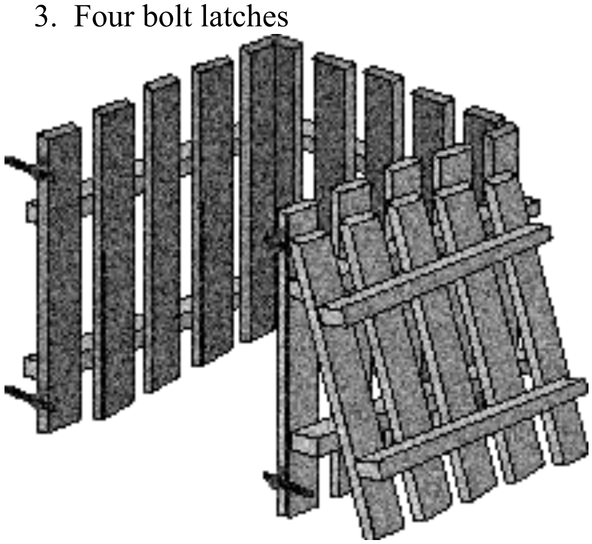
Overview: A very inexpensive bin can be made using wooden pallets. These bins cost almost nothing and you divert pallets that would eventually end up in the landfill. This design includes a removable front to make it easy to turn the compost.



Time: 40-60 minutes

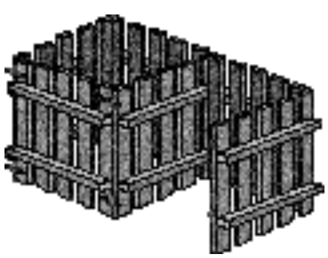
Materials:

1. Four wooden pallets
2. 32 wood screws or bailing wire
3. Four bolt latches

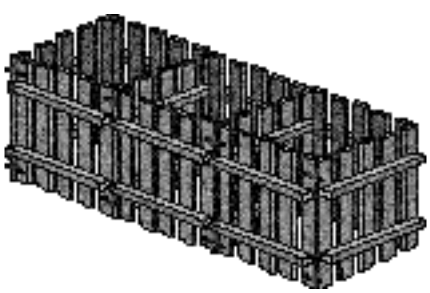


Procedure:

1. First, find out if your community has any local regulations pertaining to composting. Your municipality may have a setback ordinance requiring composting bins be located a certain distance from lot lines.
2. The right location is important for a successful compost pile. Choose a level area outside with good drainage. Standing water will slow down the pile. If possible avoid direct sunlight and areas exposed to strong winds, which can dry and cool the pile. A half-day sun situation is ideal. A shaded area is fine but pay attention to limited rainfall through a canopy of leaves, and slow drying out of a saturated pile. Avoid placing under a wide overhang that would limit rainfall, or under a drippy eave or rainspout that would continually saturate your pile.
3. To assemble compost bin screw or wire three of the pallets together.
4. Attach bolt latches to the front edge of the bin and the last pallet to make a removable door.
5. Tip for dryer climates: For dry climates, this bin should be lined with plastic. This helps keep the pile moist and decrease the composting period. Staple a sheet of plastic to the three sides of the bin and staple a separate plastic sheet to the front door.
6. Variations: This bin can be easily converted into a two-bin system using just 6 pallets. In a two-bin system the compost is turned by emptying the full bin into the empty one and back again.



5. If you have lots of compostable material you could expand it to a three-bin system using 10 pallets. You build a pile in the first bin turning it into the second and then the third.



Appendix C.4B Compost Tracking

Start Date:_______________

DAY	DATE	TEMP. °F	DO/CO2 LEVEL	% MOISTURE	ADD H2O?	TURNED?	ADD MATERIAL?
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Appendix C.5 Vermicomposting

Grade Level: Adaptable for all grade levels.

Overview: Vermicomposting is the process of using worms and microorganisms to turn food waste into black, earthy-smelling, nutrient-rich humus. It provides an opportunity for students monitor the decomposition process of cold compost.

Goal: Observe the vermicomposting process over several months and harvest worm castings for use.

Objective:

1. Students will understand nature recycles everything and that worms assist with that process.
2. Students will also have a basic understanding of worm characteristics and functions.
3. Students will be able to decipher between organic and inorganic material.
4. Students will understand that composting organic waste is an alternative to landfill disposal and is a form of recycling.

Time: 40 minutes.

Materials:

1. Vermicomposting worm bin
2. 1lb of Red worms (*Eisenia foetida*), also know as red wigglers, manure worms, red hybrid or tiger worms.
3. Shredded Newspaper
4. Non fatty food scraps

Advance Preparation:

1. Construct Vermicomposting worm bin (see Appendix D.5A).
2. Obtain red wiggler worms. These can be bought at bait store or ordered online.
3. Obtain newspaper and shred into ½" strips. The bin needs to be 2/3 filled with shredded newspaper bedding. The bedding needs to be moistened prior to filling the bin with worms.
4. Obtain non-fatty food scraps, approximately 1lb of food scraps for every square foot of surface area in the worm bin.

Background: There are over 5,500 species of earthworms found worldwide, except in polar and arid regions. Earthworms are approximately six inches in length, have five pairs of hearts (10 total) and are monoecious (both male and female-though they usually don't fertilize themselves). Worms lay eggs that hatch small, but fully developed worms.

Eggs look like a small milky/glassy colored seed and can easily be found in a developed compost bin. Earthworms do not have eyes and some species can regenerate body parts. They are cold blooded and move up and down in the soil layers to regulate body temperature. They breathe through their skin and when the soil is saturated, must move up out of the soil to breathe. Earthworms secrete mucus, which helps soil particles “stick together.” As they move through the soil they aerate and turn the soil moving nutrients into the root zone of plants. Red Wigglers (*Eisenia fetida*) are commonly used for vermicomposting because of their ability to thrive in the acidic layer of soil where decomposition takes place. Red wigglers eat 1½ times their body weight in organic matter each day. Worm casting (worm poop) or compost is the best organic humus known and contains 40% more organic matter than topsoil. Worm compost holds nutrients in the soil and provides a stable source of nutrients for plant uptake. It also balances soil pH and improves soil structure.

Health Considerations: If you are aware of any students in the class with allergies or asthma, those students should not handle compost without gloves, and should not stir the compost or put their face into the compost bin. Observing from the side of the bin should not present any problem. They can add material, but another should do the burying or stirring. Observing the compost samples without smelling or touching them should not present any problem. Students with compromised immune systems should not participate in this activity without their doctor's approval.

Students must always wash their hands with soap after adding material, stirring or handling the compost. The majorities of soil organisms are harmless to humans and cannot survive our body temperature, but prevention is the best medicine. In general, working with compost does not present any more of a health concern than gardening, but it is important to wash hands after working with soil.

Procedure:

1. Show worm bin. Explain that holes are in the bin so worms can breathe. A small amount of organic matter (non fatty food scraps) is placed under moist, shredded paper. Discuss the meaning of: organic and inorganic. Worms are added to the bin and they eat the organic matter or “your garbage.”
2. Discuss what food scraps are appropriate for vermicomposting. This includes all vegetable and fruit waste (don't be surprised that some seeds may germinate and potato peels with eyes sprout), pasta leftovers, coffee grounds (with filter) and tea bags. Worms may have a problem with garlic and onionskin. Worms have a gizzard like chickens so fine grit should be added to help the worms digest food. This gritty material includes cornmeal, coffee grounds and/or finely crushed eggshells (dry the shells and then crush). Avoid large amounts of fat, meat scraps or bone. Start slowly with the food scraps. Spread in a thin layer on top of the bedding and then cover with an inch of bedding.
3. Discuss worm characteristics. Ask students, “What is that black stuff?” Lead them

to the answer that it's worm casting, compost, or poop. Discuss the fertilizer value of compost and the nutrient cycle. The earth uses worms (any many other creatures) to recycle.

4. Bedding needs to remain moist. If it dries out, mist the paper with water from spray bottle and dampen the bedding again.
5. Harvest worm castings from the bin by hand, careful not to remove any worms.

