INTRODUCTION:

Plants are essential to life on Earth.� Their autotrophic nature creates the base for food chains, through exposure to sunlight they create food insuring their survival as well as that of the animals on this planet.

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We, as a human race rely quite heavily on the plants that inhabit the land with us for survival.� In turn these land plants, with the exception of ferns and bryophytes, rely quite heavily on seeds for their own survival.� Biologists suspect that plants evolved from a group of green algae called �charophytes�.� They believe that competition forced plants onto land where the plants evolved for their new habitat.� As well as making structural, transportation, and gas exchange adaptations, the plants also had to develop a reproductive system that would not involve water in fertilization or embryo dispersal.� The most advanced of land plants, gymnosperms and angiosperms, solved this problem with dependent gametophytes and the development of seeds (Campbell).

These seeds are convenient little packages containing an immature plant and enough food for its first few days of life.� These seeds are created in great abundance and carried away from the mother plant by animal, wind, water, or expulsion to land in new places.� There is no way of knowing where that place will be, perhaps it will be a gravel driveway, or somebody�s well maintained lawn, or maybe perfectly fertile and well-watered soil.� The plant has no insurance as to where the final destination of its seeds will be, many of the little embryos will never reach maturity, and only the fittest and the luckiest will survive.� Those that are adapted to the environment they land in will germinate and flourish.� It is because of this that many plants have seed adaptations that encourage advantageous placement of their seeds, or allow the seed to wait out harsh conditions and germinate only in an environment that is best suited for that particular plant.

Some plants develop attractive, tasty fruits to hold their seeds and encourage animals to eat the fruit and transport the seeds.� These plants insure proper dispersal by only letting the fruit reach attractive maturity when the seeds inside are also mature.� Other plant create hard fruits that are difficult for animals to open and are often buried to be opened later by the animal, this burial creates optimum growing conditions for the seed.� Plants that grow by water, and rely on an abundance of water for survival may drop their seeds into the water, which will disperse them somewhere along the banks of that body of water, thus putting them in an environment favorable to their survival.�

Yet, for many plants after they reach their destination, conditions are not favorable, perhaps there is a lack of water, nutrients, or light.� In this case some seeds will wait it out until conditions become favorable.� Plant embryos, amazingly enough, can stay viable inside the seed for some period of time; the frozen seeds of an Artic lupine were planted and grew 10,000 years after they were buried by lemmings. (Northen).� This �seed hibernation�, called seed dormancy enables seeds to postpone germination until conditions for survival are favorable.� At this time germination may be triggered by temperature, water, light, or the breakdown of the seed coat.

For example, many seeds must endure a period of cold before they will germinate.� The soil of late summer may be quite moist and warm, encouraging germination, but the following winter would surely kill the young plant.� So plants like the spruce trees have adapted to combat this condition.� A spruce tree seed must be exposed to several months of low temperatures to activate chemical changes in the seed, which then allows the embryo to respond to spring growing conditions and when the seasons change the plant my germinate in a welcoming spring environment.� This phenomenon is referred to as �after-ripening� and is also active in many other plants like apple, lily, rose and dogwood (Northen).

Another interesting answer to seasonal germination is in seeds that are sensitive to the length of the day.� The amount of daylight that occurs during a twenty-four hour period is related to the season.� Plants like the *Begonia evansiana,* *Veronica persica,* and birch germinate in response to the amount of daylight in a day and so regulate germination to the season favorable to their survival. (Northen).

Other plants produce seed coats that are so hard they can only be cracked by the intense heat of fire.� In this way forest fires may split seed coats, which in turn induce germination and the repopulation of an area devastated by fire.� The new growing plants have fertile soil and the advantage of little competition.

Still other seed coats, are broken down by abrasive agents in their environment.� Water cannot pass through the tough seed coat, which is only made penetrable after contact with rough soil particles, frosts, water, and bacteria, fungi.� A simple break in the impenetrability of the seed coat will allow water to enter the seed imbibing it and starting the process of germination.� These tough seed coats stall the germination of the seed, and allow the embryo to sprout in favorable conditions far away from the competition of the parent plant. (Gibbons).

