Weed Seed Control

By Tim Braun

Most of the herbicides that are available do not control weed seeds. Once the weed germinates and produces either roots, shoots, stems, or leaves the weed can be controlled by herbicides and other weed control methods, but in the seed stage the weed is not controlled by the application of a herbicide. The weed should be controlled before it becomes a seed or after the seed has germinated. Preplant herbicides are applied to the soil to kill weeds after they have germinated and post plant herbicides are applied to kill weeds after the weed seed has germinated.

Pre-plant herbicides like Treflan are applied to the soil before planting at rates that are low enough that the herbicide will not harm or kill the crop that is being planted. When I say will not harm the crop I am stretching because most of the preplant herbicides do cause a certain amount of harm to the crop until the crop has established a healthy plant that can overcome the harm to the crop.

On the soils in the Yuma area that use Colorado river water I have applied liquid forms of zinc in test plots pre plant mixed in with the Treflan that was applied. The seedling cotton that emerged in the test area that had the zinc and Treflan applied was growing ahead of the areas in the test plots where there was no pre-plant application of zinc. I thought that I had found soil that was in need of zinc applications, but when the cotton crop reached a growing height of over six inches the cotton looked the same and when we harvested the cotton that fall there was no difference in the yields. I found out that the rate of weed killer that was applied was strong enough to hold the cotton seedlings back, but when the cotton plant’s roots grew larger the cotton plant was able to overcome the Treflan herbicide and grow to maturity without loss of yield. I also found that tests of Colorado river water has zinc contained in it but evidently not enough at the seedling stage when roots were not at their best stage. Once the roots begin to grow due to warmer soils they pick up the zinc available from the Colorado river water.

The manufacturers of herbicides know what rates of herbicides to use to kill weeds and still produce a good crop. They are not attempting to sterilize the soil. They recommend just enough to kill the weed seedlings but not the crop seedlings. This is another reason to expect to use herbicides in the next crop you plant, by now the recommended level of herbicide that you applied last year has disappeared from the soil. A very good guide for herbicide applications are the plant back instructions on the label.

Weed seeds can and do escape herbicide applications. Some weed seeds are located too deep to be affected by the herbicide that is applied before planting and then these seeds can be brought up to surface soils during bed formation. These missed weed seeds that germinate are usually in the furrow or on the edge of the bed where they can be controlled by cultivation. They are also subjected to a shading death due to crop growth. Weeds that have already germinated can survive herbicides that just kill the roots and shoots of germinated weed seeds and emerging weed seedlings. Usually new weed roots and stems are susceptible to preplant herbicides, but mature weed plant cuttings are not controlled by most of the preplant herbicides. A good example are the adult purslane cuttings. Unless a contact herbicide like paraquat or a systemic like Roundup is used before preplant disking of the field, these cuttings will make contact with the soil and start growing roots from their meristem cells that I discuss later in this course.

These small and occasional weed infestations can tell us something about a crop and what is causing the problems if there are any. When I had a company that applied fertilizers I was called on by one of my customers who had some of his lettuce seedlings showing growth problems. We had applied the pre-plant dry fertilizer to his lettuce crop and the grower felt that the problem might be caused by our application. I went to the field to look at the young seedlings and the grower was right about the fact that the young lettuce seedlings had troubles with wilted leaves and stems that were sick or ill .

While inspecting the field I found several areas in the field that had the same symptoms. As I was looking at the entire field I observed that in these areas that had sick lettuce seedlings, the rare weed seedlings were growing just fine. I noted that a few individual weed seedlings were growing in the same areas where the sick lettuce plants where trying to survive. These rare weed seedlings had not been hurt by the preplant herbicide application. The weed seedlings seemed to be able to grow without any damage from whatever was hurting the nearby lettuce seedlings.

Another thing that I noticed was that the weak lettuce seedlings appeared to be in slightly lower spots in the field. The field had been leveled with a laser rig, but there are always very fine elevation and soil differences in areas of most fields. These different spots showed that the most serious areas of sick lettuce plants occurred in these areas of the field. I took soil temperatures in the area and the damaged lettuce areas measured slightly cooler than the other areas of the field. I decided that the very small change in elevation and or temperature caused a weather difference. These spots had the cooler soil temperatures and this temperature effect was allowing the chemical or poison to do its damage to the emerging lettuce seedlings. I couldn't understand why the occasional weeds like wild oats that were growing in all areas of the field were able to survive when the lettuce seedlings were affected by the same cool and sandy soil condition.

When I checked other fields of lettuce seedlings in the area where we had applied the same fertilizer a few weeks earlier I found the same occasional weeds growing in the fields and observed the same low temperature areas and sandy soil areas in these fields, but I found no stunted lettuce seedlings. I asked the grower what the previous crop was and what herbicides were used on this particular field. We tried to find something that was different between this field and the other fields in the area. When we went over exactly what he had done differently we found the answer.

In these fields the grower had applied a new liquid fertilizer that contained a mixture of nitrogen phosphate and liquid sulfuric acid. The material was applied directly under the planted lettuce seed and the liquid nitrogen phosphate fertilizer contained ammonium nitrogen. This liquid formulation of sulfuric acid and ammonium phosphate had been used on several fields in the same area during the planting season which starts in this area in September. The damage didn't appear until the mid to late November period of the year. The results of the extra phosphate did a good job on fields where this fertilizer had been applied and the lettuce emerged when the soil temperatures were high enough for the roots to grow vigorously. High amounts of roots can consume more fertilizer salts without damage to the plant. In cool soils the plant roots are growing at a slower pace producing less and weaker roots. These seedlings are more likely to burn from ammonium salt damage. This fertilizer had a concentrated ammonium salt.

Soil temperatures in this Arizona area tend to go below the fifty five degree F. levels around the fifteenth of November and warm back up around the fifteenth of April. The low elevation areas in a field are cooler than the level spots in the field and the root damaging fertilizer salt was only injected under the lettuce seed and was not under the occasional weed seed that survived the pre plant herbicide application because it was growing out in the furrow.

In most cases the lettuce seedlings recover from this problem, but there are situations when applied fertilizer can kill the young lettuce seedlings. In this case the lettuce survived and produced a good crop.

Vegetables are one of the most fertilizer salt sensitive crops that are grown in this area. When fertilizers are broadcast and disked or mixed into the soil properly, fertilizers rarely cause salt damage. The closer and greater the amount of fertilizer placed near the seed the more salt damage can occur. Placing fertilizer directly under the planted seed is likely to cause salt damage. But this depends on the type of fertilizer and the soil temperatures. Ammonium phosphate containing fertilizer causes more salt damage than straight phosphate fertilizers like straight phosphoric acid that is injected directly under cantaloupe seeds in the cool soils of December, February and March.

When consulting vegetable growers in Arizona and California, I was occasionally called upon by growers to look at skips, streaks in fields with weak and yellow seedling areas in the fields after the crop emerged. Before this particular incident I investigated fields that had received applications of dry ammonium phosphate fertilizer that had not been disked or mixed with soil after application. The fertilizer had been folded into the beds. This practice puts a high amount of high salt ammonium phosphate directly under the vegetable seedlings and resulted in some damaged seedling vegetable crops, but in most cases the vegetable seedlings survived. One year we had a shortage of phosphate pre plant fertilizers and growers had to use 16-20-0 instead of their 11-52-0 phosphate fertilizers. This caused them to use higher amounts of ammonium nitrogen (16 instead of 11) to get the same amount of phosphate needed for vegetable production. When the growers didn't mix the fertilizer by disking the applied fields before bedding up, they experienced the same salt damage that we encountered in this field.

The occasional weed seedlings that I found in this field survived an application of herbicide and this gives us an example of how weed seeds are able to survive many of our control measures. It has been stated that we are constantly breeding crops that can produce higher and better yields, while nature has been breeding weed seeds for millions of years that have survived many adverse situations.

<u>Where Do Weed Seeds Come From</u>?

The field that I mentioned above is still producing vegetable crops in that area near Yuma, Arizona called Dome Valley. If the grower should happen to stop using herbicides when the field is prepared for the next crop, the field will probably be infested with weeds after the first irrigation. Even today you can see fields that were taken out of agricultural production and turned over to building contractors for the building boom that we just went through. The first year of the home building bust left acres of bare ground without weed herbicide protection. The low amount of rain encouraged the weeds in these fields to germinate. Tumble weeds or Russian thistles are one of the bigger weed problems, but winter weeds, summer weeds, annual weeds and perennial weeds are found growing in these fields that used to have at least one application of herbicides per year when the growers planted crops in them. I've watched these Yuma fields produce crops using herbicides annually for the last thirty five years.

One thing we do know is that weeds just like any plant become adults and produce seeds that the plant releases right back to the soil and this number of plant seeds can be huge. Most of the seeds die, but that still leaves a large number of weed seeds that will fall to the ground and be buried until the right conditions occur to allow these weed seeds to germinate and become a problem when growing the next crop. Just one growing weed that matures can produce thousands of weed seeds. Scientists that study weeds have counted how many weed seeds are produced by one weed plant. Barnyard grass can produce seven hundred thousand seeds per plant and the seed can live for five years in the soil before germinating. Common purselane can putout one million eight hundred thousand seeds per plant and the small number of surviving seeds can last in the soil for twenty to twenty five years. A single Sheperdspurse weed plant can produce one hundred and fifty seeds and the seeds can live in the soil for fifteen to thirty five years.

These are just a few examples of the more than eight hundred species of plants identified as weeds and out of this number only two to two hundred and fifty known plants are considered to be major problem weeds in agriculture. Most of the weed seeds just won't germinate, animals and insects eat the seeds and many weed seeds break down and rot in the soil. but thousands of weed seeds survive and can take over a field or a growing crop very rapidly unless some weed control system is used.

Because of the high number of weed seeds in the field compared to the number of planted crop seeds, many of these weeds can survive unfavorable conditions in which a planted crop has trouble living in. Then when good growing conditions occur the weed seeds germinate and the grown weed can flood the field with weed seeds. It only takes a short growing period for these weeds to germinate, grow to maturity and produce more seeds. Even under poor growing conditions, weeds can grow and produce seeds in a period of six to eight weeks. This collection of weed seeds in a particular field is referred to as the <u>weed seed soil bank</u>. This is caused by seeds that were produced by weeds that were able to grow to maturity in the field as well as weeds that were brought into the field by animals, equipment, wind, irrigation water and other means of transportation. This seed bank builds up over a period of years.

In one test done in nineteen eighty six after keeping a field weed free by killing emerging weeds before they could produce seeds, researchers found that the field population was reduced to five percent of the starting population. But in the sixth year when no weed preventing methods were used, the weed population reproduced ninety percent of the weeds that were originally produced in the first year. This is why weed control in a crop field has to continue whenever a crop is planted in that field. The weed seed bank will be replenished very rapidly by natural occurrences. *This information on longevity of weed seeds was taken from the California Weed Science Society's Principles of Control third edition 2002. Thompson Publications, Fresno, California.*

Weed Seed Dispersal

When boarding a commercial airline we are told to remove our shoes. This is done for the flying safety from people who might hide a bomb in their shoe or boot. Weed seeds aren't bombs, but picked up in a weedy area these seeds can cause a lot of problems. How many times have I checked a field for insect pests and didn't even think that I might be spreading a weed seed that I picked up in the weeds on the edge of the field I'm checking.

Humans spread weed seeds in several ways and one of the most common methods occurs when the weed seed is transported on the clothing or on boots or shoes. When traveling by walking, riding in autos, boats, and aircraft the spread of weed seeds covers great distances on our earth. Studies have been done on tourists as spreaders of unwanted weed seeds and the results show that this type of weed dispersal is one way that weeds get started around the planet. Humans drive equipment from field to field while harvesting, spraying, disking, cultivating and many other activities used to grow crops. Taking the time to clean the clothing and equipment is often not a priority, but this spread of unwanted weed species is a large problem that has been studied and researched over a long period of time.