Appendix C.5A Vermicomposting Bin Plans

Worm bin construction
Plastic worm bin

This bin is used mainly for fruit and vegetable trimmings. It is very easy to build and tidy for indoor use. The plastic bins keep compost moist and will require regular additions of dry bedding. Budget $6 to $20 for new materials, or better yet, use salvaged materials.

MATERIALS

Plastic storage container with a tight fitting lid measuring 12" to 18" tall; 12" x 24" base.

TOOLS

Power drill with 1/4" bit

METRO

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30 percent post consumer waste .07356

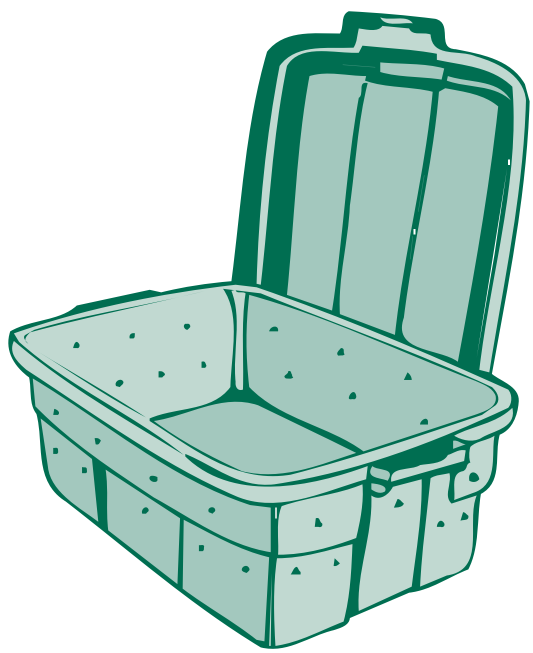
ASSEMBLY

For outdoor use

Drill at least 6 holes per side for ventilation about one-half to three quarters of the way up the sides of the bin. Drill at least 12 holes in the bottom of the bin for drainage.

For indoor use

Drill at least 6 holes per side for ventilation about one-half to three quarters of the way up the sides of the bin. To avoid a future mess from moisture dripping out the bottom of the worm bin, you can either forgo drainage holes, or drill drainage holes and use a second plastic storage bin as a catchment tray. If you forgo the drainage holes, be sure to monitor moisture levels and prevent puddling. When moisture content is high, add dry bedding under and on top of the food and worms to absorb excess moisture.



Worm bin construction

Wood worm bin

This wood worm bin is used mostly for fruit and vegetable trimmings. The bin may require occasional watering. The bin also doubles as a seat. Basic carpentry skills are needed for construction. Budget $30 to $50 for new materials, or better yet, use salvaged materials.

MATERIALS

- ☐ 4' x 4' piece 1/2" exterior grade non-treated plywood (1)
- ☐ 2 x 2" wood: 6' (3)
- ☐ 2 x 4" wood: 4' (1)
- ☐ 4 penny galvanized nails (1 lb.)
- ☐ Light cable or chain: 16"
- ☐ 1/2" wood screws (2)
- ☐ 2" hinges (2), with 3/4" wood screws (2)
- ☐ Solvent-free, low VOC, waterproof wood glue

TOOLS

Power saw or hand saw, hammer, measuring tape, pencil, square, drill with 1/4" and 3/32" bits, sandpaper.

Use proper eye, ear and body protection.

ASSEMBLY

Glue all wood pieces before nailing.

Base

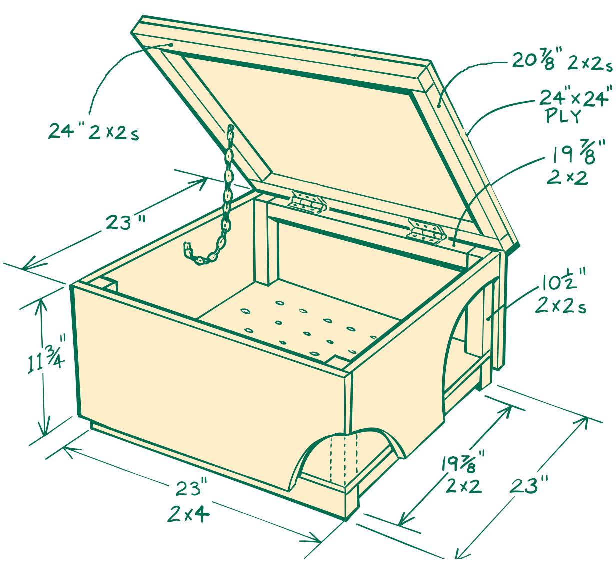
Nail two 23" 2 x 4s and two 19 7/8" 2 x 2s to bottom of 23 x 23" plywood as drawn. Drill at least twenty-four 1/4" holes for drainage.

Side

Front and back walls: Nail the four 2 x 2 uprights to the two side walls along the 11 3/4" edge, with one end of each 2 x 2 flush with the top edge of the walls. Nail a 19 7/8" 2 x 2 hinge support to the top edge of the back wall piece, leaving 1 1/2" on each side for 2 x 2 uprights. Assemble box by nailing the 1 1/4" overhang of the side walls to the 2 x 2s on the base as drawn. Nail the front and back walls to the 2 x 2 uprights and to the 2 x 4s on the base as drawn. Be sure the hinge support is at the top of the bin.

Lid

Nail lid together as drawn. Attach to box with hinges, making sure to pre-drill screw holes into the 2 x 2s and position hinges as drawn. Attach chain with 1/2" wood screws so lid can rest in an opened position.



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Appendix C.6 Agricultural Irrigation

Grade Level: Adaptable design appropriate for high school students

Overview: Agricultural irrigation is a critical element of modern agriculture. Effective irrigation management can increase crop yields, support healthy plant growth, while encouraging water and soil conservation.

Goal: To understand when and how much irrigation is necessary for optimal plant growth, as well as demonstrate how to construct a micro-irrigation system.

Objective:
1. Students will define and understand basic irrigation terminology.
2. Students will become familiar with problems associated with under and over-irrigating crops.
3. Students will understand and demonstrate how to use irrigation equipment for effective irrigation management.

Time: 20 minutes for explanation, observation and discussion 30 minutes to an hour for set up. Several months for observations.

Materials:
1. 1 healthy potted plant, 1 potted plant overwatered for 3-4 days, 1 under watered potted plant starting to die.
2. Images of effective irrigation systems.
3. Irrigation materials such as soaker drip line or hose, t-tape, drip emitters or emitter lines, mainline tubing, connectors, figure 8 ends, pressure regulators, timers, and u-shaped hold downs.

Advance Preparation:
1. Obtain three plants exactly the same type and growth stage, water one regularly, over water one for 3-4 days and underwater one to the point in which it begins to die.
2. Gather images of effective irrigation systems and layouts that are relative to the micro-irrigation project the students will be working on.
3. Obtain irrigation materials. These can be purchased at garden centers, online or donated from irrigation companies.

Background: Irrigation is the artificial supply of water to land, to maintain or increase yields of food crops, a critical element of modern agriculture. Irrigation can compensate for the naturally variable rate and volume of rain. Proper irrigation management is required to maintain adequate soil moisture in the crop root zone for healthy plant growth and optimum yield. The objective of irrigation management is to establish proper timing and amount of irrigation for greatest effectiveness. It also helps reduce the potential for runoff and reduces soil erosion. In order to understand irrigation management, there are two important concepts to understand in regards to crops: crop water use, also called evapotranspiration and soil water status.

Crop water use, evapotranspiration, can be defined as the combined process of both evaporation from the soil and plant surfaces and transpiration from plant canopies through the stomata to the atmosphere. In the evapotranspiration process, water is transferred from the soil and plant surfaces into the atmosphere in the form of water vapor. Crop evapotranspiration can be measured directly using advanced techniques. Soil water status is an indication of the amount of water present in the soil profile and can be describes in two ways: soil water content and soil water potential. Soil water potential determines availability of water to plants and is a direct indication of the energy required for plants to obtain water from the soil. As water is removed from the soil, the remaining water molecules are bonded to soil particles and to other water molecules, and are not readily and easily removed from the soil by plants. Matric potential indicates the energy that must be available in the plants to extract water form the soil.