Many desert plants rely on a water-triggered germination for survival. If the short exposure to water that induces germination in other plants, caused desert plants to sprout, they would be doomed.� The light rainfalls that sometimes occur in the desert would not be enough to support the full life cycle of desert plants.� Only a good heavy rain will wash away the water-soluble, chemical inhibitors in a desert plant�s seed coat and allow germination of the seed. (Northen).

For some seeds the wait for germination is not a matter of environmental triggers, but only matter of time.� There are plants with volatile inhibitors that evaporate over time and when they have fully disappeared the embryo is allowed to grow.

The rate of germination for sweet clover is instrumental to its survival.� The little clover plant releases seeds that germinate after different lengths of time in order to insure that should a disaster befall some of the seeds others will be left to carry on survival. (Northens).� Some plants have germination that is staggered by such lengthy time periods as entire seasons. (Gibbons).

These special adaptations by plants in their seeds have allowed these amazing autotrophs to flourish.� Plants are rooted to the ground and cannot carry their young to places where their chance at survival is greater.� Yet every season new plants take root and reach towards the sun.� The little seeds survive incredible environmental conditions to continue the Kingdom Plantae, and so continue life on Earth.� Each little seed is invested with this incredible responsibility and in turn with incredible adaptations.� I decided I would like to explore one of these special adaptations that are so instrumental to life.� I decided to explore the importance of light in seed germination

Henry and Rebecca Northen�s book Ingenious Kingdom says, �Some seeds depend on light... Bluegrass, lettuce, and many bromeliads and begonias must have light to germinate.� They have such tiny seeds that if they germinated at some depth the small shoot would not reach the surface soon enough to start making food for further growth.�� This special adaptation immediately interested me.

I could easily understand how this adaptation would facilitate survival in the species.� That seems to make sense, it is detrimental to the survival of a species for seeds to germinate that will soon die for lack of light.� This would seem an obvious evolutionary change, plants that could hold out until light was available would survive, others, which could not, would die.� The aspect of this adaptation that really interested me was how this impressive trait actually worked.

Light is a very interesting component in the survival of plants.� Not only is it indispensable in the process of photosynthesis, but it also affects many other plant functions.� There is the phenomenon of phototropism, the plant adaptation that causes a plant to bend towards light.� It seems that this response is created through the function of a hormone called auxin.� This is the same hormone that is responsible for geotropism, which causes the root of a plant to grow downwards and the shoot to grow upwards.� In the case of geotropism auxin accumulates on the underside of plant parts to encourage growth in the right direction.� In phototropism this same hormone, auxin accumulates on the shaded region of a plant encouraging growth there; and so, bending the plant towards the light. (Northen).

Photosynthesis is perhaps the most important light reaction in a plant.� Plants contain photosystems in their thylakoid membranes.� When a photon hits a pigment molecule that molecule becomes excited passing energy from molecule to molecule in photosystem II until the energy reaches the reaction center.� At the center the energy fuels an oxidation-reduction, an excited electron is passed to the electron acceptor.� An electron transport chain passes I the electron to photosystem.� This passing down the chain fuels the creation of ATP, an important energy source.� The electron than falls into place in an empty spot in photosystem I.� Excited electrons are then passed from photosystem I to create NADPH, another important energy molecule.� Meanwhile the hole created in photosystem I is filled by the splitting of water molecules and the creation of oxygen molecules.� This entire process creates energy for the plant and is integral to the survival of the plant. (Campbell).

An interesting study was done on the response to light by young plants in relation to their development.� A bean plant will germinate without light but will not uncurl from its starting bent position and open its young leaves.� Yet a brief exposure to light and a return to darkness will cause the sprout to unfurl its young leaves and straighten up.� The response to light is almost magical.