Research of weed seed spread in the international grain trade has shown that this country to country transfer of grain has added to the spread of weed contamination into distant areas where these weeds were not growing before. In two thousand eight they were able to find weeds that were transported as seeds in grain harvested in Canada that were growing in fields of wheat in Japan. They found the contaminating weed seed in transportation vehicles, storage sites along the transporting line, barges and port elevators. This weed seed dispersal is caused by the result of human activities that are needed to get the job of grain transfer accomplished.

As a person drives down any road whether paved of not the side of the road will probably have weeds growing where ever there is soil deep enough to grow weeds. Autos, trucks, pick-ups, SUVs, and even bicycles can pick up dirt in the form of mud or dust sticking to the many parts of the vehicle and this soil can contain weed seed. One study carried out in Australia found that the highest amount of weed seeds were picked up by human driven vehicles during their autumn months of the year which by the way is opposite to our autumn of the year. Autumn is usually the time when weeds produce the greatest number of seeds. They found that the seeds were found in just about all parts of the vehicles with the underside of the back of the vehicles having the highest number of weed seeds, but the auto’s cabin, radiator, engine and tires also collected good amounts of weed seeds.

Rains or even foggy conditions can wet the vehicles allowing mud to cling to the frame. When checking fields with this wet vehicle weed seeds can be picked up and spread from field to field. Some tests have shown that weed seed loads are fourteen times larger when conditions are wet. When the mud containing weed seeds dries on a vehicle the weed seeds can travel as long as the vehicle stays dry. This can be a long time in the desert conditions of Arizona and southern California. Next time you wash your vehicle take a look at the waste water. When scouting fields we may also be transporting weeds from one area to another. Some studies have shown that the vehicles that have to be driven off of the paved roads pick up twenty times more weed seeds than vehicles that only drive on paved roads. The next time you are asked to keep your vehicle out of a field you will know that there is a good reason for the request. Just by cleaning the outside of the vehicle isn’t enough when weed seeds are the problem. High pressure cleaning equipment should be used and is necessary to get the weeds held by dry mud on the underside of the vehicle.

Locomotives create powerful gusts of wind that lift and spread weed seeds up and down railroad tracks. The Dwarf Snapdragon weed is found along railroad tracks where it’s very tiny seeds are blown back and forth along the dry gravelly soil by the movement of the railcars. The tufts of hair on the Snapdragons aid in their spread created by the air movement of the fast moving freight cars.

Forestry officials are constantly fighting the invasion of weeds carried by off road vehicles and camping enthusiasts that unknowingly visit and carry weeds seeds to the public forest areas. Motor boats that visit the recreation areas can carry unwanted aquatic plant seeds when they come from another lake or stream that is a distance away. The mowers used in citrus groves are another source of unwanted weed seeds that can contaminate a crop with new weeds. Livestock that is being transported up and down highways and country roads can carry and spread manure from the animals containing unwanted weed seeds. Another source of weed seeds is the bales of hay that carry weed seeds in the bales that are buffeted by the wind from the truck movement down the roadways allowing seeds to disperse along the sides of the roads.

The further that a weed seed is located from the parent weed plant the competition with the mother plant for survival becomes less and less a problem. This survival can depend on the fact that seed predators may feed and fill up on the other seeds and leave one or two as survivors. Even the plant that produced the seed becomes a competitor for nutrients, living space and water with the seed that it produced. Some birds like the Three Wattled Bellbird carries seeds from their parent tree named Lauraceae to other dead Lauraceae trees where they perch and are more visible to other bellbird mates. They drop their fecal matter containing seeds from living Lauraceae trees to the surrounding soil and the seed produces more living trees that do not have to compete with living Lauraceae trees. Coming from the birds gut which contains nutrients, the seed often has a better chance for survival when it lands on and is covered by the soil around the dead tree.

There are weeds that produce seeds that go through the digestive system of the birds and animals that consume them without any damage being done to the seed. The weed seeds have very hard seed coats that will not break down in the animal's digestive system. The seed is passed through the animal, then dropped to the ground where it can germinate. Seeds produced by Black Nightshade produce small fruit that contains seeds that pass through the small birds and mammals that eat them. The animals, like cattle, that feed on the vegetation of weeds consume some seeds if they are present on the growing plants. These seeds can pass through the animals system along with the fecal matter which becomes manure for the weed seedling to thrive in. The weeds in this category include: Giant Ragweed, Wild Carrot and Curly Dock. The weed spreading animals include rabbits, deer and livestock.

When seeds are carried away from the weed that produced them by ants the seeds are not only removed from other seeds that will compete with them for nutrients and water, but the transported weed seed is buried or planted in the soil tunnels that the ant carries them to. These seeds carried to ant nests buried in the ground are protected from any fire and dry conditions with nutrients available when they begin growing. Ants spread a favorite seed that has a seed coat that is made up of a material called, elaisome. The sticky coating of elaisome gives off a chemical smell that ants are attracted too. The ant adult and larvae use this gel-like coating on the seed as a source of nutrition. The seeds are discarded when the gel is gone. Then the abandoned seeds germinate and become a pest for farmers. Several wildflowers including Hogworts depend on being spread by ants.

Some weed plants produce seeds in pods that explode when they dry up sending the seeds away from the plant. There are weed seeds that are round shaped allowing them to roll away from the seed plant that produced them. Some weeds have their seeds develop in seed pods that are able to cling onto the fur of animals and onto the clothing of humans. The seeds or seed pods have hairs with hook shapes, barbs or sticky hairs. Lesser Burdock, Beggars Ticks and Common Hedge are a few names of these clinging weed seeds. Other weeds like the Prostate Spurges and English Plantain become sticky when they are wet. This condition makes them stick to animal hooves, webbed feet and even human shoes.

For years people have spread plants throughout the agriculture areas of the this planet. These plants were thought to provide food and forage for livestock, or as ornamental flowers and shrubs. The reason that they became pests was that they were moved to areas that did not have their natural predators and this allowed these weeds to spread throughout particular areas taking over space, nutrients and sunlight. Yellow Sweet Clover was first planted as a feed for livestock and as a nectar for honeybees. Ecologists who care for prairies are now fighting this clover as a weed pest and it can be found all through the United States growing on railroads, meadows, pastures and waste areas. The species, Dame's Rocket, has spread rapidly across woodlands, thickets and fence rows. It was originally brought to the United States of America as an ornamental for flower beds and even though it has been considered to be an invasive weed it is still sold and used as an ornamental plant.

Some plants can fling their seeds over distances. This allows the plant to cut down on the competition of their offspring. As the plant matures it creates a release mechanism with its stems. The seeds are contained in pods. Some Spurges as well as Yellow Wood Sorrel and Storks's Bills have this ability to fling weed seeds to distances of several inches to several feet depending on the plant.

Seed dispersal by humans and other animals has been found to be beneficial in areas where large rain forests have been destroyed by humans clearing land. The renewal of the rain forest vegetation that was destroyed by some farming and lumber harvesting has been carried out successfully when the restoration of the forest is concentrated around the edges of existing forests rather than trying to start new groves in isolated areas. The amount of seed carried by humans and other mammals out of the edges around these remaining parts of old established forest areas is greater than trying to start entire new areas from scratch. Bats that feed on fruit are the planters of over one hundred and fifty types of fruit bearing trees. These bats that are fruit eaters carry the fruit to areas adjacent to the forest where they occupy a branch while they consume the fruit and drop the seeds to the soil below where the seed germinates producing new fruit trees.

Tumble Weeds

One of the better known spreaders of weed seeds is the famous weed called the "Tumble Weed". The term "weed" is used to describe an "an unwanted plant". There are several weeds that have the qualities of the "tumble weed", but the one weed usually referred to as the culprit is the Russian thistle. Other weeds that share the famous title of "tumble weed" include: *Amaranthaceae,* commonly called: pigweeds; *Centaurea* named: Knapweed; *Lessingia glanddulifera* named: Valley lessingia; *Kochia* named: Plains Tumbleweed; *Atriplex rosea* named: Tumbling Saltbush or Tumbling Orach; in the *aster* family: a Knapweed; the legume family has a tumbling plant called: *Plantago Cretica*; in the mustard family one called: a Resurrection Plant; and in the mushroom family one called: an Earthstar.

The above tumbling weeds grow into a ball shape when they dry out and are blown by the wind dropping seeds as they go. There are some tumble weeds with twigs that form flowers that dry up and fall off of the main plant then form a small ball that is blown by the wind and begins tumbling. One of these is in the parsley family. Another inflorescent is one called the "Baby Breath". when it dries up it falls off the main plant and tumbles through hayfields and pastures in the western United States.

Weeds are traced by scientists to find out where they came from. What area of the world they started in and where they are a native. The (*Amaranthaceae*) or pigweed type of tumble weed is said to have come to the United states from South America. The (*Chenopodiaceae*) Goosefoot family tumble weeds are said to come from south east Russia and western Siberia.

A paper given at the 1996 symposium for California Exotic Pest Plant Council by David A. Bainbridge of the Biology Department of San Diego State University states that when Dutch and Swiss religious members of the Mennonite religion were forced to move to Russia in the seventeen hundreds where they farmed flax as one of their grain crops and then because of their religious beliefs they were again forced to leave this country, Russia, in the eighteen hundreds and moved to the United States. They brought Russian thistle or tumbleweed with them. When they moved they were thought to have carried flax, wheat and barley seed that was contaminated with Russian thistle. It has been said that the main source of these seeds was from a farm in

South Dakota. Because the tumble weeds were first noticed along the railroad and cattle yards near Lancaster, California the transport of the contaminated seed was blamed on grain seed shipped by rail from the eastern United States' fields. It was also reported that one outbreak of the tumble weeds in Yakima, Washington was traced to weed seeds in cattle feeds in eighteen ninety six.

The taxonomists that have tried to pin down the exact species in the genus of the Russian thistle tumble weeds in order to avoid confusion have declared that there are enough differences in Russian thistle to claim that there are different species in the genus: *Salsola tragus, Sassola iberica, Salsola kali* and *Salsola australis* due to the differences in the flower size and shape. Russian thistle is reported to infest over one hundred million acres in the western United States. The weather in the western agricultural areas is ideal for the growth of this weed.

I travel between Yuma and Phoenix a great deal of the time on interstate 8 and the freeway has an abundance of tumble weeds on both sides. I noticed that a forty acre block of open land near the Dateland area had a number of large piles of tumble weeds. On one of the trips I noticed that these piles had been set afire. I spotted them at about six in the morning and when I came back on the next day around four in the afternoon the piles were still smoking. Burning will clean up the trash but the seeds are still viable and produce seedlings that will have to be destroyed before they produce seeds.

Tumble weeds grow best in soils that have been disturbed. If the soil is solid or firm the tumble weed seed isn't able to penetrate it. When farmers cultivate a field after harvesting a crop and leave the ground alone and a rain occurs that wets the field or the grower may have irrigated the field and hasn't planted another crop in the field. The soil having been disturbed by disking is ideal for the growing of the tumble weeds. We had a number of crop fields in the Yuma area that were turned over to house building contractors and the building boom stopped, but the building lots with their loose soil were ideal for tumble weeds. Fields with emerging crop seedlings or that have been recently tilled will sometimes have green tumble weed seedlings appear in trails where the Russian thistle tumble weeds dropped their seeds while being tumbled across the field by the wind.