In general, the more clay in a soil, the greater the water content at any given matric potential. The impact of excess water on crop growth and yield is influenced by crop type, soil characteristics, duration or excess water or flooding, initial soil water and nitrogen status of the soil before flooding, crop stage, air temperature, etc. When a crop receives too much water they will "drown" because they need oxygen to survive. Adopting proper irrigation management strategies can reduce negative impacts of over-irrigation and provide balance between the crop water requirements and available water. Over irrigation leads to water loss increased energy use for pumping, causes leaching of nitrogen and other micronutrients and wastes time.

Procedure:

1. Show the three potted plants. Have students describe what the differences are between the plants. Ask them to describe what type of condition was present for each plant. Explain that plants require a certain amount of water to thrive.
2. Discuss problems associated with over and under irrigating.
3. Discuss basic irrigation terminology, why irrigation first started, and what the impact of irrigation has been on food supplies
4. Discuss what type of tools students think are used in agricultural irrigation. Show students the irrigation materials that they will be using in the micro-irrigation project.
5. Discuss what will be irrigated. For example pots, raised beds, rows all with existing plants.
6. Now illustrate what an effective irrigation system would look like for the area that you will set up micro-irrigation in. For example if you will be irrigating raised

beds show images of effective irrigation layouts for raised beds. This can be done with computer or overhead images or drawn on the board.

7. Assign groups for students to work in to set up their micro-irrigation.
8. Assist students in the set up of their micro-irrigation.
9. Test the micro-irrigation systems to ensure that they are working properly.
10. Observe the effects of irrigation management by comparing the plant growth and health in micro-irrigation set-up to a control with similar plants but no micro-irrigation. These observations may take several months.

Appendix C.7 Plant Parts for Food

Grade Level: Adaptable design appropriate for high school students

Overview: Plant parts that we eat are each unique and exhibit specific characteristic that can be used for identification. By examining specific fruits and vegetables those characteristic can be isolated and an understanding of what part of the plant is being used for food can be reached.

Goal: Through observation students will determine what plant part each particular fruit or vegetable is derived from. They will cite specific evidence as to how they came to this determination.

Objective:

1. Students will review the basic parts of a plant and their functions: specifically roots, stems, branches, lateral buds, leaves, flowers, fruits, and seeds.
2. Understand the diversity of adaptations of the plant form.
3. Understand that biologists use some terms differently from everyday English.
4. Practice evidence-based reasoning and scientific argumentation.

Time: 40-45 minutes

Materials:

1. Paper plates (one for each fruit or vegetable for each group)
2. Plastic or metal knives for dissection (one for each group)
3. Fruits and vegetables for students to identify (5 different kinds per group)
4. Hand lens (one for each group, optional)

Advance Preparation:

1. Obtain different fruits and vegetables for identification
2. Copy handouts for each student (see appendix D.7A)

Background: Each part of a plant has characteristic features that students can use for identification. Many plant parts have been modified by natural selection or artificial selection and no longer serve their original purpose, but still resemble the original parts in most ways and can be identified with careful observation.

Stems can be located either above or below ground. They have segments, which consist of nodes and internodes. Lateral buds are located at the nodes and can give rise to lateral branches or leaves. The main purpose of stems is to connect leaves and roots and to support the above ground part of the plant so leaves can capture sunlight. Some underground stems, such as white potatoes, have been modified for storage and can be quite fat and fleshy. The presence of branches or leaves emerging from nodes (eyes) indicates that the structure is a stem. The internodes in some root vegetables can be very compressed leading to extremely short stems, but small leaves can sometimes be seen protruding. In onions and garlic the stem is reduced into a flat plate below the bulb, which connects the leaves, which form the bulb to the stringy roots below.

Leaves can be located either above or below ground. If they are above ground, their primary purpose is photosynthesis and they will be green. Developing leaves emerge from the stem at lateral buds that occur at the nodes. Most of the leaves we eat as vegetables come from dicot plants that have a wide flat portion called a blade and a stalk-like part called the petiole. In monocot plants such as onions, garlic and scallions, some leaves located underground are modified for storage and may be fleshy, while others aboveground are green and slender. A conspicuous feature in all leaves is the presence of veins.

Roots are primarily located below ground. Their two main functions for plants are anchorage and absorption of water and nutrients, but many root vegetables are important storage organs. Sugars manufactured above ground through photosynthesis are stored in large taproots such as sugar beets, carrots and sweet potatoes. Do not confuse yams, which are underground stems similar to white potatoes, with the sweet potatoes they resemble, Large taproots can have lateral roots and root hairs, but they do not have nodes and internodes like stems.

Flowers and flower buds are located above ground. They are the reproductive structures of the plant designed to attract pollinators. They are often, but not always attached to the terminal ends of branches. In broccoli and cauliflower small round buds are clustered tightly together. If these buds are opened, the small pistils and stamens of flowers can be seen with a hand lens. An artichoke is the bud of a larger flower and the pistils and stamens can be found in the central choke portion.

Fruits are located above ground. They are reproductive structures of the plant designed for seed dispersal. A common way for plants to disperse their seeds is to attract animal dispersers by making their fruit sweet and colorful. The animals will then eat the fruit and disperse the seeds later in their feces. The same qualities that attract animal dispersers also make fruit attractive and tasty to humans. Botanically, a fruit is defined by the presence of seeds. If a plant part has seeds it is a fruit.

Name	**Plant Part**	**Evidence students could cite**
Artichokes	<u>Flower</u>: The artichoke we eat is a flower. The interior choke portion is where you will find the multiple anthers and pistils.	Flower parts, the shape looks like a bud or flower

Name	Plant Part	Evidence students could cite
Broccoli	Flowers: Supported by branched stems; the head of broccoli is composed of unopened flower buds.	Green, looks like a stem, has leaves on stem, tips of stem have buds
Cauliflower	Flower: Supported by branched stems; the head of cauliflower is composed of unopened buds.	Looks like a stem, has leaves on stem, tips of stem have buds
Apple	Fruit: The apple is a swollen ovary and another modified organ called the receptacle. Some flower parts may be found at the base of the fruit.	Seeds inside, remnant flower parts, sweet flesh
Banana	Fruit: A fruit with small-unfertilized seeds inside.	Small unfertilized seeds inside, sweet flesh
Citrus	Fruit	Seeds, sweet flesh, juicy
Corn	Fruit: Each kernel is an individual seed. The tassels are pistils. Each tassel connects to a single kernel. The seeds are attached to a stem, which we call the cob.	Seeds inside, sweet flesh
Peas/Beans	Fruit: The pod is the entire fruit and individual peas and beans are seeds.	Seeds, flower parts (sepals)
Prickly Pear	Fruit: The fruit of the prickly pear cactus, which is enclosed in a portion of the stem.	Seeds inside, sweet flesh
Tomato	Fruit	Seeds, brightly colored, sweet and juicy, flower parts (sepals)
Strawberry	Fruits: With seeds on the outside	Seeds, brightly colored, sweet and juicy
Brussels Sprout	Leaf: Each individual sprout is composed of tightly folded leaves centered around a short stem, which forms a side branch on the plant.	Leaves coming from stem
Celery	Leaf: A celery stalk is technically a petiole, not a stem. The petiole connects the stem to the leaves. The stem of the celery is the solid core that connects the petioles to the roots	Green, leaves, no branches coming off the stalk as might be expected from a stem; stalks come out from the stem

Name	Plant Part	Evidence students could cite
Garlic	Leaf: Each garlic clove is a group of modified leaves centered on a short stem base.	Has stem inside swollen leaves, roots coming down from base, leaf veins
Lettuce	Leaf	Leaves coming out from stem
Onion	Leaf: Onions are a group of modified leaves centered on a short stem base.	Has stem inside swollen leaves, roots coming down from base, leaf veins
Spinach	Leaf	Green and shaped like a leaf
Carrot	Root: An underground storage organ. Sometimes has lateral roots extending from the main root.	Root hairs, leaves grow up out of the top
Parsnip	Root: Parsnip is a root much like a carrot.	Root hairs, leaves grow up out of the top
Radish	Root:	Root hairs, leaves grow up out of the top
Sweet Potato	Root	Root hairs, not green
Asparagus	Stem	Lateral buds, green.
Cinnamon	Stem: The bark of a tree.	Brown, hard
Ginger	Stem: A modified stem that functions as an underground storage organ.	No root hairs→stem White and branched→roots
Turnip	Stem: A modified stem that functions as an underground storage organ. The slender taproot on the bottom is a true root.	Leaves come out in rings from stem→stem; Roots hairs, not green→root
White Potato	Stem: A modified stem that functions as an underground storage organ. Each "eye" can sprout into a stem.	Stems come out of multiple “eyes”; roots only come out of one place on potato
Yam	Stem: A modified stem that functions as an underground storage organ.	Stems come out of multiple “eyes”; these may not be as obvious as in the white potato.