So, how does the presence of light trigger the germination of a seed?� Is it related to the amount of heat that is generated by the presence of light, is that key to inducing germination?� The segment in the Northens� book would seem to refute that theory, as would the nature of evolution; the soil could be warm far down, inducing germination without the guarantee of exposure to light.

Another idea would be that light has a reaction with������ a chemical present in the seed coat causing the seed coat to split and germination to occur.� Seed coats such as the hard waterproof coat of the locust seed are often the barrier to germination.� It seems feasible that an organism whose chemical composition uses light to create its food could also have a seed coat that uses light to trigger germination.

This brings-up another theory involving photosynthesis.� Perhaps the wavelengths of light are able to travel through the seed coat and trigger a photosynthetic reaction within the embryo.� In most plants photosynthesis does not occur until the embryo has sprouted and is somewhat mature.� But perhaps seeds that require light for germination are able to begin photosynthesis immediately and germinate when the presence of light allows for photosynthesis.

I decided to explore this possibility with my project.� Early in the AP Biology class we conducted a lab in which sections of a coleus leaf were covered with different colors of plastic wrap and their photosynthetic activity was monitored.� Different colors of plastic wrap transmitted different ����� wavelengths of light, affecting the rate of photosynthesis.� Thomas Engelmann conducted an experiment on different wavelengths of light and their importance to photosynthesis in 1883.� He exposed different regions of algae to different wavelengths of light. Engelmann then added bacteria that are attracted to oxygen sources to the algae.� He observed where the bacteria were most concentrated, and, by doing so, where the most photosynthesis was occurring.� Engelmann saw that the bacteria were most concentrated around those regions that were exposed to red and blue light (Campbell).

I reasoned that if the rate of photosynthesis differed by color for Coleus and for the algae the same is probably true for the plants I would experiment on.� So if photosynthesis was linked to germination, and the rate of photosynthesis was affected by the wavelengths of light, then the rate of germination would be linked to the wavelengths of light the seeds were exposed to.

I decided to explore this idea with two different seeds.� I selected two seeds that the Northens� book said needed light for germination: Kenblue Kentucky bluegrass, and Grand Rapids, Tipburn Resistant Lettuce.� These plants have several other interesting characteristics.� The bluegrass is a monocot and has a light colored seed coat, while the lettuce is a dicot and has a black seed coat.

The scientific name for Kentucky bluegrass is *Poa pratensis*.� It is a monocot of the order Cyperales, the family Poaceae, and the genus Poa L (USDA).� It is a �sod-forming grass� from Europe.� This grass is used extensively as a lawn grass, is quite often used in pastures in combination with white clover, and is also used for erosion control.� It is grown in all fifty states, and most extensively in those of the middle and northwest. (USDA)�

Bluegrass grows best in well-drained limestone based soils that are of fine or medium texture and does well when planted in spring or late summer.� It favors soils with pH levels close to neutral, and has a low tolerance for salinity.� The grass does best in areas with high moisture and will not survive drought conditions.� Kentucky bluegrass is a perennial grass and interestingly is apomictic, meaning it may reproduce without the formation of gametes and fertilization. (US Varieties)

According to the USDA website Kentucky bluegrass has a long lifespan, growing in the spring, fall, and summer and reaching a mature height of one and a half feet.� And perhaps most relevant to my research project, is the fact that seed production is very high. (USDA)

The particular variety of bluegrass I used, Kenblue, is, �Consistently superior in performance to all named varieties and to seed lots of foreign origin, in tests at Kentucky AES, Lexington. Superiority attributed to resistance to diseases and tolerance to sod webworn.� and is intended for use as pasture and turf.�� (US Varieties)

Grand Rapids Leaf Lettuce is the other plant I used in my research project.� It is a dicot of the order Asterales, the family Asterceae and the genus Lactuca L (USDA). Leaf lettuce is a hardy, cold tolerant plant.� It is called leaf lettuce because it does not grow heads but just a collection of rumpled looking leafs. (botany.com).� Like bluegrass it is grown in all fifty states, but unlike bluegrass it is grown primarily to be eaten, in salads.