The tumble weed plant can produce over two hundred and fifty thousand seeds and even though only ten percent survive and germinate the seeds that live can survive in very harsh conditions. The tumble weeds are very salt tolerant and the oxalates given off by the seedling dissolves the insoluble soil phosphate giving the tumble weed a source of phosphate that other plants can't obtain. Other seedlings do not have this source of nutrient fertility and cannot compete with the Russian thistle. It only takes a very limited amount of soil moisture lasting only a few hours with temperatures in the fifty two to ninety degree range for the coiled, naked embryo inside the tumble weed seed to start growing. As the two foot long taproot uncoils it extends into the soil reaching the deeper soil moisture levels that are unavailable to other plants trying to survive in the same area. This entire activity can occur in a period of twelve hours. If the soil is firm and not disturbed the tumble weed seedling will not be able to grow into the soil.

The Russian thistle seedling tumble weed is a bush that has leaves that are narrow, around one inch in length and dark green. These leaves are needle shaped, similar to pine needles. At this growing stage because the leaves are tender, livestock will use them as a source of food. As the plant matures the stems which have reddish to purplish colored stripes are anywhere from eight to thirty six inches long. As the plant matures the leaves become very stiff and form sharp pointed tips. At the base of these pointed leaves that are attached to the stems, flowers without petals begin to grow. The flowers are protected from animals that eat flowers by pointed bracts that are small hard modified leaves that form where the stems and leaves join together.

Mature fully grown Russian thistles are round shaped and can have a diameter of eighteen inches to six feet. When I worked in Bakersfield, California a co-worker who worked in the Wasco area about thirty miles away often stated that I'd probably see him tumble by Bakersfield in a Russian thistle tumbleweed whenever we had a wind storm. He was six foot four inches tall.

The Russian thistles begin germinating in late winter or early spring. They are annuals that reach maturity from July to October. The stems die when they reach their mature stage. The dry stemmed tumble weed's base becomes very brittle and breaks off from the root at the soil surface when the weed reaches maturity. The wind blows the tumble weed across the soil allowing the seeds to be spread until the weed is stopped by fences, other shrubs and trees. Both the major canals in California and Arizona are bothered by tumble weeds falling into the water and clogging their outlets. The wind-blown tumble weed can hamper highway traffic. Russian thistle can become a fire hazard when the weeds pile up on fence lines. Prairie fires can be spread by the inflamed tumbling weeds that become balls of fire. The weed attracts several insect species that attack commercial crops. There are people who are allergic to the thistle and others who break out from the scratches that they receive from the thistle. Trains carry seeds collected from rail side tumble weeds scattering them throughout the country. Highway vehicles collect and spread these tumble weed seeds where ever they go.

Biological control has been tried by entomologists in their battle with the Russian thistle and one of the more recent is called the *Aceria salsolae.* It is a native of the Mediterranean Basin. This is a mite that stunts the growth tips of the Russian thistle. Other biological control agents include: seed-feeding and stem-boring caterpillars and two different weevils. There are several herbicides that control Russian thistle. The practice of killing the thistle plant before it sets seed should be the main goal when using herbicides.

Pre-emergent herbicides include: Aatrex, Hyvar, Telar, Velpar, Arsenal, Devrinol, Princep and Oust. Always follow the label. Other less effective herbicides that are used as preplant applications include: Lasso, Predict, Surflan, Prowl, Endurance, Kerb and Treflan. Russian thistle has shown some resistance to Telar and Oust; therefore it would be wise to limit the number of applications of these two products.

The use of post emergent herbicides has to be timed very early before the thistle becomes hardened. Early seedling stage is the only time that post emergent herbicides are able to give some control. Properly applied 2,4 D, Banvel, Rely, Roundup and paraquat will control very early germinating thistle weeds before the seeds harden and mature on the plant.

The Evolution of Weed Seeds

Weeds and plants are the same thing in nature, but to people in agriculture weeds are a pest and plants are a crop that has to be protected from weeds. The commercial crop seeds that are purchased have been bred over a period of time with the goal of increasing yields in certain growing environments. Weeds have gone through millions of years of breeding by nature to survive very harsh conditions. The first known plants date back four hundred million to four hundred and fifty million years. Plants or weeds are believed to have evolved from algae and algae still live today in water. Before animals moved from the water to the land, plants had already gained a place on land. Because animals get many of their life giving amino acids by eating plants or other plant eating animals, plants had to lead the way onto the earth's soil to provide animals with these vital amino acids..

Plants and algae have their DNA within a membrane bound nucleus within their cells. Because of this body part algae and plants are called eukaryotes. Bacteria do not have their DNA contained in a membrane inside of their cells. Bacteria have the DNA located in an area within their cells. Plants have an embryo stage of life. Algae do not have an embryo stage of life.

Most of the algae are one celled while plants have many cells. Both plants and algae have chloroplasts in some of their cells and can carry on photosynthesis. They obtain their energy from the sun. Algae and plants have cell walls that give them support. Animals have skeletons and their cells do not have walls. Plants, algae and animals all have cell membranes.

As the plants moved from the water to the land they had to adjust to a completely different environment. The plants had to grow skin that would hold water inside their bodies or they would dry up (dehydrate). Algae live in the water and don't need protection from dehydration, but plants had to develop cuticle containing covers for their bodies above the soil level to keep the water that entered their bodies from leaving their bodies.

The liverwort, hornworts and mosses do not grow to heights that are above where water cannot seep into their bodies. If they were any taller they would die from dehydration. Ferns, horsetails, gymnosperms and angiosperms developed a vascular system that included the xylem that transfers water from their roots to the top of their plant bodies and a phloem system that moved nutrition from where it was made in the leaves by photo synthesis to the growing areas and storage ares of the plants and from storage points to growing points of the plant's body. This transfer system is referred to as the vascular system and all plants other than the liverworts, hornworts and mosses have some form of a vascular system.

Liverworts

As plants moved from the water to land one of the first to do this was the liverworts. The body of a liverwort is similar to the mosses that developed on land. Liverworts have leaves that are lobed. The leaf is fan shaped coming out of a central area to form what appears to take the place of a stem. Mosses have a definite stem that their leaves grow from. Mosses also have a rib in their leaf. Liverworts are only about four inches long and less than an inch in width which is smaller than the mosses. The liverwort has no roots but they do have one celled rhizoids that they use to obtain nutrients from beneath them and to cling to rocks and other objects. Mosses have many celled larger rhizoids that they use to cling to rocks and soil gaining nutrients through them. Located in the bodies of some cells of liverworts are small areas of oil. Mosses do not have these oil bodies inside their cells.

Liverworts have chloroplasts and carry on photosynthesis, but they do not have stomata for taking in carbon dioxide and expelling water and oxygen. Inside their cells they do have a membrane surrounding their vital genome (DNA) making those eukarytes. They have cell walls covering their cell membranes like other plants. They lack a vascular system to draw water much higher than the soil level; therefore the liverwort plants are only two to three inches in height.

Their life cycle starts when a spore grows into a mass of thread-like filaments. These filaments merge into the flat oval shaped leafs of the liverwort. This body is the liverwort plant which is the gamete which will have the sex organs and is the primary form of the life cycle of the liverwort. From the leaf emerge small stalks with a cluster on top. One is a male sex organ, the antheridia. Liverworts do not produce pollen but do produce sperm cells.

The female sex organ of the plant is called the archegonia. The archegonium has the eggs that plants produce. The female organ (gamete) or archegonia is situated inside the top of the dome shaped cluster at the top of the stalk. In some liverworts both sex organs on stalks are located on the same leaf, but on other liverworts the sex organs may be on individual plants. The female has her eggs protected by the fact that the eggs are in holes in the top of the fan shaped object at the top of the stalk sticking from the top surface of the leafed body.

When the liverwort is mature its meristem cells will produce sperm in its antheridia. The sperm has two tail like extensions, flagellae, which extend from their bodies. These are used to swim to the location of the female organs where the egg is located in the archegonium. Water has to be present in order for this to happen. These sperm may be aided in their journey by rain drops splashing on the leafs. In some cases the leaf of the liverwort is able to flex their leaf sending the water containing drops of sperm and water to a distance of almost three feet. Once the sperm joins the egg; fertilization occurs. The fertilization (a joining of the male cell and the female cell forming one cell called "meiosis") produces a sporophyte which has two sets of DNA chromosomes. One came from the male and one from the female. The sporophyte is now diploid with two sets of chromosomes.

The body of the sporophyte has three areas: A foot, a capsule, and a seta or stalk. The foot anchors the sporophyte to the plant and transfers nutrients from the plant to the sporophyte which is the capsule where the spores will be produced. The seta or stalk which is set between the capsule and foot connects them. When they are all three connected the seta begins to grow lengthways and pushes out of the female archegonium and into the air. Inside the capsule the cells begin to enlarge and multiply producing more spore cells and "elater cells". The elater cells are spring like and will push against the inside walls of the capsule. When the inside pressure is great enough the capsule will burst. The spore produced cells will be dispersed or thrown into the surrounding area.

. The cells grew by a system where the cells divide (this is named mitosis) thus growing in number. At this period in the life of the liverwort the cells will also go through a stage of cell growth called meiosis. Meiosis occurs when genes are shuffled. This shuffling or mixing of genes produces different gene combinations. The change in genes allows the plant to live through changes in the living conditions on this earth which are also changing on a regular basis. The spores are pushed out by the enlarging elater cells and disperse out into the area by the wind and in some cases animals like insects to start growing into another liverwort plant that can grow sex organs and start another life cycle.

In some cases the tips of the liverworts stay green and growing when the rest of the body dies. This is a form of asexual reproduction or regrowth. Other liverworts have what is called gemma. These are single cells of the liverwort body that are modified buds that can break away from the main body and begin growing. This is also a form of reproduction similar to cuttings which occurs in several plants. In commercial plant nurseries this gemma can spread throughout a greenhouse vary rapidly. Then they become unwanted weeds that have to be controlled.

Hornworts

The hornworts are very often the tiny green weeds that invade gardens and fields that have to be cultivated. They are unwanted plants when they are found in this environment. They exist in wet or moist situations, but in some cases they can show up in desert areas where they suffer from dehydration, but they are able to survive. They also grow on the bark of trees.

Like liverworts, hornworts do not have a vascular system they cannot grow to any major height. In their adult stage they are about two inches in height. The cells contain one large chloroplast that is fused with a large organ type object that joins with the chloroplast to store and manufacture food from the sun's energy. This is also seen in the water organism called algae.

The liverwort has the appearance of a thin, shiny, and light leaves. It has uneven edges similar to a thin crumpled leaf. There are several layers of cells that give the plant its thickness. The hornwort plant has rhizoids on its underside to cling to rocks or to tree bark. The color of the hornwort is green or yellow green. When colonies of bacteria called cyanobacteria have grown inside of the hornwort plant the color of the hornwort changes to a bluish green. The hornworts have stomata that they take in carbon dioxide for making the sugars with the aid of sunlight. This sugar is what they live on. Liverworts do not have stomata. Mosses and hornworts do. From the rosette surface of the adult hornwort the male and female sex organs look like small bumps on the leaf's surface. The organs are visible when the skin cells disintegrate.

The female sex organ is called the archegonium and the male sex organ is called the antherida. In most of the hornworts both sex organs are on the same plant, but on some they may have only male with another plant with only female. When there is enough water to allow the male sperm with the use of its legs called flagellates to swim to the female sex organ fertilization takes place forming the zygote.

The first cell that is formed grows in length not in width. The first part of the new body is the foot. This is made up of a group of cells that obtain food from the plant thereby feeding the new zygote. Then just above the foot the second part appears that is a group of meristem cells that start multiplying to form a location for the capsule to form which is the third part of the new body. In the capsule are two layers of sterile cells and between these two layers of cells there are elater cells that are produced among the new spores that rapidly gain in size. The growing elater cells split the capsule length wise from the tip of the capsule back to where the leg joins the capsule. This activity releases the spores to find a new life on land and become liverwort plants.