Procedure:

1. Distribute handout to each student. Have each student read and fill out the handout. Discuss with the students the different parts of the plants and their functions: specifically roots, stems, branches, lateral buds, leaves flowers, fruits and seeds.
2. Give some examples of plant parts that we eat from the background chart to prepare the students for the observation they will conduct.

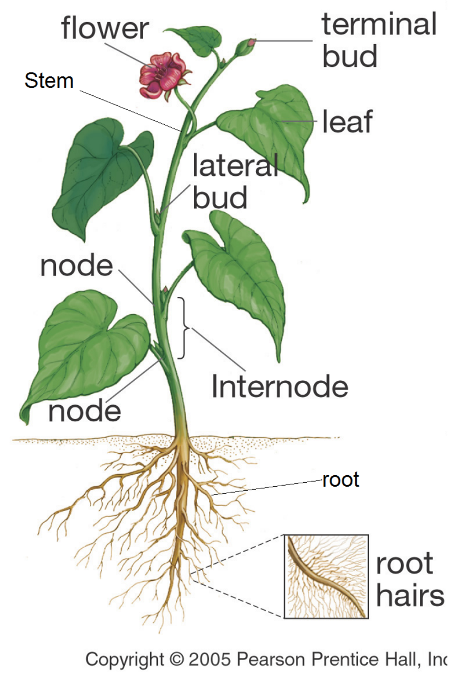
3. Divide students into groups of four or five.
4. Each student group should identify the part of the plant for around 5 fruits/vegetables. This small number will allow ample time for students to closely observe each specimen and debate within their group what type of plant part it is and what evidence they used to make their decision.
5. Within their groups, students should be guided to use evidence and scientific argument (debate) to identify each plant part.
6. To collect the best evidence, explain that they need to cut open each plant part (e.g. cutting open a green pepper allows students to observe the seeds, cutting a celery bunch in half allows students to observe that all the stalks are growing out of a single short branch). If supplies allow, it can sometimes be useful to cut the specimen in several ways, e.g. cross sectional and longitudinally. If you do not want to provide a cutting instrument, you can precut each specimen.
7. After each group has finished you may choose to have each student group report their findings to the class.
8. If you have chosen to include replicate sets you may also choose to have students from groups that identified the same types confer with one another before presenting to the class.
9. To finish the activity, have students participate in a class discussion summarizing what they have learned about plant parts from the activity.

Appendix C.7A Plant Parts for Food Handout

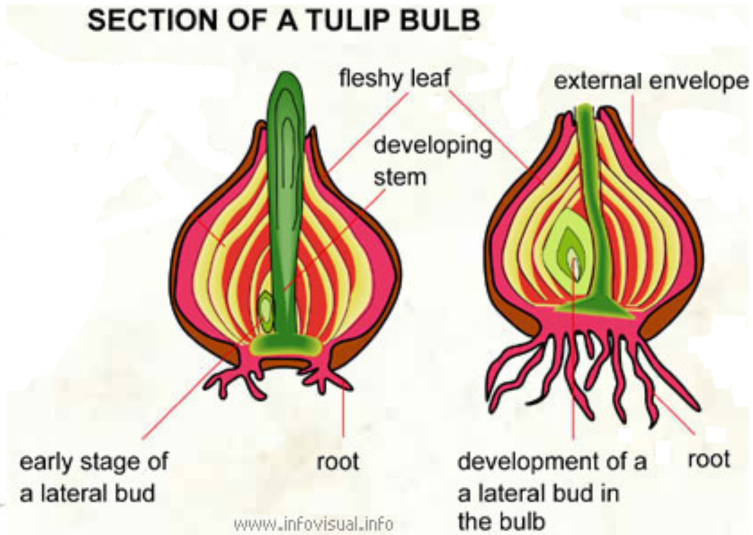
What parts of a plant do we eat?

All flowering plants have the same general body plan: roots, stems, branches, leaves, flowers, and fruits. Complete the table below by describing the function for each plant part.

Plant Part	Function
Leaves	
Stems and Branches	
Flowers	
Fruits	
Roots	



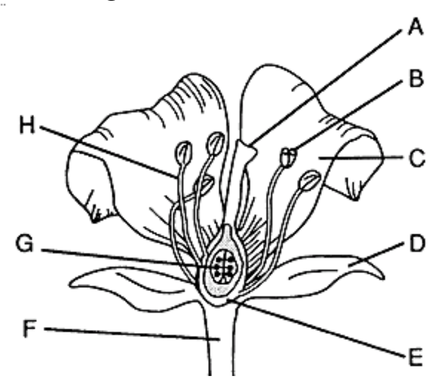
Over the last 140-180 million years of angiosperm evolution natural selection has resulted in many different variations on this basic form a**nd not all of the parts are where you might expect them to be.** For example, much of a tulip's belowground energy storage is not in roots like most plants but in an underground stem surrounded by fleshy leaves, a bulb. (See image on next page).



Humans began domesticating plants over 12,000 years ago. During domestication, plants (and animals) undergo evolution by selection as farmers choose which individuals in the population will reproduce. When this human preference is the environment that exerts a selective force on a population, we call the selection artificial selection. By only allowing plants with traits we enjoy, like larger and sweeter fruits, to reproduce, humans, like nature, have caused many changes in plant form.

Your goal is to identify which part (root, stem, leaf, flower, or fruit) of a domesticated plant we eat. Before you start it will be helpful to review the structure of flowers and the meaning of the word "fruit."

Label the parts of a flower in the diagram shown below.



Which part of the flower becomes a fruit?

How can you tell if a plant organ is a fruit?

Sometimes, a plant organ that is biologically a fruit is called a “vegetable” in everyday English. This is because these fruits have lower amounts of the sugar fructose and are used in savory rather than sweet cooking.

Can you think of two fruits that are called vegetables?

Your teacher will supply several foods and vegetables for you to examine. In the table below, record which part of the plant each of these is, what evidence you used to make that conclusion, and whether it is a fruit or a vegetable in everyday English. It will be helpful to refer to the figures and table on pages 1 and 2 and ask yourself, “How can I tell if this plant part is a root/stem/leaf etc.?” If you have conflicting evidence, what else would you need to know to make your decision?

Name	Plant Part	Evidence/Further information	Is this called a fruit or vegetable in everyday English?

Appendix C.8 Seeds and Greenhouse Propagation

Grade Level: Experimental design appropriate for high school students

Overview: Greenhouse plant propagation can be an important step in producing crops, especially annual vegetables and flowers. Greenhouses are often used for starting seeds and raising young plants that are then transplanted. Greenhouses enable crops to be raised in an efficient way by controlling large numbers of plants needing intensive care in a small area. Additionally greenhouses allow for controlling environmental aspects such as temperature, moisture, and light. Thus they can help to extend growing seasons.

Goal: To introduce students to ecologically based transplant propagation. The health and productivity of young vegetables can be improved by optimizing the ecological conditions in the greenhouse to favor the crop. Students will learn how to prepare mixes and sow seeds into flats or other containers. They will also learn the basic maintenance of a controlled climatic environment. Students will identify the various stages of transplant development.