Lettuce does well in cold environments, and leaf lettuce is best planted in early spring.� It is recommended that the soil be very fertile and the plants given a lot of space.

The lettuce and bluegrass were both to be exposed to the same conditions and monitored to determine the special trigger involved in their germination.� Or rather to determine if that trigger was related to photosynthesis or if that possibility should be ruled out.�

I placed thirty seeds each in nine trays covered with different colors of plastic wrap.� So, there was a tray filled with thirty Grand Rapids Lettuce seeds and covered with three layers of blue plastic wrap taped to the clear plastic cover, and their was also a blue tray filled with thirty Kenblue Kentucky bluegrass seeds.� The same was done with red, green, and clear plastic wrap, and there was also a tray that was painted, as to prevent any exposure to light.

The plastic wrap that was secured to each tray would regulate the wavelengths of light that the seeds would be exposed to.� Any light that entered each tray of thirty seeds would have to do so through the plastic wrap.� After the trays were set up they were to be checked each day for the number of seeds that had germinated.� The experiment would terminate after twenty-one days, which is the end of the germination period for the bluegrass and well past the seven to ten day germination period for the lettuce.� If the rate of germination in each tray is related to the color of the plastic wrap covering the tray it might be theorized that perhaps the germination trigger is related to photosynthesis.� Yet this is not the only conclusion that can be made.� There is a chance that different wavelengths of light could trigger seed chemicals that are unrelated to photosynthesis or that the different wavelengths create different temperatures for the seeds and affect germination in that way.� Or there is the possibility that the seed coats themselves regulate the wavelengths of light and the colors of the wrap will not be very important.

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HYPOTHESIS:

If the germination of lettuce and bluegrass is linked to a photosynthetic response from the embryo, then the seeds� rate of germination with different wavelengths of light should be similar to the rate of photosynthesis of plants under different wavelengths of light.

MATERIALS:

����������� 9 �Peat Pellet Greenhouse� trays, each with 10 pellets

red, blue, green, clear Reynolds wrap

Kentucky Bluegrass seeds

Grand Rapids, Tipburn Resistant Lettuce Seeds

white and navy paint and brushes

teapot

measuring cup

flashlight

water

sunny, protected area

PROCEDURE:

1)      Cover and tape eight of the clear plastic tray covers with three layers of plastic wrap: two trays with blue wrap, two trays with green wrap, two trays with red wrap, and two trays with clear wrap.� Now take the ninth tray cover and paint the outside with the white paint and the inside with the navy paint.

2)      Label each tray with the color of its top and the type of seeds it contains

3)      Boil water in teapot and then combine it with cold water in a one to one ratio.� Measure out 16 ounces of this warm water for each tray and pour it over the pellets.� The pellets should expand and absorb all the water, let this occur and then set them out to cool.

4)      Press three seeds into each expanded pellet.� Lettuce in the trays marked �lettuce�, and bluegrass in the trays marked �bluegrass�.� The painted tray is the control, �no light� tray and seeds are not expected to grow; therefore five of this tray�s pellets will contain bluegrass seeds and five will contain lettuce.

5)      Cover all trays with tops corresponding to their labels.

6)      Line the trays up in a protected and sunny area.� *I placed mine on top of an elevated surface (estimated 4.5�) and surrounded them with bricks to prevent them from being blown away.�* Leave the seeds to germinate and be monitored, watering occasionally when the pellets go dry.

7)      Check the seeds daily for germination, being careful to minimize exposure to light.� *I checked mine at night with a flashlight.*� Make sure all trays are under the same conditions always being checked and watered uniformly.

OBSERVATIONS:

DAY 1:� Seeds are planted

DAY 2:� No development in any of the trays

DAY 3:� No development in any of the trays

DAY 4:� No development in any of the trays

DAY 5:� 12 lettuce seeds in the �no light� tray have sprouted

DAY 6:� 2 more lettuce seeds in the �no light� tray have sprouted

DAY 7:� All of the �no light� lettuce seeds have sprouted,� The lettuce package specified that the lettuce would take seven to ten days to germinate, this is the beginning of that germination period.