<u>Mosses</u>

Mosses are not able to grow very tall in fact they hug the ground and are no more than four inches in height at their tallest. Although there are exceptions and in the case of the specie, *Dawsonia*and, that gets up to a height of twenty inches. Mosses stay in clumps of simple leaves on moist or wet soils. Mosses like liverworts and hornworts do not have a vascular system. Their bodies are made up of stems and leaves. Their leaves have cells with chloroplasts that they use to carry on photosynthesis to obtain their energy like other plants. They get their nutrients from the water that is in the soil or in the area that they live on. Their leaves consist of single layers of cells without air spaces between their cells. The stems that can be either simple or branched are upright or flat. Mosses are without roots but they do have rhizoids that unlike liverworts have multiple cells. The rhizoids are used to grasp or hang onto rocks and other substrate where they live. The rhizoid can conduct water and nutrients into the moss from any wet surface.

The moss life cycle starts when a moss spore is released and begins to grow or germinate. It emerges as several filament cell stems with leaves growing out from the stems. A mass of these filaments have the appearance of green felt. These mats grow on bark, rocks, concrete or any other surface. In some cases the place that the moss is growing from shouldn't have moss growing from it and then moss becomes a weed that has to be controlled. From these clumps, moss shoots begin to grow. These shoots produce modified leaves which are the male and female reproductive organs. Some mosses have both male and female sex organs on the same leaf and other mosses have only male or only female sex organs on each individual leaf. The shoots with the modified leaves protecting the female sex organ is made up of leaves surrounding a flask shape with a neck that is open to allow male sperm cells to swim into it. Water has to be available in the protecting leaves for the sperm to swim to the female sex organ. Many of the surrounding leaves form a cup which contains this water. Once the fertilization takes place a sporophyte is formed that will produce spores.

The immature sporophyte begins to grow and contains a stalk and a capsule which is contained in a sheath called a calyptra. The foot of the of the stem is imbedded in the bottom of the female shoot or archegonial . The sporophyte is able to obtain nutrients from the moss plant. Inside the capsule spore producing cells go through the mieosis stage whereby genes are mixed and the new spores are formed. The cover of the calyptra falls off. Inside the capsule a great deal of pressure has built up by the capsule swelling elater cells. The high pressure blows the spores into the surrounding air where the wind spreads these spores to areas where the spore can germinate and start a new life.

Lycophytes (Club Mosses, Spike mosses and Quillworts)

The lycophytes were some of the first plants to have vascular systems. They lived some two hundred and ninety to three hundred and twenty million years ago and they were the main plants in the swamp forests of North America and Europe. These trees grew from thirty to one hundred and ten feet tall. These large trees died out due to the drying up of the swamps about two hundred and ninety million years ago. Their remains became some of our major coal mine sources. The plants that survived were much smaller and exist today as the Club Mosses, Spike Mosses and Quillworts.

<u>Club Mosses</u>

Lycopodiacea include the club mosses. These are not to be confused with true mosses that were previously discussed. Club mosses evolved after the regular mosses evolved and they have a vascular system that allows them to grow to the height of a bush and are not required to hug the ground at two to three inches as regular mosses do. Club mosses grow in Canada, the United States in the northeast, and even in the artic. They do not thrive in the arid southwest.

They are trailing plants with horizontal branches growing from a branching underground stem that has roots and aerial branches. The tubelike leaves are small and arranged in spirals or spokes from the center. Some of the plants labeled Lycopodiaceae have leaves that produce spores on them. Other Lycopodiaceae have their spores on cones arranged on the tips of separate stems sticking up into the air among the leaves. The spore is all the same size. The spores grow into free living gametophytes with sex organs both male (antheridia) and female sex organs (archegonia). The gametophytes may grow above the soil and produce their food from the sun by photosynthesis and below the soil getting nutrients from the soil. The male antheridia produce sperm that swims to the archegonia female organ where it mates with the egg. The result is an embryo that produces a new plant. The plant can take as long as twenty years to grow to maturity and produce more spores that produce gametes with sperm and eggs. Many club mosses produce roots that produce new plants instead of the slow sexual process. In some states the Club Mosses are a protected species because it takes so long to reproduce.

<u>Selaginellaceae or Spikemoss</u>

This is the largest of the lycophytes. They live in tropical areas, but they are found in Canada and the United States. They are sometimes found in deserts where they go dormant during the driest seasons. They have branched prostate stems with roots and stems that have leaves that stick straight out from stems that grow straight up from the ground. The stocks produce the gamete sex organs that are cones at the end of the branches. The large cone produce female archegonia with eggs and the small cones are antheridia that produce sperm. The male cones grow until they burst when the rain or other water conditions allow the sperm to swim to the female cone. The cone grows until breaking open. This allows the female archegonia to stick out from the cone producing an egg. Fertilization takes place and new spikemoss embryos are produced. The embryos get their food from the spore. They are unlike the free living club moss embryos that get their food from the soil or from the sun and air by photosynthesis.

Isoetaceae or Quillworts

Quillworts are found in fresh water in cool climates of the United States and Canada. It has a thick bulb like stem or corm that is underground; the roots grow from under the bulb like stem. The leaves are long slender and stiff. They look like onions or rushes with quills. They have a spoon shape at their base. Quillworts do not form cones. Their gametophytes consist of male microspores in the center of the stem and the female megaspores. Female sex organs, are located out from the center. The gametophytes or sex organs are inside the walls of the plant. The gametophyte male antheridium produces sperm that swims in the water to the female gametophyte archegonia's eggs at fertilization. This forms an embryo that grows into a new sporophyte that produces more gameotphytes.

Ferns and Horsetails

According to the fossil record, ferns date back as far as three hundred and sixty million years. The ferns we see today started around one hundred and forty five million years ago. Ferns have a vascular system including a phloem to carry sugars from where the plant produces them in leaves and stems to where the sugar is used for growing areas or in storage areas that are usually found in the roots. Ferns also have a xylem that transports water from the root system to the leaves. This allows the ferns unlike the mosses, liverworts and hornworts, to grow to heights as high as eighty feet. The ferns carry on photosynthesis, have membrane containers in their cells for their chromosomes, and start their life cycle from spores. They are also perennial plants that can live for several years. They can start new growth from stems, leaves and rhizomes. They form clones of the same type of vegetation in large colonies of fern plants.

The fern weeds that are a problem are the so called bracken ferns that are taking over abandoned fields and forests that have been cleared of trees. This is the weed side of the ferns. Ferns do well in the tropics, but have trouble surviving in the arctic and antarctic regions. Tropical rainforests support a large number of the ferns.

The spore of the fern is the starting point of a new plant. The spore comes from spore cases or sporangia that are grown on the fern leaf. The spore shape is tetrahedral with three lines where the original four cells were joined together when meiosis after eggs and sperm joined sexually before the spore matured. There is also another spore formation that has the appearance of a bean. Spores do not carry on photosynthesis but they do have food stored when the spore is being formed. The walls of the spore are sometimes thick and sometimes thin depending on the fern. The spores with thick skins can exist for a long period of time. Some spores have been germinated after a period of one hundred years. Spores germinate on damp surfaces whether the surface is rock, soil or organic matter. Some spores with thin coats have chloroplasts and are green in color. They require a much shorter period of dormancy before germination when compared to seeds.

The germination of the spore results in the formation of very small plants named "gametophytes". The gametophytes contain both the male and female sex organs of the fern. The first thing that emerges from the spore is a growing rhizoid. This is a foot like object with a single growing green cell. This cell is the first of many cells that form the gametophyte. The meristem cells start to appear and these cells will change into needed functional cells that are instructed by the plant's DNA as to what types of plant organs they will grow into. These cells are surrounded by flat like wings that are one cell thick. When the gametophyte is full grown it is a small third of an inch long and a third of an inch wide. This is why these gametophytes are rarely seen.

Because the fern is a perennial like Bermuda grass a great deal of the ferns that take over certain areas are the result of pieces of the fern plant breaking off and starting new plants. These pieces of fern plant include parts of the roots, stem and leaves. Because this type of production of new ferns is done asexually without a change in genes; therefore all of these ferns are called clones. This type of asexual spreading of fern populations is small when compared with the spreading of sexually produced spores for new fern plant populations.

On the tiny gametophyte plant the sex organs are formed. They have a name for each sex organ. The male organ is called the antheridium. The female or egg producing sex organ is called the archegonium. The antheridium is made up of number of cells that form a raised bump below the skin level of the small gametophyte. The antheridium is made up of a coat of several sterile cells covering either several hundred sperm cells or just twelve or so. The female sex organ, the archegonium, is lower on the leaf-like gametophyte. The shape of the archegonium is similar to a bottle. The archegonium is made up of four rows of cells that form the neck canal cells with the bottom cell just above the egg. There is only one egg present in this archegonium container.

The sperm can come from the male sex organ on the same gametophyte plant or from another gametophyte growing nearby. This depends on the amount of moisture that is present in the area. The sperm swim in the water that is present on the gametophyte leaf surfaces toward acids put out by the female archegonium that attracts the sperm. The male sperm have hair like objects on their bodies that propel them through the water to the neck of the archegonium down to the egg where fertilization takes place. Rain drops can scatter the sperm over several other archegoniums.

After the egg is fertilized the neck of the archegonium is closed and the embryo starts developing. The first cell of the new embryo grows inward. This cell starts multiplying into many of the same cells by a process called mitosis. This growth stage produces the first leaf and stem. The outer cell multiplies and becomes a foot that digs into the plant that produced it and absorbs fluids for food. This foot dies off and is replaced by a root. The root grows out from the stem. The gametophyte remains attached to the new sporophyte providing food until the root penetrates all the way into the soil. Then the gametophyte plant shrivels up and dies. The embryo continues to grow into a new fern plant.

Tree ferns can grow to eighty feet in height and have stems become tree trunks that contain vascular systems. There are ferns that grow in ground hugging clumps with rhizomes instead of roots. The stems grow from meristems that provide cells for growth and are located in the top of stems and below in the roots or rhizoids. Some ferns are annuals that complete their growth and production of spores in a season then die, but these ferns are very rare. Most of the ferns are perennials that live for years.

The leaves of ferns grow by unrolling from the tip of the leaf with a so called fiddle head. Flowering plants expand by unrolling from a folded condition with a tip containing meristem growth cells. Fern leafs have the tip meristem cells, but these growth cells are protected by the curled over spiral or unrolling leaf tip. When the fern leaf formation is complete the tip is gone.

The spore production of fern plants go on throughout the life of the plant. Most of the fern plants are perennial and can live for several years. The spores are produced on the fern leaves in capsules. The wall of the fern capsule can be thin or thick. In some ferns the capsule can be very large with a couple of tough layers. Other capsules can exist with a single thin layer. The water fed to the leaves from the vascular system of the fern plant puts pressure on the walls of the sporangia. When the time of the year comes for the outer layer of cells to quit growing, the pressure from the water molecules that keep coming up from the roots cause the spore walls to erupt. thus flinging the spores out into the wind. Some of the capsules are on elaborate stalks. This is true of the newer evolved ferns. Once the spore has been sent out by the fern a new life cycle for spores begins with the tiny gametophyte plants growing male and female sex organs that was discussed earlier.

Horsetails

Another spore producing plant that has a vascular system and grows to heights of ten to twenty feet is the horsetail. The leaves grow in whorls in the nodes. The plant is found today growing in most areas of the earth. A perennial plant growing from roots in most cases and often treated as a weed. Many of the systemic herbicides and even Roundup have trouble controlling the horsetail. Horsetails grow best in acid soils so applications of lime that raises the soil pH from acidic to basic soils has been used to assist in controlling horsetails. They have rush type stalks with the whorls of leaves emerging straight up from the leaf base. The horsetail name refers to the shape and horsehair that hangs on horses, but the horsetail on this plant sticks straight up.