Objective:

1. Students will prepare a soil mix from bulk raw materials.
2. Students will plant seeds.
3. Students will understand how greenhouses function ecologically.
4. Students will identify the various needs of seeds and young vegetable plants.
5. Students will understand the importance of managing biological and climatic conditions for seedling growth.

Time: 40-45 minutes for activity, several weeks for observations

Materials:

1. A greenhouse, hoop house, cold frame, or propagation trays with domes
2. Seeds of vegetables
3. Seed flat propagation trays
4. Labels and markers
5. Possible seed sowing mix ingredients:
    - Vermiculite, Perlite or Rice Hulls for drainage
    - Coco peat, peat moss, or top soil
    - Compost
    - Worm castings
    - Bone meal (P)
    - Blood or cottonseed meal (N)
    - Greensand (K)
    - Gypsum or Limestone (Ca)

- Or other premixed ecological nutrients (see resource references)

6. Possible liquid fertilizer
    - Compost tea (see resource references)
7. Containers to combine ingredients for seed sowing mix
8. Gloves
9. Watering cans

Advance Preparation:

1. If a freestanding greenhouse is not available, construct a hoop house or cold frame (see resource references) or obtain domes for the propagation trays.
2. Obtain seeds. These can be purchased at garden centers, online or donated from seed companies.
3. Obtain seed mix ingredients. These can be purchased from garden centers, online or donated from bulk distributors.
4. Decide on the seed mix that you would like to use and make a completed seed mix to show the students.
5. Obtain propagation flats. These can be purchased or donated, if donated be sure to wash and sterilize.
6. Sprout some seeds several weeks in advance to show students mature transplants.
7. Gather images of the stages of seed growth from sprouts to mature transplants.

Background: The seed, or matured ovule is made up of three parts. The embryo is a miniature plant in an arrested state of development. Most seeds contain a built-in food supply called the endosperm (orchid are an exception). The endosperm can be made up of proteins, carbohydrates or fats. The third part a hard outer covering called a seed coat. It protects the seed from disease and insects, and prevents water from entering the seed, which would initiate the germination process before the proper time.

Germination is the resumption of active embryo growth. Prior to any visual signs of growth the seed must absorb water through the seed coat and micropyle. In addition, the seed must be in the proper environmental conditions; that is, exposed to oxygen, favorable temperatures, and for some correct light. The radicle is the first part of the seedling to emerge from the seed. It will develop into the primary root from which root hairs and lateral roots will develop. The portion of the seedling between the radicle and the first leaflike, (plumule), are attached to a structure called the hypocotyl which becomes the stem. The seed leaves and cotyledons encase the embryo and are usually different in shape from the leaves that the mature plant will produce. Plants producing one cotyledon fall into the group of monocotyledons or monocots. Plants producing two seed leaves are called dicotyledons or dicots.

The goal of seed mix is to supply nutrients, provide drainage, facilitate moisture retention, provide aeration, and discourage pathogens through safe renewable ingredients that are biologically active. Some seed mixes contain 40% peat moss or coco peat, 40% vermiculite, perlite or rice hulls, 20% compost or worm compost. The peat products provide water-holding capacity with porosity. The vermiculite, perlite or rice hulls provide drainage and aerations. The composts provide organic matter, nutrients and live microorganisms.

Greenhouses are highly efficient management system for seedling growth. They may have hundreds of thousands of plants in one concentrated area. Greenhouses conserve the farmer's time and energy. They also conserve water, nutrients, and pest control efforts because the plants are concentrated in a small readily accessible area instead of spread out on a farmer's land. The transplants will eventually cover the land once they are strong enough to grow with out such intensive assistance. Greenhouses also allow farmers to control the temperature inside and thus they can start crops earlier than they would be able to start them outside on their land. Starting plants in a greenhouse also shortens the time needed for a plant to be growing in the filed before it produces a harvestable crop. The warm, moist environment in a greenhouse also allows for the beneficial organisms to thrive and for the soil mix to provide nutrients to the transplants for optimal growth.

Procedure:

1. Show the students what the prepared soil seed mix looks like and what it contains. Explain each ingredients function and importance.
2. Briefly demonstrate how to combine the ingredients to make a soil mix, showing them in the chosen proportions of each. Have a clear written recipe for them to see. Ask students to help add water while you demonstrate wetting and mixing the bulk ingredients.
3. Return to the premade seed sowing mix and demonstrate how to fill the tray with mix in preparation for sowing. Be sure to adequately fill and settle the soil mix within the tray.
4. Ask two students to be responsible for the soil mixing process and instruct the other students to start filling the trays. Once the two students complete mixing, have all the students finish filling the trays with the newly made soil mix.
5. Once all the students have shared trays designate and hand out labels, markers and seeds to each student. Ask students to make up labels for their tray before they start sowing. Instruct them to include the variety, species name, date and any other important information. Explain the importance of each piece of information.
6. Ask students what seeds are. Where do seeds originate? Are they alive? What do they need to grow? Explain that seeds are tiny embryos that develop after a flower is pollinated. We find seeds in fruits. Ask students to give examples of fruits and even vegetables that they have found seeds in (e.g. tomatoes, cucumbers, peppers, apples, oranges, melons). Ask them to give examples of foods that they eat that

are seeds in themselves (e.g. rice, beans, peas, sunflower seeds, corn). Explain that seeds are living organisms that are dormant and waiting for the right conditions to germinate or sprout. Ask the students what conditions are necessary for germination.

7. Then demonstrate for the students how to sow the seed.
8. Tell the students how many seeds to place in each cell. Explain that different crops and seed sources can have different germination rates and prices and such factors need to be considered in deciding how many seeds to sow in each cell.
9. Ask the students to start sowing and assist students as needed.
10. After everyone has finished sowing their seeds, ask students to place trays in the selected area. Demonstrate how to irrigate the trays, showing the students how to be sure the trays are well soaked during the first watering. Also show the students how to water in the future by demonstrating on some more mature seedling trays.
11. Demonstrate to students how the temperature and airflow are regulated in the greenhouse or dome for climate and disease control.
12. Have any examples or signs of pests (insects, rodents, microbial, etc.) and their management methods available.
13. After the students are finished, take them to a mature seedling tray and show them how plants come out of each cell when the root development is strong and the plants are ready for transplanting. Explain that later seedlings may receive fertilizer supplements such as compost tea.
14. Ask the students how long they think it takes different crops to grow to maturity. Ask them how long they think the mature seedlings took to grow from seed. Then ask them how long it takes the seedling to grow to maturity, set fruit and seed and complete the reproductive cycle. Pick a common crop they know (if possible a long season crop) so they can appreciate the time it takes to grow a mature vegetable and appreciate the role that greenhouses play in that process.

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Seeds of Change
www.seedsofchange.com

Territorial Seed Company
www.territorialseed.com

Appendix C.9 Integrated Pest Management & Companion Planting

Grade Level: Appropriate for high school students

Overview: Integrated pest management (IPM) encourages regular monitoring of insect populations to determine when and if treatments are necessary to minimize unacceptable levels of damage. It employs the use of physical barriers, companion planting, and cultural techniques, in addition to least toxic controls to maintain a proper balance between pest and predator insect. This management technique is takes into consideration the health of the environment as well as the people employing the practice.

Goal: Introduce concepts of IPM and explore why a well-managed IPM system increases ecological balance and reduces environmental and health concerns.

Objective:

1. Students will become familiar with IPM and the terminology used within the practice.
2. Students will understand how IPM compares to other pest control methods.
3. Students will become familiar with companion planting and the strategies employed within the practice.
4. Students will explore how companion planting is an integral part of a well-managed IPM system.