DAY 8:� Additional germination: 4 clear lettuce, 1 blue lettuce, 5 red lettuce, also drained excess water form trays

DAY 9:� Additional germination: 1 green lettuce

DAY 10:� Additional germination: 1 clear lettuce,� The lettuce package specified that the lettuce would take seven to ten days to germinate, this is the end of that germination period.

DAY 11:� Additional germination: 2 �no light� bluegrass

DAY 12:� Additional germination:� 3 �no light� bluegrass

DAY 13:�

DAY 14:� Additional germination: 3 �no light� bluegrass,� also added water to trays.� Additional observation:� Clear lettuce and �no light� plants appear to be doing better after germination than most of the others.� According to the bluegrass package the expected seed germination period begins today.

DAY 15:� Additional germination: 2 �no light� bluegrass

DAY 16:� Additional germination: None

DAY 17:� Additional germination:� 1 �no light� bluegrass

DAY 18:� Additional germination: None

DAY 19:� Additional germination: None

DAY 20:� Additional germination: None

DAY 21:� Additional germination: None

**Temperatures for Trays (degrees Fahrenheit)**

Evening Temperatures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test | Red | Blue | Green | Clear | "No Light" |
| 1 | 64 | 62 | 64 | 62 | 60 |
| 2 | 74 | 68 | 66 | 64 | 70 |
| 3 | 66 | 64 | 66 | 62 | 60 |

Mid-Day Temperatures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test | Red | Blue | Green | Clear | �NoLight� |
| 1 | 104 | 104 | 110 | 120 | 84 |
| 2 | 102 | 108 | 110 | 116 | 86 |
| 3 | 104 | 110 | 112 | 112 | 88 |

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**Grand Rapids, Tipburn Resistant Lettuce**

**�����������������������** (\* �No Light� data is doubled for comparison)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |
|  | **Day** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |  |
|  | Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Red | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Green | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | �No Light�\* | 0 | 0 | 0 | 0 | 24 | 28 | 30 |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Day** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |  |
|  | Clear | 4 | 4 | 5 | 5 | 5 | 5 | 5 |  |
|  | Blue | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |
|  | Red | 5 | 5 | 5 | 5 | 5 | 5 | 5 |  |
|  | Green | 0 | 1 | 1 | 1 | 1 | 1 | 1 |  |
|  | �No Light�\* | 30 | 30 | 30 | 30 | 30 | 30 | 30 |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Day** | **15** | **16** | **17** | **18** | **19** | **20** | **21** |  |
|  | Clear | 5 | 5 | 5 | 5 | 5 | 5 | 5 |  |
|  | Blue | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |
|  | Red | 5 | 5 | 5 | 5 | 5 | 5 | 5 |  |
|  | Green | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |
|  | �No Light�\* | 30 | 30 | 30 | 30 | 30 | 30 | 30 |  |
|  |  |  |  |  |  |  |  |  |  |

Table1

��������������� Figure1

**Kenblue, Kentucky Bluegrass**

(\* �No Light� data is doubled for comparison)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Day** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |  |
|  | Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Red | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Green | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | �No Light�\* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Day** | **8** | **9** | **10** | **11** | **12** | **13** | **14** |  |
|  | Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Red | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Green | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | �No Light�\* | 0 | 0 | 0 | 4 | 10 | 10 | 16 |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **Day** | **15** | **16** | **17** | **18** | **19** | **20** | **21** |  |
|  | Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Red | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | Green | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |
|  | �No Light�\* | 20 | 20 | 22 | 22 | 22 | 22 | 22 |  |
|  |  |  |  |  |  |  |  |  |  |

����������������������������������� Table 2

Figure 2

CONCLUSION:

I terminated my experiment after twenty-one days of growth and observation.� The data for these observations is recorded in tables 1 and 2, and figures 1 and 2.� While the overall germination rate was surprisingly lower than I expected, interesting conclusions can still be drawn from the data I could collect.