The stems have chloroplast in their cells allowing them to carry on photosynthesis using the suns energy to produce their food. The plant produce spores in the tips of their stems in cone like structures. These spores produce gametophyte plants which have male and female gametophytes or sex organs. The sperm swims in water to fertilize the eggs. Fertilization produces an embryo that grows into a horsetail plant. The horsetail plant produces capsules that produce spores that produce new gametophyte plants that have sex organs and the life cycle goes on. Because the plant is perennial most of the plants grow without sex from living parts (roots and stems) that produce plants that are called weeds and have to be controlled.

Gymnosperms

This word, gymno and sperm is used to highlight the naked seed. Similar to the same word, gymnasium, a place to get almost naked for exercise. As the earth aged and changed more changes in plants had to occur in order for these plants to survive as they moved further from the oceans and streams and deeper into the land areas. One of the changes was the development of seeds. Instead of spores, the gymnosperm has seeds. This occurred about three hundred million years ago when plants started using seeds instead of spores as a vital part of their life cycle. Gymnosperms do not have the sealed seed coats or carpels surrounded by fruit that the later arriving angiosperms or flowering plants have. Unlike the ferns that preceded the gymnosperms, gymnosperms do produce seeds instead of spores.

There are four divisions of plants in the gymnosperms. These include: Ginkgophyta, Cycadophyta, Gnetophyta and the Pinophyta. The Pinophyta are conifers and pine trees.

Gymnosperms have a vascular system with a xylem that is made up of tracheids that carry water and soil nutrients to the top of the plant. The tracheid water transporting system is also found in the ferns, the horse tails and lycophytes that were discussed earlier. Gymnosperms and ferns both have food produced by photosynthesis that is carried throughout the body in the living phloem of their vascular systems. Liverworts, hornworts and mosses do not have vascular systems. That’s why lycophytes, ferns, pine trees and flowering plants can grow so tall and liverworts, hornworts and mosses stay close to the ground.

Gnetophyta

One of the gymnosperm, gnetophyta, has vessels as well as tracheid in their vascular systems. Gnetophyta are considered to be gymnosperms, but this vessel condition puts them very close to the angiosperms. Gnetophyta are more likely to be found in desert conditions. They even lose their leaves and carry on photosynthesis with their green stems to survive. Many of them are vines or brush.

Ginko

In the life cycles of most of the gymnosperms the seeds develop on the surface of leaves or scales arranged inside a cone shape. The ginkgo has their sex organs at the end of short stalks instead of cones. They produce seeds that are covered with a very smelly fruit-like cover; therefore people who grow Ginkgo trees do not use seeds. Instead of using smelly ginkgo seeds to produce trees the ginkgo trees are grown from cuttings. On a cruise through the Panama Canal I visited a coffee plantation in Costa Rica where they planted ginkgo trees among the coffee bushes. The ginkgo had roots with galls containing bacteria that produced nitrogen similar to alfalfa and clover. The ginkgo also provides shade with their fan shaped leaves that are leathery with parallel veins and turn a very bright yellow in the autumn months. Ginkgo do not grow in the wild anymore. They are domestically cultivated.

Cycads

The cycads are similar to the palm trees. The feathery leaves stick out of the leaf branches at a ninety degree angle. When they reproduce, cycads develop a huge cone in their center at the top of their plant or tree. This cone is their sex organ or gametophyte. The plants are either male or female. Cycads, because they are vascular with a system that can transfer water from its roots to its top leaves can reach a height of several feet. They have a long life and grow very slowly. Cycad plants have been known to have reached ages of over a thousand years. They are very similar to a palm or a fern. They inhabit the tropical areas of the earth and exist around the globe. Cycads can exist in some desert areas or semi deserts, and they are numerous in rain forest areas. They are versatile and live in: shade or sun, sand, rock or swamps with low sources of oxygen. When conditions are right they form a reproductive or gametophyte cone in their top area of growth. The cone produces pollen that is carried by beetle to the female organ who is in a cone on another cycad plant. Fertilization occurs and embryos are produced. Water isn’t needed to spread the sperm.

The trunks of the cycad plants are round with leaves growing from the trunk. Sometimes the trunk is below the soil level and the leaves appear to grow out of the soil. The leaves are often larger than the trunk. The leaf looks like it has ribs sticking out as the leaflets form at ninety degree angles from the leaf stem. Some varieties have a central vein on the leaf stalk, but on other varieties they have more than one vein and the veins run parallel to one another.

The cycads can be grown from shoots by cuttings that are placed in soil. They can also be grown from seeds, but their seeds do not go dormant. They can dry out and the radicle or emerging root is susceptible to fungi. They are very slow growing; therefore it takes some patience to wait for them to develop.

Conifers

The conifers are the most common and abundant gymnosperm. They include: firs, pines, junipers, spruces, yews, cedars, redwoods and cypress with leaves that are long, thin and evergreen. The leaves are referred to as pine needles the conifers do shed the leaves, but they are constantly growing new ones. This is why the trees are called, evergreens. In their cones they produce spores. When the plant is ready to produce seeds the meristem cells at the growing tips of the trees receive messages from their DNA that make them start producing cells that form cones instead of leaves. The cones produced are either small cones that produce male pollen grains, anthergonias, or larger cones where the female sex organs, the archegonia, are produced. The female sex organs called archegonia which have eggs in each archegonia.

The male cone which is much smaller than the female cone produces pollen grains which in some cases have wings and are very light. These wings help the pollen to float in the wind. During the mating period clouds of pollen are produced and some of them make contact with the female cones. Once the pollen grain gets inside the female cone and enters the very small entrance into the ovule coat, the pollen grain matures and produces a couple of sperm cells in a pollen tube. The sperm cells are able to be conveyed inside the pollen tube that is produced by the activated pollen into the ovule where the sperm cells join with the female eggs.

This is how fertilization occurs in the conifers and gnetophytes, but the sperm of the cycads and ginkgo have flagella on their cells that they use to swim to the eggs inside the ovule. They do not use a pollen tube therefore
they need water to swim to the eggs.

After one of the a sperm and one of the eggs join in fertilization the other sperm and egg in the archegonia disintegrate. Now there is only one zygote or new future plant left in the ovule. The parts of the other egg, sperm and archegonia will become food for the new embryo. This new embryo, called a sporophyte, will eventually become a new plant. But the ovule will become a seed with a wing shaped object that will be used by the wind to disperse the new seed to another area where it will grow into a new pine tree.

Angiosperms or Flowering plants

The first angiosperms developed from the gymnosperms between two hundred million years and two hundred and forty five million years ago. The flowering weeds that we find at the present time existed one hundred and forty million years ago and are still changing or evolving today. These plants changed the way they grow to fit the changes that have taken place on this earth during the last one hundred million years. During the last sixty to one hundred million years the number of conifers which are gymnosperms have been passed up as the leading tree plants by the angiosperm trees that produce seeds in flowers instead of seeds in cones.

The advantages that the angiosperm has over the gymnosperm include faster production of seeds. Instead of having to grow a cone for more than a year to produce pollen, the angiosperm flower with its smaller anthers produces smaller pollen within a shorter season. The angiosperm also produces fruit that surrounds the seeds. Animals are attracted to this fruit and pass the seed through their system after carrying the seed to areas away from the mother plant where she can't compete for nutrients and space with her young.

There are two types of angiosperms. One is predominantly grass called the monocots. These monocots have only one first leaf (mono) on the embryo called the seed leaf. Monocots have parallel veins. The dicots have two seed leaves on their embryos. Dicots have netted veins in their leaves. The vascular system of dicots has the xylum tissues, transporting water and soil nutrients, located in the center of the stem while the phloem tissues are located around the xylem. In the monocots the phloem and xylum tissues are scattered and do not have a definite position inside the stem.

When conditions are right for the formation of flowers the plants meristem cells at the growing tips go through a change from apical meristem that produce cells for leaves to meristem cells that produce reproductive cells. Conditions that start the plant to form flowers include the following: the temperature at that time; the maturity of the plant; for many plants the length of the day or photoperiod; and the necessary growth hormones

The DNA signals begin a process that produces different cells for four groups of reproductive cells. (1.) Sepals are similar to the plants' leaf cells and become the base of the flower. The sepals form into a whorl around the base of the flower at the bottom of the flower. The bottom of the flower is given a name, the calyx. (2.) Another whorl above the calyx is formed by petals usually colored. This whorl of petals around the base of the flower is named the corolla. (3.) The third whorl is made up of stamens which becomes the male part of the flower.

Stamens are usually formed as stalks and are the same in number as the petals. In some species the stamens are wide or leaf like with structures called anthers. The anthers are located at the top of the stalk. Some plant stamens secrete fluids or nectars at the base of their stamens. This nectar is sweet and attracts insects like bees, wasps and other pollen spreading insects. The anthers contain the pollen which contains the sperm. The pollen that is on the anthers is blown around by wind or it can stick to insects where it is carried to other flowers where the pollen becomes stuck to the female reproductive part of the flower called the pistil.

The pistil of the flower is located in the center of the flower on a stalk called a style that arises from a swollen base of the flower surrounded by the last whorl of stamens. The swollen base of the style is similar to a vase with a narrow neck where the pistil is located. The swollen base at the bottom of the style contains the ovary with ovules. These ovules become seeds after fertilization. The stigma at the top of the style is usually sticky allowing pollen grains to stick to it as the pollen drifts around in the wind or the pollen may be carried to the stigma of the flower by insects. Some flowers only have one pistil. Other flowers may have several pistils at the top of their style.

In the flowering plants, which are the dominant type of weed that growers have to deal with, the swollen base of the style which is the flower's ovary can have one or more ovules. The ovule contains eggs and a central cell called the *polar nuclei*. The ovule has two protective layers which will become the seed coat. Flowering plants or angiosperms have a protective seed cover unlike the gymnosperm with its naked seed. Inside the ovule are four megaspores (four eggs). Three of these megaspores disintegrate. The remaining megaspore splits in two to become a large cell called polar nuclei (mentioned above) and another cell called the egg.

The wind-blown pollen carried by insects lands on and sticks to the stigma at the top of the style which is a stalk or shaft that goes clear down to the ovule inside the ovary. When the pollen lands on the stigma it is held by the sticky material and immediately grows a pollen tube. The pollen tube grows through the style opening down inside the style to the ovary and then enters an ovule where the pollen tube discharges the two sperm cells that have traveled down the pollen tube. One of the sperm cells fertilizes the remaining egg cell. This action produces an embryo that will become another plant. The other sperm joins with the polar nuclei cell forming an endosperm. This endosperm becomes a source of stored food for the embryo inside the seed which is now sealed until the seed germinates. This endosperm gives the seeds like wheat and barley their main size and ingredients. It is full of nutrients and foods produced by photosynthesis by the plant.

If the pollen comes from the same flower and isn't carried from another plant, the process is called self-pollination. When pollen is carried from another plant a higher mix of genes occurs. This mixing of genes will produce a variety of the same plant but if different conditions occur, some of these different plants can survive the new conditions and the species has a better chance for survival. Some plants have flowers with stamens that appear after the plant has already been fertilized and its pollen is carried to other flowers. This is another natural way plants receive mixed genes and produce the variety of growing species that aids in the weed's survival.

Fruit

One of the parts of the evolved plant that occurred when the angiosperms or flowering plants emerged was the formation of fruit. Fruit growing and research is another entire industry.

Fruiting plants are another advance in the plant's existence to move and enlarge the populations of plant species here on earth. Just as the vascular phloem and xylem systems allowed the plants to grow taller, the epidermis material, cuticle, kept the water inside living plants and flowers enticed insects to carry and spread pollen to fertilize plants therefore mixing their genes allowing new species to strengthen the ever increasing populations of plants that emerged from seeds. Fruits evolved and attracted animals to move the plant's seeds into new areas on the planet earth.

Just as the pollen is moved from plant to plant by insects that are attracted by the sweet nectar other animals, including humans, are attracted by the fruit that they consume and then discard the seeds. Some seeds are carried for great distances by aircraft before they settle into a growing environment where they can grow into a plant producing more seeds in another location. Birds that consume fruit can swallow the seeds along with the fruit and discard the seeds in their fecal matter. Large groves of trees have gotten their start from this spread of viable seeds from fruit.