Time: 40 minutes for explanation and discussion, a class period for set-up, several months for observations

Materials:

1. Images of beneficial insects or actual beneficial insects if possible
2. Images of beneficial flora or actual beneficial flora if possible
3. Images of companion planting or actual companion plants if possible

Advance Preparation:

1. Gather images of beneficial insects, flora, and companion planting.
2. Gather beneficial insects, ladybugs can be purchased at local garden centers or on the Internet.
3. Gather beneficial flora that will be planted to attract beneficial insects.
4. Gather companion plants that will be planted for observations.
5. Flora and plants are available at garden centers, from farmers or can be planted from seed earlier in the year.
6. Make an overhead or computer slide of beneficial insects, flora and companion plants.

Background: IPM encourages regular monitoring of insect populations to determine when and if treatments are necessary to minimize unacceptable levels of damage. It employs the use of physical barriers, companion planting, and cultural techniques, in addition to least toxic controls to maintain a proper balance between pest and predator insect. In IPM, total eradication of pest populations is not sought, since it would upset the ecological balance. The individual needs to determine how much pest-related damage can be tolerated (the injury or damage level) without harming the health of plants or people. Following this, the pest population must be studied to assess how rapidly it will increase to produce that level of damage. The final step involves development of a treatment strategy that will keep the pest population small enough so that it doesn't cause an unacceptable level of damage.

As part of a well managed IPM system, strategies employing intercropping and companion planting are utilized to, increase crop diversity. In this system, many different herbs, flowers, and even weedy groundcovers are used to deter pest insects and attract beneficial predators. Insects locate their preferred food by means of sight, smell, and taste. They use sensitive receptors on their feet and mouthparts that allow them to find a certain crop from a great distance (e.g., the white cabbage butterfly can recognize the mustard oils of the broccoli family from a distance of ten miles).

Plants produce substances that either attract or repel insects. These include:

- Attractants: Some examples include mustard oils of the brassica family, that attract cabbage butterflies, apple skins that attract codling mots, onions that produce sulfur and attract the onion maggot.
- Stimulants: These substances encourage feeding and/or egg laying behavior. Bitter chemicals in cucumber and melon skins stimulate feeding by the cucumber beetle.
- Deterrents: These substances inhibit feeding or egg laying. Mustard oils sicken spider mites and Mexican bean beetles.
- Repellants: These substances force insects to move away from a plant. Juglone from the roots of the black walnut tree keep elm bark beetles away. Citronella and catnip sprays repel many insects.

Beneficial insects to attract include:

Ground beetles and lady beetles:

- Attracted by clovers, tansy and yarrow for egg-laying material; eat aphids, slugs and many soft-bodied pests.

Hover or syrphid flies (also known as flower flies):

- Flat, open flowers such as marigolds or daisies provide areas for egg laying. Their larvae parasitize aphids.

Tachinid flies:

- White clover and members of the carrot family (carrots, parsley, lovage, queen Anne's lace, cilantro) provide sites for egg laying. Adults are parasites of Mexican bean beetles and gypsy moths.

Lacewings:

- Increase in numbers when provided with nearby evergreens for shelter. Adults and l larvae are fierce predators of soft-bodied pests.

Flowers providing nectar and pollen for adult beneficials include:

The whole compositae family is attractive to most beneficial insects and includes such things as:

- Daisies, goldenrods, Black-eyed Susans, coreopsis, asters, bachelor buttons, and lettuces that have bolted and are blooming.

Other flowers and/or herbs that attract beneficial insects include:

- Bee balm (monarda), yarrow, the carrot family, mints, hyssop, and salvia.

Legumes such as peas or beans are used as companions to increase nitrogen levels in the soil. White clover can be used in between cornrows, as well as peanuts. Vetch can be used as nitrogen providing mulch around fruit trees.

Specific companions that make good neighbors:

Beans:	Plant rosemary, marigolds and nasturtiums to repel Mexican bean beetles.
Tomatoes:	Good planted with basil (a possible fly repellant) and asparagus.
Brassicas:	Try with dill, mint, sage, onions, and southernwood to repel cabbage butterflies.
Chamomile:	Good hosts for hover flies and wasps.
Cucumbers:	Plant with marigolds and onions.
Garlic sprays:	Combine with hot peppers and onions (blenderized) for aphid control.
Carrots:	Plant with peas, leeks, and onions.
Catnip sprays:	Try this for control of aphids and flea beetles.
Peas:	Plant with shade lovers such as spinach and lettuce.

Aversion techniques:

Copper strips:	To repel slugs. Also try fermented yeast traps to attract and drown them. Non-alcoholic "Kingsbury Malt beverage" was the brew of choice (or non-choice) that provided good slug control. Pull mulch away from transplants if weather is rainy and slugs are congregating there.

Procedure:

1. Using a blackboard, dry erase board or paper taped to the wall, create space for three lists with the following titles: PEST, PESTICIDE, and IPM.
2. Ask the class, what are examples of pest? Write responses under the heading PESTS and guide brainstorming as necessary. What makes these critters pests? Are they always pests, or only in certain places, or at certain times? What role might these species play in a natural ecosystem when they are not pests?
3. Ask the class, looking at our list, what words do you think would be important to have in a definition of “pest”? Write responses on the list, and guide brainstorming as necessary. If important concepts are still missing, ask leading questions until you have the makings of your definition, then synthesize to a complete sentence or statement, which you write at the bottom of the list.
4. Repeat this process to define the term PESTICIDE.
5. Give students a hypothetical pest problem. For example, tell a short story about a house where there is a roach problem in the kitchen and living room. The family who lives there has two small children and a dog. Ask the students, what are some ways the family might try to solve their cockroach problem? What might they do to prevent them from coming back? What economic, health and environmental risks should they consider? You can list responses on the board or paper. You may ask them to brainstorm in small groups and then report back. If certain concepts are not well represented, you might ask leading questions, or add other things to the list. This hypothetical pest problem can also be applied to garden and food production at the school.
6. Talk with the students about pesticides and environmental health. How can pesticides and other environmental contaminant get into out bodies, or the bodies of animals (pets or wildlife)? What do they do when they’re in there? This may be a good transition to talk about other aspects of human exposure to pesticides, such as cholinesterase inhibition and the symptoms associated with it.
7. Look back a the list of pest control options generated earlier, ask the students which of these options have the lowest risk for human, animal, or environmental exposure to pesticides? List low-risk options under the IPM heading. Again, ask leading questions or give hypothetical situations if certain themes are not making it on to the list.
8. What are some common factors among the low-risk options that have been selected, that you think might be are part of a definition of IPM? List responses, then synthesize into a definition sentence or statement.
9. Transition into a discussion of IPM and how it can be helpful in agriculture and gardening practices. Explain the concept of companion planting and intercropping and how increasing diversity can help to repel pests. Show overhead or computer slide of beneficial insects, make sure to include images and if possible share with the class the actual insects that have been gathered or go to a garden or farm to

view.

10. Repeat this process for beneficial flora and companion plants.
11. If possible wrap up this lesson by planting companions into existing garden beds or pots to be used for observation over the next few months.

Appendix C.10 Appropriate Technology

Grade Level: Adaptable design for high school students

Overview: Appropriate technology is technology that is created to be suitable for the intended use. Most appropriate technologies are sustainable, requiring fewer natural resources, and find their beginnings in the hands of their users. Generally appropriate technology should e simple to use, easy to maintain and cost effective.

Goal: Introduce concepts of appropriate technology and explore applications of appropriate technology in different fields.

Objective:

1. Students will understand the concept of appropriate technology and the context of appropriate technology.
2. Students will be able to give examples of applications of appropriate technology in different fields.
3. Students will conduct an inquiry on an appropriate technology project and present their findings to the class.

Time: 40 minutes for explanation and discussion, several weeks for student inquiry, several class periods for student presentations

Materials:

1. Images of appropriate technology
2. Appropriate technology brainstorming handout

Advance Preparation:

1. Gather images of appropriate technology projects and create overheads, a power point or a poster with printed images
2. Copy one appropriate technology handout for each student

Background: Appropriate technology can be described as the simplest level of technology that can effectively achieve the intended purpose at a given location. Below are some examples of appropriate technology:

BUILDING CONSTRUCTION

Building methods regarded as appropriate technology:

- Adobe or super adobe baked bricks composed of sand, clay and straw
- Rammed earth
- Compressed earth blocks
- Dutch brick, composed of concrete, sand and soil

- Cob, similar to adobe
- Earthship, passive solar house made of recycled materials
- Other environmentally responsible materials or locally available materials

It is important to take into consideration the local environment, for example mudbrick may not be durable in a high rainfall area.

