

SPORE PROPAGATION OF FERNS

Presented by the American Fern Society
Outreach Program

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Blechnum spicant
Deer fern

“If it were required to know the position of the fruitdots ,or the character of the indusium, nothing could be easier than to ascertain it; but if it is required that you be affected by ferns, that they amount to anything, signify anything to you,that they be another sacred scripture and revelation to you, helping to redeem your life,this end is not so easily accomplished.”

Thoreau



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Why propagate ferns from spore

Those of us who are intrigued by ferns needn't ask, "Why?" when it comes to spore propagation, but for the novice the lengthy process may need justifying.

For instance why not just make a division? You might be reluctant to divide your prize plant.

What if you need many more ferns than your divisions can offer?

Or, your plant may be too small to divide.

Or a particularly prized plant is unavailable except as spore?

Or the fern you want can't be divided as it has only one growing point. (for example: Bird's nest ferns, and some Staghorn ferns.)

Asplenium nidus
Birds' nest fern



Platycerum superbum
Staghorn fern



In revegetation projects it is a common requirement that plants are site specific.

This would require that ferns are grown from spore which was collected on site.

Spore grown ferns reproduce sexually thereby maintaining the gene pool.





When growing ferns from spore there always is the exciting potential that a new variation may appear.

Because of the many restrictions on importing plants from abroad fewer new and interesting species are available. However since spore are more easily imported than live plants, new species can be available through growing of the spore.

Importing fern spore rather than fern plants also protects endangered or threatened species and limits the accidental introduction of unwanted pest and plant diseases.

Perhaps one of the biggest reasons for doing something special and new is to satisfy the sense of curiosity, challenge, or just being able to say, "I have done it!" It is akin to reliving the childhood desire to grow a big sunflower. Remember the thrill of watching it grow and to see it finally bloom.

Growing ferns from spore is the same except there are more thrills and challenges.



Ferns are unique.

Two independent plants in one!

Ferns are unique in having two very distinct plants in their life cycle: there is the mature plant which we are familiar with, and also the young gametophyte plant which few people have seen, let alone understand.

A lengthy sometimes frustrating process, spore propagation can provide an understanding of ferns and their unique life cycle.

Mature frond of *Dryopteris arguta*
Coastal wood Fern



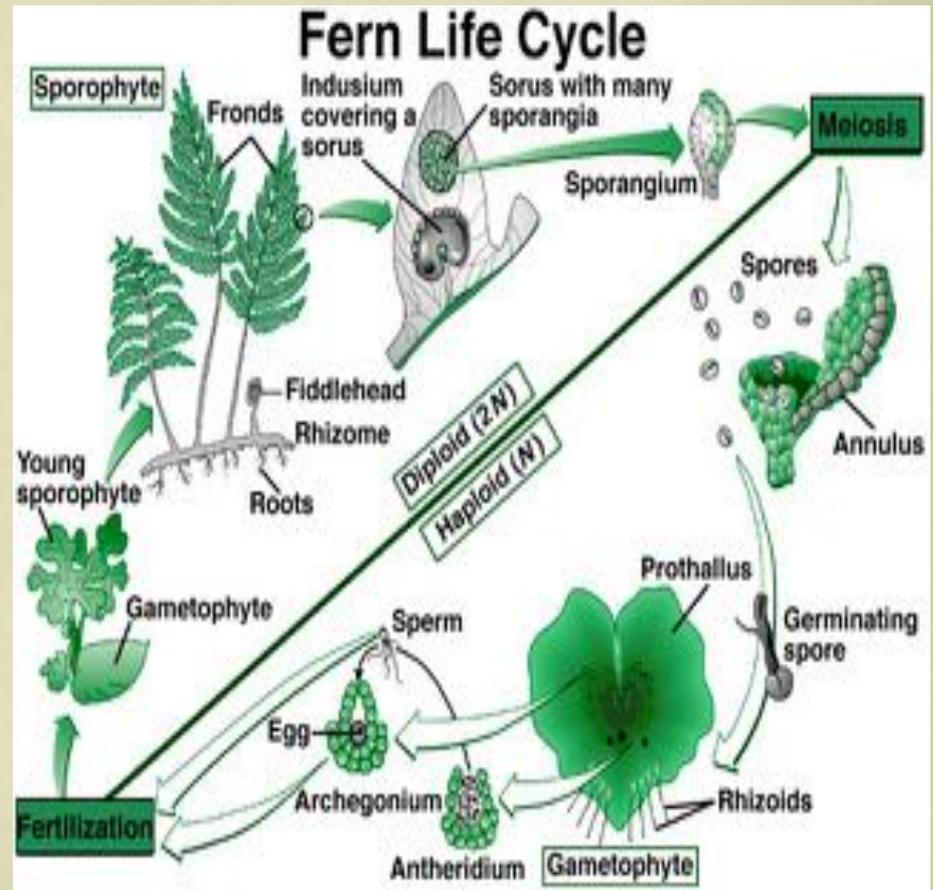
Young gametophytes of *Dryopteris arguta*
Coastal wood Fern