A plant produces fruit when it goes through fertilization and this is referred to as fruit set. The pollen that is spread to the flowers of the plant contains auxins that activate the formation of fruit by the plant. There are synthetic auxins made by various companies that are used in the place of natural auxins. These auxins are specific and some of them can be used to retard fruiting. In some cases the plant may produce fruit without fertilization. Fruit growth without fertilization is called "Parthenocarpy". Some citrus crops and vineyard crops produce fruit without pollen fertilization.

Failure to produce by flowers on plants is very common and the failure rate can be as high as fifty to seventy five percent. The anthers and pollen often abort due to heat and desiccation. Insects may fail to visit flowers. The death of plants can be due to weak pollen or the plants may be incompatible. Disease can also become a factor in aborted fruiting. The plant needs enough food to support the fruit and when it doesn't take in enough food their isn't any fruit set.

The ovary in some plants have petals, sepals, stamens and style which are parts of the flower and are used in the fertilization of the plant. These parts of the flower fuse together and fall off of the plant. In other cases they may fuse with the ovary and ripen with it forming the fruit. The ovule contains two viable eggs. One of the eggs is fertilized by one of the two pollens cells and the second egg is fertilized by the second pollen cell. The endosperm is formed when the second pollen grain and the second egg join together to form a source of food for the embryo. The ovule becomes a seed with a cover named the pericarp.

This cover or ovule wall ripens and is divided into three layers of fruit. The starches turn into sugars because the enzymes cause certain changes. Acid levels drop. The chlorophyll is lost. These changes are aided by the production of hormones provided at the start by the pollen. As the fruit develops it provides its own hormones. Nutrients including nitrogen, phosphate and potassium will the leave the stems and vegetative parts of the plant and enter the ovule wall and increase the fruit growth. There are several different types of fruit formations. Some plants have clusters of flowers that form groups of fruit. Examples of this include pineapples. These individual groups of ovaries can form masses like the fig with its many seeds. Other fruits form single ovaries like the berries. Other examples include cucumbers that have a hardened skin with ovules of seeds inside. Another group are the berries and the citrus with a rind containing a juicy interior with ovules or seeds.

The fruit that evolved over the years survived because the dispersal of the seeds to areas far enough from the producing plant where competition for nutrients, water and sunlight wasn‘t a problem. These fruit structures encourage travel away from the producing plant with the use of animals, water, wind and even explosive activities. Some fruits are made of spikes or burrs that keep animals from eating them, but these spikes or burrs can stick to animal hair and furs giving them a ride to other areas. Some fruit consist of shells that contain oils that rodents crave. The rodent hoards these seeds in the ground where they can germinate later and become plants. Some fruits are thin or flattened out like wings that can be carried by the wind to far off new places. The fruit on coconuts allow these seeds to float in the ocean to great or small distances on other islands. Plants like the impatiens that are tightly held together during the drying stage become very tightly bound and when disturbed they explode sending the seed great distances. The so called sand box tree can fling seeds as far as three hundred feet when disturbed. Plants produce young that can travel and multiply without the use of legs or wings that animals have. Evolution is the use of anything that allows survival to happen and fruit is one of those attributes.

The plant's fruit can also provide protection for the living seed. Walnuts and other shelled seeds are protected from nature with their fruit which is a hard shell. Some of these dry nuts include: peanuts, acorn, hazelnuts and many others called nut fruits.

Plant Tissues

As meristem cells change into the cell form that they will function in, they go through a process called cell differentiation and become basic cells with specific duties. Plant cells make up the tissues of the plant. There are three types of plant tissue; dermal, vascular, and ground. The dermal tissue includes the epidermis which is a single layer of cells that protects the plant. It has a substance called the cuticle used to keep plant fluids inside the plant. In trees the bark or periderm is dermal tissue. Stomata that are openings in the stems and leaves are dermal tissue. These stomata cells open and close the holes in the epidermis to allow carbon dioxide in and water and oxygen out of the plant.

Ground tissue cells include parenchyma, collenchyma and sclerenchyma. Parenchyma cells control photosynthesis. They change sunlight energy and carbon dioxide into food for the plant and store it. Collenchyma cells help to support plants without reducing growth because they lack hardening agents and secondary walls. The sclerenchyma cells are much more rigid with a hardening agent in their walls and are a basic source of support for cell walls.

The vascular tissues are found in the roots and stems as well as the leaves. They function in the long distance transport of food solutions, hormones and water in the plant. The vascular system has two tissues called the phloem and xylem. This system evolved in plants to allow plants to grow tall as I've mentioned before. The xylem is a pipe or conduit that moves water and dissolved minerals from the roots to the top stems and leaf veins of the plant. Xylem is formed from live tissue, but it dies and becomes dead tissue that becomes a pipeline where water and dissolved nutrients move upward in the growing plant. The phloem has living tissue and moves liquid products produced in the areas of photosynthesis in the leaves and stems to the roots, storage areas and growth areas of the plant that needs food.

Meristem Cells

When I mow my lawn the grass seems to be growing right back in a very short period of time, but I found out that the grass is growing from all new cells at the base of the cut off blades of grass. These are brand new blades of grass grown from areas called intercalary meristem cells. These meristem cells are located in all the areas of the plant that need new cells to perform different duties needed by the plant in its day to day growing needs. These meristem cells are mature cells with cytoplasm, a nucleus membrane encompassing the chromosomes inside the cell and a very small vacuole used for storage. These meristem cells are mature cells, but meristem cells haven't been specialized to do any specific activity like the other cells that exist in the plant. The other cells are specialized to do a certain function and they have a specific form. These cells that have differentiated are no longer meristem cells but they can elongate when encouraged to do so by hormones. Meristem cells divide and the other cells in the plant do not divide. By being able to divide meristem cells produce all of the new cells in the plant. This dividing or meristem cells and plant cell elongation is how plants grow in size.

Meristem cells are located in certain locations in the plants body. As the embryo is forming in the seed the stem cells are placed in locations of the embryo's body where they can function as the body of the embryo grows. Shoots and roots have meristem cells called apical meristems. The growth of these shoot meristem cells is the primary growth of the plant producing height. This results in a taller plant that can absorb more sunlight. The other apical meristem location is in the root which gives the plants a means of obtaining water and nutrients from the soil by growing downward. Roots and stems also grow in width and these meristem cells are referred to as lateral meristems. Lateral meristems also give the plant its vascular system and give the plant stability when growing taller. The other meristems are called the intercalary meristems. These allow the plant when injured to grow new cells in the injured areas. An example is the regrowth of grass blades that produce new leaves at the base of cut off blades of grass. Then I have to mow the grass again.

The plant has its growth or cell division regulated by plant hormones. The meristem cell keep multiplying, but eventually they have to become a certain type of cell that is needed by the plant for its existence. The meristem cell physically changes into a certain needed cell like an epidermal cell or structural cell. One major signal that designates what kind of cell is needed is the location in the plant. Either a cell is in the root, leaf or any specific area of the plant. Inside the plant cell's nucleus is the chromosomes with the genes. The genes are in every cell of the plant and different genes produce different cells, but once the cell has formed into a certain type of needed cell, the cell will start operating as that type of cell and it cannot change again into another type of cell. A plant meristem cell can become any type of cell that the meristem's cell can become, but there are no changes later on

Hormones

Hormones are the big decider on what the meristm cell becomes. One of the known hormones is called cytokinins. Another known hormone that can decide the fate of the plant cell is called the auxins. The two of these together are able to stimulate the meristem cells to become either root cells or shoot cells. If there is more cytokinin hormone than auxin hormone the meristem cell will become stems, leaves and flower buds. If the auxin hormone level is higher in the mix then the meristem cells will become root cells.

Just a very small amount of hormone is all that is needed; therefore hormones can be used in the location where they are produced by the plant and they can be moved very easily to other locations where they regulate vital plant processes. Hormones determine the formation of stems, leaves, and flowers. They cause the droppings of leaves and they are responsible for the ripening of the fruit of plants. Animals have glands that specifically make hormones. All of the differentiated plant cells have the equipment to produce hormones. But only certain plant cells do.

The plant has a system that can move plant hormones throughout the plant. Some hormones like the auxins are sent from the apical meristem cells in the very top of the plant to all the stem tips below to lower the growth of these stems. This transfer of auxin that slows tip growth of lower stems gives the plant the pointed, Christmas tree shape. This shape allows more light producing photosynthesis to take place in more of the plant.

Hormones move throughout the plant in four different methods. (1) The movement called cytoplasmic streaming where molecules move very slowly within the cell and (2) from cell to cell by diffusion. This occurs where high levels of molecules move to locations of lower levels of hormones. (3) Moving hormones from one area of the plant to another area occurs in the plant's phloem. Products like sugars are being moved from areas where photosynthesis is producing the sugars to growing areas where sugars are stored, or where growth activities are using the sugars as energy to carry on the growth. This type of movement is caused by crowding of new produced material that pushes the material along to empty areas.
(4) In the xylem tissues, that are dead tubes, water molecules are moving when the water molecules evaporate through openings or stomata in the leaves and stems. This *evaporation* creates a pulling of the hormones along with the water molecules to the top of the plant. The water molecules are also moving up in the plant by the *adhesive pull* to the sides of the xylem tubes. The water molecules attract one another by sticking together called *cohesion*. The hormones are carried along with the water molecules to the top of plants in the xylem tubes by the pull of *evaporation, adhesion and cohesion.*

Once the hormones reach their destination the plant cells that they enter either respond to the hormone or do not respond to the hormone. Plant cells react to hormones at different and specific growth stages. The hormone effects on the cell can diminish before or after the specific time when that cell needs it. The plant also must be able to stop the effects that hormones have produced when the cell no longer needs these effects. Hormones are produced in meristem cells before the cell has differentiated. These hormones can be moved to other parts of the plant or the hormones may be stored in the undifferentiated meristem cell until being released later or they may be used in the undifferentiated meristem cell.

Plants control and regulate the amount of hormones present in the plants body. Plants control the amount of chemicals used to form hormones. Plants can store hormones, inactivate them, or join hormones with carbohydrates, peptides and amino acids. Plants can chemically break down hormones. By moving the hormones around in the plants' bodies the hormones are reduced in quantity as they are spread around the plant.

Scientists first did some early scientific studies on hormones in the late eighteen eighties, but the real studies and analysis of hormones was done in the nineteen seventies. Most of the hormone discoveries have occurred during the last seventy years. Researchers have grouped hormones together based on their structural make up and how the hormone affect plant physiology, but all hormones can't be put in these classifications. There are now several synthesized hormones produced by humans. 2-4D is a synthesized hormone that inhibits plant growth and is classified as a herbicide. Other synthesized hormones are produced to give positive results in plant physiology. Scientists have grouped the hormones into five major classes.

<u>Auxins</u>

Auxins were one of the first class of growth regulators discovered. They influence cell elongation by causing the plant cell walls to soften up and allow the cell to grow larger. They are also involved in the bud formation and root growth. They have been found to be involved in stem root growth which includes lateral root and adventitious root development. In seeds auxins regulate protein production and this causes the plants fruit to develop around the seed. Auxins can inhibit the growth of buds lower down from the apical meristems at the top of the plants allowing light to reach a greater surface of the plant's leaves. Nurseries use auxins to stimulate root growth in plant cuttings.

Cytokinins

Auxins work from the apical meristems at the top of the plant to control the plant growth below. Auxins are controlled by the downward pull of gravity. The hormone, cytokinin, that are raised up from the roots of the plant by gravity join with auxins to regulate the growth of plant parts. Cytokinins when mixed with auxins counter the slowing down of growth caused by auxins. Cytocinins increase growth and auxins decrease growth. The two hormones, auxins and cytokinins along with the hormone, ethylene, end up causing abscission of fruit, leaves and flower parts allowing them to fall from the growing plants when ripe.