ENERGY AND LIGHTING
Appropriate technology may range from low to high cost renewable and alternative energy sources. Some of these include:

- Solar panels
- Wind power
- Hydro power
- Human powered generators
- Biodiesel
- Vegetable oil fuel
- Anaerobic digestion power plants
- LED lights
- Compact florescent lamps

WATER SUPPLY AND TREATMENT
Some household or community level examples include:

- Pourus-ceramic filtration
- Slow sand filtration
- Reverse osmosis
- Irradiation with ultraviolet light
- Deep and shallow wells
- Rainwater harvesting
- Fog collection
- Hand pumps

TRANSPORATION
Human powered-vehicles, such as bicycles and bicycle rickshaws and well as animal powered-vehicles.

SANITATION
Greywater treatments and composting toilets are good examples of appropriate technology.

FOOD PRODUCTION AND PREPARTATION

- Permaculture
- Urban Gardening
- No-Till Farming

- Animal Pulled Plows
- Greenhouses
- Solar cookers
- Wood Stoves

Procedure:

1. Discuss the concept of appropriate technology with the class. Write each main heading from the background on the board or piece of paper and ask students to give examples of what they think appropriate technology is for each category.
2. Show images of appropriate technology.
3. Give students examples to help them brainstorm projects on the attached handout.
4. Have students research an appropriate technology project or an organization that is implementing an appropriate technology project.
5. Present findings in one page essay and short presentation to class with visuals.

Resources:

Appropedia-the sustainable wiki, www.appropedia.org

Akvopedia-the open water and sanitation resource, www.akvo.org

National Center for Appropriate Technology, www.ncat.org

The Appropriate Technology Collective, www.apptechdesign.org

Appropriate Technology Handout

Wordie created this image of words that describe appropriate technology. Below this image brainstorm a list of projects that you think are appropriate technologies.

Appendix C.11 Nutrition, Harvesting & Tasting

Grade Level: Adaptable design appropriate for high school students

Overview: Many of us know that we should eat 5-9 fruits and vegetables a day, but we do not know the nutritional benefits provided by, for example, tomatoes, as compared to collard greens. Through this lesson, students will see that color of a fruit or vegetable is associated with specific phytochemical that are essential to a balanced and nutritious diet.

Goal: To introduce students to a diversity of fruits and vegetables that are grown and harvested for market and provide an opportunity to harvest produce that is in season. Students will also learn the nutritional values of eating fresh produce.

Objective:
1. Students will about venues that produce food for market.
2. Learn how to harvest for a particular market.
3. Identify plant parts.
4. Learn what nutrients are present in different colored vegetables and fruits and what they do for human health.
5. Compare the taste of store bought and freshly harvested vegetables.

Time: 40-45 minutes

Materials:
1. Fresh vegetables or fruits growing in a farm, garden or containers
2. Boxes or baskets for harvesting (one for each group)
3. A place for washing vegetables
4. Digging tools, harvesting knives and gloves
5. Copies of 5 A DAY the Color Way Handout and Harvest Worksheet for each student (see Appendix D.11A)
6. One type of vegetable that will be harvested purchased from the grocery store for a taste comparison

Advance Preparation:
1. Gather supplies for harvesting
2. Copy 5 A DAY the Color Way Handouts and Harvest Worksheet
3. Obtain one type of vegetable from a grocery store for taste comparison

Background: Each crop has key nutritional benefits. The 5 A DAY the Color Way handout outlines these benefits. Different phytochemical have different roles in the plant. Phyto comes from the Greek work for plant, so phytochemical are found in plants. Some contribute to color, other to flavor or aroma. For example blueberries contain different phytochemicals than green spinach, and oranges smell differently than onions.

Phytochemicals typically are associated with the blue and purple vegetables and fruits and include anthocyanins and phenolics, whose antioxidant and anti-aging effects are being researched. These foods may help with maintaining urinary tract health, memory function and healthier aging.

Many orange and yellow fruits and vegetables contain Vitamin C and other oxidants, as well as two classes of phytochemicals called carotenoids and bioflavonoids. These foods can help promote good vision, a healthy heart and a healthy immune system.

Phytochemicals typically associated with green vegetables include lutein and indoles, which are being studied because of their potential antioxidant, health-promoting benefits. These foods may help build strong bones and teeth and maintain healthy eyesight.

Lycopene and anthocyanin's are among the phytochemicals that may be found in red fruits and vegetables and are being studies as health promoting compounds. Red fruits and vegetables may help contribute to better memory function, a healthy heart and a healthy urinary tract.

Phytochemicals typically associated with white, tan and brown fruits and vegetables may help maintain heart health as well as healthy levels of cholesterol. Allicin is a phytochemical common in onions, garlic, and their relatives.

Procedure:

1. Assemble the students and ask them how they get their fruits and vegetables. Where do their families buy them? Do any of them have a garden? Do any of their family members have a garden that provides them with food?
2. Explain that today they will be harvesting. Show them how to harvest more than one vegetable or fruit. Include as diverse a group of crops as the season and location may allow. If possible harvest crops in each phytonutrient (color) group.
3. Show students a mature crop and an immature crop. If possible show the crops in different growth stages. Contrast the differences.
4. Break the students into groups of 4-6. For each crop, pass out any needed harvesting equipment to the appropriate group and demonstrate how the tools should be used for harvesting. Then instruct the group to harvest some of the crop. Supervise the work of various groups as they harvest the crops. If you are on a farm this should be done with the farmers' harvesting schedule if possible.
5. Once the students are finished briefly demonstrate the steps of cleaning the crops, grading, and sorting. Explain how this processes is important to farmers that produce crops for market or CSA shares. Let the students participate in these steps and supervise them.
6. Ask the group what they learned from seeing the crops harvested. Were they surprised by how the plant grew or by what part of the plant is used for food? Was it difficult? Fun?

7. Gather all the crops harvested and divide evenly between the groups. Have the students write the names of the crops in the first column of the Nutrition Worksheet. Use the 5 A DAY the Color Way handout to fill in the worksheet and identify the important nutrients present in the vegetables and fruits.
8. Explain that the phytochemicals are natural plant compounds that not only protect plants, but also may provide important disease protection to humans. These nutrients are not commonly found in processed food or pills.
9. Also explain the importance of eating fresh, locally grown, and in season crops if possible. Many communities have local produce availability charts (see resources references).
10. End this activity by tasting the crops harvest. Also have students do a taste test comparison. Have them taste of a store bought vegetable and contrast the taste with the vegetable that was harvest during class.

Resource References:

Humboldt Local Produce Availability Chart
http://caff.org/wp-content/uploads/2010/07/Produce_Availibility.pdf

5 A DAY the Color Way
http://www.fruitsandveggiesmorematters.org/

Appendix C.11A Nutrition Handout 5 A DAY the Color Way & Harvest Worksheet

5 A DAY the Color Way

Colorful fruits and vegetables offer the wide range of vitamins, minerals, fiber, and phytochemicals that your body needs.