Even after the specified germination period for the bluegrass, there was no growth other than that of the �no light� seeds.� So most of this evaluation of data will be done on the lettuce trays. It is however interesting to observe that many of the bluegrass seeds in the painted trays did germinate ahead of their supposed germination period, which was fourteen to twenty-one days.� Some of the bluegrass germinated as early as three days ahead of this time period.

Obviously the biggest surprise of the experiment came form the supposedly �no light� tray.� As you can see from the charts and tables for both the bluegrass and lettuce germination rate for the painted tray was much higher and faster than that of all the other trays.� I would have to assume that light had filtered through the top and onto the seeds.� But why was germination so accelerated in these particular trays?�

Perhaps it was a consequence of the temperature in each tray.� I decided to test this theory by filling the trays with water and placing a thermometer in a tray of each type.� The temperature of the water in each tray should indicate any difference in temperature experienced by the seeds.� The results for the data can be seen in table 3.� The interesting observation that can be made from this data is the consistency of temperature for the �no light� tray.� Perhaps the rapid germination rate of this tray can be attributed to this factor.� The temperatures for the other trays seem to vary by much wider margins. During the evening the clear tray had some of the lowest temperatures, during the afternoon, some of the highest.� A consistent temperature seemed to be best for the seeds; but the clear tray, with the wildly fluctuating temperatures, but more exposure to light, came in a close second.

It is interesting to observe that the lettuce seeds with the highest rate of germination, aside from those in the painted tray, were the seeds in the clear and red trays, as can be seen in figures 1 and table 1. Remember in Engelmann�s experiment, that the algae with the highest rate of photosynthesis was that algae that was exposed to the red and blue light.� It is interesting that the red should experience such rapid rates of germination; the red tray had temperatures close to that of the green tray at night and close to the blue tray at mid-day, which both only had one seed germinate.� The germination rate of the red is almost identical to that of the clear tray, which was receiving all wavelengths of light, but had sufficiently lower temperatures in the evening and higher temperatures at mid-day.� This would suggest that red wavelengths of late have an important impact on seeds, or perhaps that the temperature in the red tray was more consistent, encouraging seed growth.� The lack of germination in the blue-covered seeds would suggest that this impact is not related to photosynthesis.� In Engelmann�s experiment the blue-lit seeds seemed to photosynthesize just as rapidly as the red.� The difference in the germination rate of my red and blue covered seeds, (as seen in figure 1) would suggest that the importance of red wavelengths of light on seeds is significant, but unrelated to photosynthesis.

����������� There are several recommendations I would make to anyone interested in attempting this experiment.� First of all, make trays that actually do not expose the seeds to any light.� I though by painting the tray I had sufficiently blocked out the light, but I apparently did not.� So although the painted tray produced some interesting results for consideration it would also have been nice to have trays that were actually blacked out.� As to how to accomplish this, perhaps aluminum foil or a black, plastic garbage bag could be used.� The trick will be maintaining a temperature in those trays similar to the others.

Another problem I would hope to see solved in future experiments would be finding a way to check the seeds without exposing them to light.� I assumed that the light exposure at planting time would have little affect on the seeds as they had not yet been exposed to water, however it would be nice to see that variable controlled as well.� I attempted to minimize exposure to the light by checking the seeds at night, with a flashlight, whenever possible; but I am not quite satisfied with that approach.� Perhaps a large amount of seeds should be grown and a different batch of them exposed and checked each time.� After seeds had been checked for germination and exposed to the light they would no longer be used.

Other smaller changes would be making the watering of the seeds more uniform.� I assumed that since the trays were closed environments the water would be circulated and I would not have to replenish it often.� However, by pulling off the tops and checking the trays daily I did lose water that dripped off the tops.� Also I would measure and record the temperature of the trays daily, instead of just after the experiment was completed.

While my observations from this experiment do not prove that photosynthesis is involved in the germination of bluegrass and lettuce seeds, they do provide interesting evidence that temperature and wavelengths of light do affect the germination rate of seeds.

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