Ethylene

A material in all plant cells breaks down to form the hormone ethylene. Ethylene exists as a gas. Because ethylene is a gas and is not very soluble is water it doesn't stay in cells. As a hormone ethylene that escapes easily from the cell has its value as a hormone determined by how fast it can be developed in the cell. In developing cells and germinating seeds the ethylene levels are high and this leads to a drop in leaf growth. This increase in ethylene is greater when conditions of darkness dominate. When the new seedlings are exposed to light the reactions in the plant cells give off a signal for ethylene production to drop and the leaf growth resumes. When a new shoot from seed buried in the soil runs into an object like a rock, the shoot is damaged, but this also increases the production of ethylene thus stopping the shoot growth. The shoot swells up. The thickening of the shoot gives the shoot more pressure against the rock. If the shoot can't grow up like it's naturally programmed to do, which is against gravity, the shoot can, because of the ethylene, grow around the rock.

Ethylene affects stem diameter and height. Studies have shown that when wind causes stresses on tree limbs, the ethylene increase in the tree's cells will increase and the tree limbs and trunk and the whole tree will get stronger. The concentration of ethylene increases in fruit as the fruit ripens. Animals are attracted to the fruit and carry it for distances from the producing plant to other areas where the fruit is consumed and the seeds are dispersed.

Abscisic acid

This chemical, abscisic acid, comes from plant cell chloroplasts. Plants under stress are more likely to produce abscisic acid. It inhibits plant bud growth and extends seed and bud dormancy. As it leaves the inhibited buds, seeds, and leaves of the plant, growth begins again. This is because the hormones, gibberellins, begin increasing in the same area of the plant, causing an increase in growth.

Abscisic acid becomes a savior of warm season plants by preventing their seeds from germinating during warm spells in the winter cool season. When the weather turns back to the natural winter cold weather, the new seedlings will freeze and die if they germinate. Abscisic acid will keep them from germinating. The abscisic acid normally leaves the plant tissues at a very slow rate. This slow release from the plant tissue keeps the other hormones that take over the growth from causing premature growth that could harm the plant. The abscisic acid is degraded in the plant tissues by the entrance of water that washes in and out and the increase in cold conditions. These conditions also release the seeds and buds from their dormancy periods, if the seeds are cold season plants.

In the epidermis cells of plant stems and leaves there are openings called stomata. These stomata allow water to leave the plant and carbon dioxide that is needed in photosynthesis to enter the plant. All plants that have a vascular xylem that transports water from their roots to their top leaves and stems have these stomata openings. The stomata have guard cells that perform by swelling just enough to close the air release outlets, thus reducing the amount of water released by the plant to the atmosphere. The plant normally takes in water through its roots and releases it through the open stomata in its leaves and stems.

When water is scarce and the roots are running out of water, the roots send a signal up to the leaves. This signal causes a biochemical substance called a precursor that can form abscisic acid. This precursor material moves from the leaves to the roots where abscisic acid is formed. Then the roots form and release abscisic acid into the xylem part of the vascular system. The xylem vascular system carries the abscisic acid with water up to the stomata of the plant's leaves and stems. This abscisic acid modulates the amount of the nutrients, potassium and sodium, going into the stomata guard cells. This affects the stomata guard cells causing them to close thus reducing the amount of water lost by the leaves and stems and the plant doesn't dry out and die.

The degradation of abscisic acid in the plant affects the metabolic reactions, cell growth, and other hormone production throughout the plant. Seeds have high levels of abscisic acid when they first form as ovules in the ovary of fertilized plants. Just before seed germnation the levels of abscisic acid decreases, but as the seedling grows into a plant the leaves and stem start to increase abscisic levels again in the plant.

Gibberellins

In nineteen fifty eight I attended a biological seminar at Stanford University in Palo Alto, California. As an aid I attended with one of the professors that was at the University or California at Davis, California . He had me attend and take notes at all the meetings where gibberellins would be discussed. Gibberellins were the hot plant hormone during those days. Papers were given by about fifteen researchers from most of the agricultural research areas from all over the world.

At Davis the plant physiology department did quite a bit of weed control research and I worked in that department in a part time job to supplement my GI check for my education. One of the research projects on gibberellins that I worked on was to study their effects on the speed and spread of the auxin weed killers, 2-4D and 2-4-5T in bean plant seedlings. We used radio active carbon placed in the herbicides. Then we treated the leaves of the seedlings with the gibberellins to see how fast and far the herbicide would spread. We sprayed the growing plants and waited a certain time then washed the plants off, froze them with dry ice and laid them between two sheets of photographic paper. This allowed them to take their own pictures. It worked great. We even got it published. The gibberellins increased the spread of the herbicides in the plants fairly rapidly. Later after graduating I ran my own field tests using zinc sprays on cotton a week after treating the cotton plots with gibberellins. The yield data showed an increase where I used this hormone to increase zinc reactions.

In Japan rice growers noticed that some plants grew away from the other plants and when they investigated they found that it was caused by a fungus that they isolated. But these rice plants didn't have an increase in yield. They just grew taller than the rest of the plants. During the nineteen fifties there was a great deal of research done on gibberellins with the outlook for increased yields being the goal for their use, but many of the goals were never realized. This is due primarily to fact that the goals of increased yields and production where based on the increased use of the hormone. The increase of varieties of new crops have bred into these new crops the ability to produce more of their own portions of gibberellins; therefore added gibberellins spray applications were no longer required.

The table grape industry was the exception. The use of gibberellins to produce larger and very good quality grapes was a plus for the table grape industry. It's very rare to see small grapes in a produce grocery department. In Bakersfield, California I knew a table grape grower who when he asked what the rate per acre he would need? He was told “one pint“. He applied a gallon per acre. He was a large grower and took the New York table grape market that year. Gibberellins can be used at high amounts without causing harm to the crop. This is unlike the other hormones like auxins that do cause harm to the crop and thus they are used as herbicides (2-4D).

Gibberellins are included in a range of chemicals that include chloroplasts and carotene. The number of different gibberellins has been reported as fifty two. The synthetic gibberellins are made by companies. All plant organs contain gibberellins but the areas of the plant with the highest concentrations are in fruits, seeds, buds, young leaves and root tips. Applying gibberellins to dormant seeds even though the seeds should have ample amounts will start the seed germination process because at this period of plant life either the gibberellins are tied up or there isn’t enough available for germination. Intercalary meristems like the ones in grasses are lower in gibberellins and will react to gibberellins applications.

Mitosis and Meiosis

Living cells and this includes plant cells increase in numbers and in size. When the hormone auxin affects the living plant cell by causing the cell wall to enlarge the cell will expand and fill the enlarged space with an elongated plant cell. The other method of increasing the plant’s size is by producing more cells. Plant cells do this by replication. The cell is copied and separated into identical objects using the original as a pattern. Plant cells have <u>two</u> sets of chromosomes that are made up with DNA and proteins and they are named diploids. The gamets which are the plant’s sex organs like the sperm and eggs have <u>one</u> set of chromosomes and these cells are named haploids. The pairs of chromosomes are called homologous pairs. They are similar in structure and evolutionary origin, but not in their function that they may carry out.

Living plant cells go through life cycles. They live most of their time in interphase which is divided into three stages. The first stage is called the (first gap or <u>gap 1)</u> the second is the (<u>synthesis)</u>; and the third is named (<u>gap 2.)</u> During the (first life stage or gap 1) the plant cell goes through its normal duties or functions that keeps it alive and it may gain in size through elongation when stimulated to do so by the auxin hormone. Auxin increases the size of the cell wall allowing the cell in its membrane to elongate. During the second life stage (synthesis) the chromosome that is a strand like thread containing the DNA of the plant replicates. It grows another identical chromosome. These two chromosomes are now called chromatids and each pair of chromatids is connected to one another at their middles. Where they are connected they an item called a kenetochore.

In the final life stage called the (gap 2) the cell makes materials (spindle fibers and two poles) to carry out the division of the chromatids.

<u>Mitosis</u>

There are five phases for the separation of cells called mitosis. The names given for these phases are: prophase, prometaphase, metaphase, anaphase and telophase. These phases are a continuous process that takes place in the cytoplasm of the original cell.

In the prophase with the use of a microscope it can be seen that the chromatin become tightly coiled and the chromotids become visible as the spindle fibers form in the cytoplasm of the cell.

In the prometaphase, the nucleus membrane inside the plant cell around the chromosomes, breaks down and disappears. Then the spindel fibers form together in the cytoplasm of the main cell. These fibers attach themselves to the kenetochores of each set of chromotids. The nuclear region of the cell doesn’t have its own membrane at this time, but this region of the cell cytoplasm now has two poles on either side of the region.

When the metaphase occurs the cell's chromtids line up between the two poles in the middle of the poles. The joined chromotids have their two bodies back to back facing toward opposite poles located at either end of the region. The spindle fibers connect to the kenetochres on the chromotids and they connect to each of the poles. The fibers made of tubulin begin to contract and pull the chromotids apart toward the poles. This results in the disconnection of the chromids and the formation of two independent identical cells with two homologous chromosomes.

The poles and spindle fibers fall apart and a new nuclear membrane forms around the chromosomes and the chromosomes start issuing messages to the RNAs to build new proteins, enzymes, and other needed cell and plant parts. The life cycle of the plant cell goes into the first phase which is gap one where the plant cell enlarges and continues to produce amino acids that it uses to make proteins until the cell goes into the synthesis phase and starts replicating its DNA to enter the third phase of mitosis or gap two.

(**Root herbicides** are able to inhibit the mitosis action of the plant cell. These root mitosis inhibitors are named dintroanalines. They do this by inhibiting the formation of the **spindle fibers**. These fibers are made from tubulin. By stopping the production of tubulin the cell ends up with root cells with double chromosomes and faulty cell walls that can't continue to grow or absorb nutrients. This results in plant root tips that are clubbed and swollen and the common visual signs of nutrient deficiencies. These include: yellow or purple leaves, whitening due to loss of chlorophyll and weak stems due to poor cell walls. The herbicides are called Dinitroanilines which include: Balan, Treflan, Prowl and Surflan. They control weeds by destroying the tuberin from which the spindle fibers are produced)

Meiosis

When the time in the life stage of a plant reaches the fertilization stage the plant meristem areas are triggered by hormones and environment signals to produce sex organs. All plants go through this part of life at some time. Instead of doubling cells that results in growth, the cells produced start a new plant that is genetically different. These genetic differences allow the plant to survive in differences that will occur in their environment. The male organs of the flowering plants include the pollen which is made up of sperm cells. The female sex organs are made up of eggs. Both of these organs are cells in stages of life that only contain one chromosome. These one chromosome living cells are called *haploids* because they only have one chromosome containing their DNA. Their parents have two chromosomes and are called diploids. The sperm and the eggs are called haploids with just one chromosome.

Unlike mitosis there are two stages instead of one stage in meiosis. They are meiosis 1 and meiosis II. Interphases precede meiosis1 with prophase 1, metaphase 1, anaphase 1 and telephase 1. The interphases for meiosis 11 has the following phases: prophase 11, metaphase 11, anaphase 11, and telephase 11.

During prophase 1 the nuclear membrane containing the chromosomes in the plant cell comes apart allowing the chromosomes to exist in the cytoplasm of the plant cell. The spindle apparatus starts to form just like in mitosis. Then chromosomes join together forming tetrads that consist of four chromatids. Remember for mitosis that two chromatids are joined together as two sisters: two sister chromatids for each chromosomes.

These chromotids are called homologous. They have the same morphology and location of genes, but they can have some gene variation. Again these chromatids are joined together at the center of there long thick string like bodies in an area of their bodies called kenetochores.