COLOR	VEGETABLE	FRUIT	BENEFITS
BLUE/ PURPLE	Purple Asparagus, Purple Cabbage, Purple Carrots, Eggplant, Purple Belgian Endive, Purple Peppers	Blackberries, Blueberries, Black Currants, Dried Plums, Purple Figs, Purple Grapes, Plums, Raisins	A lower risk of some cancers, * urinary tract health, memory functioning, healthy aging
GREEN	Artichokes, Broccoli, Chinese Cabbage, Green Beans, Leeks, Green Onions, Okra, Peas, Green Pepper, Watercress, Zucchini	Avocados, Green Apples, Green Grapes, Honeydew, Kiwifruit, Limes, Green Pears	Vision health, a lower risk of some cancers, strong bones and teeth
WHITE	Cauliflower, Garlic, Ginger, Jerusalem Artichokes, Mushrooms, Onions, Parsnips, Potatoes (white fleshed), Shallots, Turnips, White Corn	Bananas, Dates, White Nectarines, White Peaches, Brown Pears	Heart health, * maintenance of cholesterol levels that are already healthy, a lower risk of some cancers*
YELLOW/ ORANGE	Yellow Beets, Butternut Squash, Carrots, Corn, Yellow Peppers, Yellow Potatoes, Yellow Tomatoes, Pumpkin, Rutabagas	Yellow Apples, Apricots, Lemons, Antelope, Yellow Figs, Grapefruit, Mangoes, Nectarines, Organs, Papayas, Peaches, Persimmons, Pineapples, Yellow Watermelon	A lower risk of some cancers, * a healthy heart, * vision health, a healthy immune system
RED	Beets, Red Peppers, Radishes, Radicchio, Red Onions, Red Potatoes, Rhubarb, Tomatoes	Red Apples, Cherries, Cranberries, Red Grapes, Pink/Red Grapefruit, Red Pears, Pomegranates, Raspberries, Strawberries, Watermelon	A healthy heart, * memory function, a lower risk of some cancers, * urinary tract health

*Low-fat diets rich in fruits and vegetables and low in saturated fat and cholesterol may reduce the risk of heart disease and cancers

Harvest Worksheet

Name:
Date:
Location:

CROP'S NAME	PLANT PART	PHYTONUTRIENTS	HOW IT HELPS THE BODY	YOUR FAVORITE WAYS TO COOK IT

Appendix C.12 Hunger 101 Game

Grade Level: Interactive design appropriate for high school students

Overview: This interactive role-play experience simulates the challenges faced by low-income individuals and families trying to obtain an adequate daily allowance of nutritious foods. This activity aims to increase awareness of food security issues. It will illuminate the challenges many people face trying to access enough food. Some participants will try to purchase food, while others will be vendors or agencies providing food or services

Goal: To explain the relationship between poverty and hunger. Students will also identify the major barriers to food security and to increase awareness about hunger, poverty and food insecurity.

Objective:

1. For the students who are the "players" to navigate through the community to obtain sufficient food (3 meals totaling 2000 nutritious calories) for one day, using the resources available.
2. For the students who are the "community members", simulate the community environment for the "players" using the role descriptions provided.

Time: 50 minutes to 1 hour

Materials:

1. Hunger 101 Game, complete detailed instructions and all necessary materials are included.

Advance Preparation:

1. Print Hunger 101 Game provided by the Atlanta Community Food Bank at http://www.acfb.org/education/hunger101/curricula/
2. Read and assemble all parts of the Hunger 101 Game
3. Set up the classroom in advance for Hunger 101 Game
4. This lesson should be taught along side lessons defining hunger, food security, and poverty

Background: Fifty-five percent of food-insecure households participated in one or more of the three largest Federal food and nutrition assistance programs (USDA 2008) The programs are the Supplemental Nutrition Assistance Program (SNAP), the new name for the food stamp program, the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) and the National School Lunch Program.

The Food Stamp Program, the nation's most important anti-hunger program, helps roughly 40 million low-income Americans to afford a nutritionally adequate diet. More than 75 percent of all food stamp participants are in families with children; nearly one-third of participants are elderly people or people with disabilities. Unlike most means-tested benefit programs, which are restricted to particular categories of low-income individuals, the Food Stamp Program is broadly available to almost all households with low incomes.

WIC provides nutritious foods, nutrition education, and referrals to health and other social services to low-income pregnant, postpartum and breastfeeding women, and infants and children up to age 5 who are at nutrition risk. WIC participants receive checks or vouchers to purchase nutritious foods each month, including infant cereal, iron-fortified adult cereal, vitamin C-rich fruit or vegetable juice, eggs, milk, cheese, peanut butter, dried and canned beans/peas, and canned fish. Other options such as fruits and vegetables, baby foods, and whole wheat bread were recently added. WIC is a Federal grant program for which Congress authorizes a specific amount of funding each year for program operations.

Perhaps the three principal programs that provide income and other assistance for poor people are the minimum wage, the Earned Income Tax Credit (EITC), and the Temporary Assistance to Needy Families (TANF) program. Other important programs, not discussed here, include Medicaid and the State Children's Health Insurance Program (SCHIP) and, for older people, Social Security and Medicare.

The Earned Income Tax Credit is the mechanism through which, by filing a tax return, low-income people and families can receive an income supplement. The EITC is designed to encourage and reward work. In 2009, the EITC lifted an estimated 6.6 million people out of poverty, including 3.3 million children. The poverty rate among children would have been nearly one-third higher without the EITC. The EITC lifts more children out of poverty than any other single program or category of programs. One way the EITC reduces poverty is by supplementing the earnings of minimum-wage workers. At the minimum wage's current level, such a family can move out of poverty only if it receives the EITC as well as food stamps (CBPP EITC.)

Procedure:

1. First explain that the room is set up to simulate the community for the Hunger 101 Game.
2. Before distributing the packets to the students explain the game and the roles of each participant in the game.
3. Explain that everyone in the simulation should take his or her roles seriously, to be creative, and to embrace the experience. The interaction between participants is a vital component to this activity.

4. Each consumer is given a role description, which states the person's monthly income and expenses. First, consumers will use a budget worksheet to figure out the amount of money they have for food for one day. Then, they will each try to "purchase" a day's worth of healthy meals for themselves from a menu of food choices, which include prices.
5. There are complex rules for navigating the system to try to get "food stamps" or "emergency assistance" to help buy the food. This is intended to simulate the real obstacles faced by poor people attempting to obtain assistance in buying food.
6. After distributing the packets explain that as "players" finish their worksheets they should begin the process of trying to access their meals for the day.
7. "Players" will have access to the Community Kitchen or Mo's Corner Store without needing transportation. To access the other locations, they will need some form of transportation.
8. "Players" may be eligible to receive assistance from the Social Service Agency, i.e. food stamps, WIC or EITC.
9. Reflection questions and a debriefing guide are included for discussion after the game.

Resource References:

Atlanta Community Food Bank. 2012. "Hunger 101 Food Game." http://www.acfb.org/education/hunger101/curricula/

Center on Budget and Policy Priorities (CBPP). 2012. "The Earned Income Tax Credit." http://www.cbpp.org/archiveSite/7-19-05eic.htm

United States Department of Agriculture, Food and Nutrition Service. 2012. "Characteristics of Supplemental Nutrition Assistance Program Households: Fiscal Year 2008--Summary." http://www.fns.usda.gov/ora/menu/Published/snap/SNAPPartHH.htm

United States Department of Agriculture, Food and Nutrition Service. 2012. "WIC: At A Glance" http://www.fns.usda.gov/wic/aboutwic/wicataglance.htm

APPENDIX D

SITE PLANNING RESOURCES

Gardens for Learning: Creating and Sustaining Your School Garden from the California School Garden Network. http://www.csgn.org

Growing, Eating, Living: A Garden Guide for Head Start a getting started guide geared for early childhood educators. http://caheadstart.org/GardenProject.html

Plant a Seed Watch it Grow online guide created by the Master Gardener Association of San Diego County. http://www.mastergardenerssandiego.org/schools/gardenbook/

School Garden Wizard: an extensive guide for proposing and planning the garden to teaching and maintenance, created in partnership the United States Botanic Garden and Chicago Botanic Garden. http://www.schoolgardenwizard.org/wizard/

The Green Schoolyard Network has an extensive list of resources to help you create a green schoolyard. http://greenschoolyardnetwork.org/

Cornell University's School Garden Program
College of Agriculture & Life Sciences
Dept. of Fruit & Vegetable Science
134-A Plan Science Bldg.
Ithaca, NY 14853-5908
Tel: 607-255-0599
http://blogs.cornell.edu/garden/

Evergreen – Canada
355 Adelaide St. West, 5th Floor,
Toronto, ON M5V 1S2
Tel: 416-596-1495
http://www.evergreen.ca