Their arms reach out and touch the arms of the other homologous chromotid. Wherever they make contact that point of contact is called a chiasmata. Both sister chromatids have chromosomes that are able to break at these locations and pieces of chromosomes are exchanged or swapped. This is how genes are exchanged and each chromosomes receives a new combinations of genes. The changes that take place will result in them being genetically different than their parent plants. These changes in the new plants can aid in the survival of the plant in the new and different changes that occur on the earth.

During metaphase 1 the tetrades strings line up on the plates in the center of the cell.

During anaphase 1 the spindle lines are attached to the kenetochore on the sister chromotids, but unlike the mitosis program the two sisters stay together and the tetrade with the four sisters together split apart and start moving to the poles at each end of the plant cell.

Telephase 1 starts as the two sister chromotids reach the poles at either end of the cell. The poles and spindle lines fall apart and a new nuclear membrane forms a new neucleus at either end of the cell with chromosomes and other plant cell parts forming. In each cell there are four chromotids. Each chromosome has two chromotids joined at their kenetochores.

Meiosis 11 starts the same way that mitosis starts. During meiosis 11 the chromotids that are still joined together in meiosis 1 are taken apart using the same steps as mitosis 1. The same type of poles and spindle apparatus with the plate in the middle is used and all four of the daughter cells are pulled apart by the fibers and poles to form a total of four cells with a single set of chromosomes called four haploid cells. This takes place in the male and female sex organs or gametes which are the male sex organ, containing the pollen, and the female sex organ, containing the egg.

These gametes are the start of a new generation. In the early plant like the mosses and ferns these gametes were plants that developed spores. These haploid gametes with one chromosome were the independent generation of the plant’s life. As plants evolved the gamete became dependent on the diploid plant that started with the embryo in the seed that has its own source of food until germination when photosynthesis produces food for the plant with diploid cells containing two chromosomes.

<u>Advantages of meiosis</u>

One of the advantages of meiosis includes the following. There is only one gene item for one genetic trait or outcome. This trait isn’t dominated by another trait and the one you get is what’s there. If there is a mutation that is lethal or harmful, this trait will be expressed and the offspring will die before it is born; therefore the bad trait will not be passed on to future generations of weeds or plants. This protects the rest of the genes from getting bad traits and keeps them strong. At the same time mixing the genes gives the offspring a variety of traits that may be needed when danger occurs. The evolving plants can handle and overcome more harmful things that may happen.

Plant Fertilization

New nucleus membranes are formed in the resulting four haploid cells. Each cell produces the necessary parts of a new cell including proteins, enzymes and other plant cell needs. The female haploid cells become eggs located in the ovules of the ovaries of the plants. Of the four female eggs only one of them will survive. This egg or megaspore goes through three rounds of mitosis resulting in seven cells. (One of the seven cells ends up with two nuclei and it is called the *polar nuclei*). Three of the seven cells end up at the bottom of the ovule and the middle one is the one to form the new plant embryo with one of the entering sperm cells. The other two are there to attract and guide the sperm cell to the target egg. Three more cells will be located at the top of the ovule. After fertilization they will die.

The sperm cells develop in the sex organ of plants. In flowering plants they are made in the anthers of the flower. Four haploid cells with only one chromosome are produced by meiosis. Each of these cells can become pollen grains. The haploid microspore goes through mitosis and with directions from the hormone (cytokinens) to form two cells: a pollen tube cell and a generative cell. The spore wall, the pollen tube and the generative cell make up the pollen grain. Once the pollen grain is carried by insects animals or wind to a flower stigma, the tube cell becomes a pollen tube and the generative cell goes through mitosis and becomes two haploid sperm cells that go down the tube to the ovule that is inside the ovary. One of the sperm cells mates with the polar nuclei to form the endosperm. The endosperm grows into a source of food for the new embryo while it is in dormancy. The other sperm haploid cell mates with the main haploid egg cell and an embryo is formed that is diploid with two chromosomes (one from the male haploid sperm cell and the other from the female haploid egg cell). The embryo inside the ovule becomes a seed in dormancy.

The joining of the haploid male cell and the haploid female cell mixes the genes of the two into two chromosomes producing an entirely new diploid plant that has a different mix of genes than either parent had. This mix will help this different plant to exist and multiply in a world that keeps changing.

The Plant Seed

After the plant goes through the fertilization process the fertilized egg grows by producing cells which include meristem cells and forms a new embryo. The embryo consists of three parts; the hypocotyl, plumule and cotyledons. These parts take shape as the cells of the fertilized egg start dividing and growing into an embryo. The first cells of the embryo are the meristem cells. The meristem cells divide into the hypocotyl of the embryo which is the main stem that the plumule and cotyledons are attached to. At the bottom of the hypocotyl is the root. The root grows from its own set of meristem cells.

The cotyledon (monocotoledon: only one leaf) and (dicotyledon two leaves or in some cases many leaves) is attached to the embryo’s hypocotyl just below the plumule. The third part of the embryo body (the plumule) is the main body of the embryo where meristem cells are located that will later (after germination) proceed to produce the true leaves. Some embryos have just one cotyledon. The embryos with one cotyledon are called monocots and their single leaf covers the emerging plant. The embryos that have two cotyledons are called di cotyledons (dicots). The shortened term (two leaves) and monocots have (one leaf). There are seeds of pines or conifers that have as many as fifteen cotyledons. The cotyledon leaves are different than the true leaves that grow on the plants after the embryo germinates but cotyledons can produce food for the emerging seedling by photosynthesis after germination..

Seed Dormancy

One of the main reasons that weeds are so hard to control is that their seeds have a dormant stage that keeps them from germinating when growing conditions are bad for them to survive. Once the plant has produced a seed, the seed will not germinate and produce a growing plant until conditions are such that the new seedling has a chance of surviving. Dormancy allows the weed seed to survive during the period of dispersal. This dispersal period of time before the seed germinates is when the seed is said to be in a dormant period of life when the seed can travel away from competing plants. Even after the seed has been dispersed it may not germinate for a period of time. Conditions that the seed may find itself in may not be good enough for the seed to survive. An example of a dormancy situation is when a winter annual weed seed finds itself in spring or summer weather conditions that would probably kill the winter annual seedling. The seed will stay dormant and not germinate until fall or winter conditions occur. There are plants that go into dormancies that can last for several years. Some plants have seeds that go into dormancy for fifty years. The method of telling how long a seed has been in dormancy called the radiocarbon dating method was used in one study on dormancy that proved that a seed was in dormancy for two thousand years. When the seed came out of dormancy it was able to germinate and grow into a living plant.

Seed scientists have done a very good job of producing seeds that give the farmer's good crops with high yields, and it has taken them several years to produce the crop seeds that we now have. Just as seed scientists have spent a great deal of time researching seed dormancy to find out how to break the dormancy. Nature has done the same thing using survival against extremely bad growing conditions to produce seeds that can live and multiply. Nature used selectivity where the hardiest survived and multiplied. Nature took the time that these hundreds of millions of years gave them to produce some very strong weed seeds. For a great many years weed seeds have been subjected to growing conditions that have been extremely severe. The weed seeds that cause our weed problems today were able to survive all of the earth's calamities because nature has not been working on only yield increases, but on survival techniques. Nature's biggest survival techniques include the shuffling of genes through meiosis and seed dormancy. This increases the variety of genes that will have to confront a variety of conditions.

It becomes hard to pin down what kind of conditions are ideal for the germination of a seed. The seed goes through growing stages and the changes in conditions have to allow the seedling's growing stages to occur or the germination process stops. There are a number of conditions that the weed seed can overcome by staying dormant because here are several types of dormancy for weed seeds to go into.

One of the stages of dormancy is called innate or primary. The dictionary says that innate means inborn or inherited or primary and it occurs during and after the seed breaks away from the plant. This is the time needed by the embryos to grow and develop. The new embryo that will become a plant needs time to leach or get rid of the natural internal inhibitors that keep it from growing. These inhibitors (usually hormones) keep the seed from germinating and growing into a new plant or weed. If conditions are such that this new weed couldn't survive, these inhibitors that the seed has will save the seed's life. But as the seed develops it no longer needs the inhibitors. One method of testing for the presence of these inhibitors is by adding gibberellic acid (another hormone) that increases plant growth. This acid overcomes the seed's own inhibitor allowing the embryo grow.

Another innate or inborn dormancy object that slows the growth of the embryo is the hard seed coat that the seed develops. Very high temperatures or very low temperatures can crack this hard seed coat, allowing the embryo to grow into another mature weed. Another method used by seed people to break seed dormancy caused by the seed's tough seed coat is the use of seed scarification which will cause germination of the dormant seed.

These innate or inborn forms of dormancy only work once to stop the embryo growth. Once the seed goes through one of its own methods of breaking its inborn cause of dormancy the seed will not produce another method to stop germination. Other outside conditions can cause dormancy.

Some plants need a period that is dry to break the dormancy. Grasses that grow in arid regions need to be dried out. When these seeds are kept in moist conditions they do not germinate, but when they dry out even in areas where the temperature is high or low the seeds will break out of their dormancy. This is true for a number of grasses.

Another type of dormancy (induced) is when a seed is exposed to heat or cold conditions that they aren‘t able to overcome and survive. If one of these weeds seeds is a winter annual and it is planted in the middle of a hot summer the weed seed will go into dormancy until late fall or even the following winter and then germinate. Temperatures that are of the opposite kind will break the dormancy. Yellow foxtail seeds and pigweed are two annuals that will go into dormancy when planted in the middle of a hot summer. These seeds will stay in dormancy until cold temperatures in the fall or winter months break this dormancy. The loss of light by shading will cause some seeds to go into induced dormancy when they are shaded out by the leaves of growing plants. Unlike the innate or inborn dormancy, induced dormancy can cause a seed to go into dormancy again and again. As long as the inducement continues the seed will stay dormant.

When environmental conditions are unfavorable enforced dormancy occurs. This type of dormancy is broken when the conditions are again favorable. These environmental conditions include: lack of moisture, lack of oxygen and some salt conditions.

Weed Seed Germination

When conditions are right for the growth of the seed embryo, germination can start. Germination of a weed seed is the stage of life that the embryo of the seed goes through while growing into a weed seedling. The period of dispersal of the seed has taken place and any type of dormancy has passed. The embryo now goes through the stages of germination. The process of germination also includes the growth when fungus and bacteria emerge from spores. The new plants are referred to as seedlings and the new spores are referred to as sporelings.

In order to germinate a seed must have a supply of water. When the seed takes in water enzymes are activated that break down the basic foods. These include starch, proteins and oils. The amount of water needed should be enough to moisten without soaking the seed. Soaking can stop the process of germination by denying the embryo the oxygen needed for the metabolism or breakdown of the food supply that the embryo has stored inside the seed coat when it was first formed. This oxygen is vital to give the embryo enough nutrition until it becomes a seedling with leaves that allow the seedling to carry on photosynthesis to produce its own food. Seed that is buried too deep in the soil can also be deprived of oxygen. The seed’s coat may be too hard or thick keeping oxygen from entering the seed. The loss of oxygen by any of these problems will cause a type of physical dormancy that can be broken when the seed coat cracks or is worn away allowing the oxygen to enter.

The seed also needs temperatures that are in the range needed by the individual embryo to keep germinating. These temperature needs can vary either up or down depending on the weed seed embryo. Light or darkness can also be needed for the embryo to keep growing or germinating. Some embryos require light and some require darkness to continue growing. The darkness or shading that crop plants provide is a form of weed control that is very affective in controlling weeds. Fast growing crops like vegetable crops provide shade to the weed seeds and this stops the germination of the weed seeds that need light to germinate. Weed control without the use of herbicides depends on the ability of the crop to outgrow and dominate the weeds. Making crops stronger than weeds by genetic engineering of the crop plants is one of the latest methods of controlling weeds with better growing crops.

The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

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