The overall process of growing ferns from spore

What is involved in the process? Very briefly it involves dusting fern spore onto a “disinfected” growing surface and nurturing this culture until the small gametophytes (sex plants) form.

The gametophyte form the microscopic eggs and sperm. When an egg is fertilized it eventually grows into the familiar fern that bears spore (the sporophyte) thus completing the cycle.





Length of growing time

The entire process of growing ferns from spore may be as short as 6 months but most ferns take up to 10 months and some may take longer.

There are several methods of growing ferns from spore. The method described in this tutorial is basic and kept as simple as possible.





Where do you start

Gathering the Materials

Once you have resolved to be patient and attentive in this adventure, the first step is to gather the materials needed.

Materials needed will be discussed in the upcoming slides.

Materials needed

Cleaned spore.

Containers to disinfect soil in.

Disinfected soil.

Sowing containers for soil.

Plastic wrap, rubber bands, and labels.

Distilled water, or cooled boiled water.

5%-10% bleach solution for disinfecting tools, and surfaces.



Fern spore

Packets of fern spore are offered by various fern societies. Ask for their spore list. However you may collect spore from mature ferns that are producing fertile fronds.

Beginners should start with easy to grow species : Lady fern (*Athyrium filix-femina*), the Autumn fern (*Dryopteris erythrosora*), the Cinnamon fern (*Osmunda cinnamomea*), the so called Australian tree fern (*Sphaeropteris cooperi*), and common *Thelypteris* species.



Athyrium filix-femina
Lady fern



Dryopteris erythrosora
Autumn fern



Osmunda cinnamomea
Cinnamon fern

Fast growing ferns are often apogamous ferns, they are species which grow directly from the gametophyte (prothallus) rather than from a fertilized egg.

Apogamous species easy to grow: the common Maidenhair ferns (*Adiantum raddianum*), Holly ferns (*Cyrtomium falcatum*, *C. fortunei*), Brake ferns (*Pteris cretica* and its cultivars) and many more.



Adiantum raddianum
Maidenhair fern



Cyrtomium falcatum
Holly fern



Pteris cretica
Brake fern

Fern spore - Fresh spore germinate the best; after one year the germination rate noticeably decreases.

Spore with a green color should be sown within a week of harvesting, viability averages about two months.

(Examples of ferns with green spore:

Osmunda, *Todea*, *Equisetum*).



Adiantum aleuticum
Western five finger fern



Blechnum spicant
Deer fern



Todea barbara
Todea



Polypodium californicum
California polypody fern

Collect fresh ripe spore from the plants of your choice. (See "How to Collect Spores" a free cd available to members of the American Fern Society, contact Tom Stuart at: tstuart@westnet.com).

The easiest method to collect spores is to put leaflets with ripe spore into a leak proof paper envelope (never plastic!) and allow them to dry and shed the spore.

(Do not "press" fleshy or wet frond in a book or put them in plastic bags as leaflets may not dry well enough to release the spore).

Shed spore will appear as a powder.

The powder will contain the spore and debris (mostly old spore cases).



Collected fertile frond of *Blechnum spicant* showing released spore. (Deer fern)



To separate the spore from the debris place the powder on a sheet of clean paper that has been creased down the middle. Gently tap the powder from the underside of the paper. The coarser debris material will bounce ahead leaving the finer, denser, more uniform - textured spore behind.



On the left is the debris or chaff, on the upper right is the cleaned spore.

Discard the coarser material. The spore may be sown now or stored until later by carefully folding them into a paper packet or leak proof envelope. If the spore seems to be mixed with a lot of fine debris that has not separated during the cleaning, sift the mixture through photographic lens paper, over a clean sheet of paper.

Most of the debris will be caught in the lens paper which is discarded. The spore may be sown or folded into a packet for later use.



Creating a spore packet

This easy to make spore packet will securely hold the cleaned spore.

From the top left:

Fold paper in half diagonally.

Fold the right third to the left.

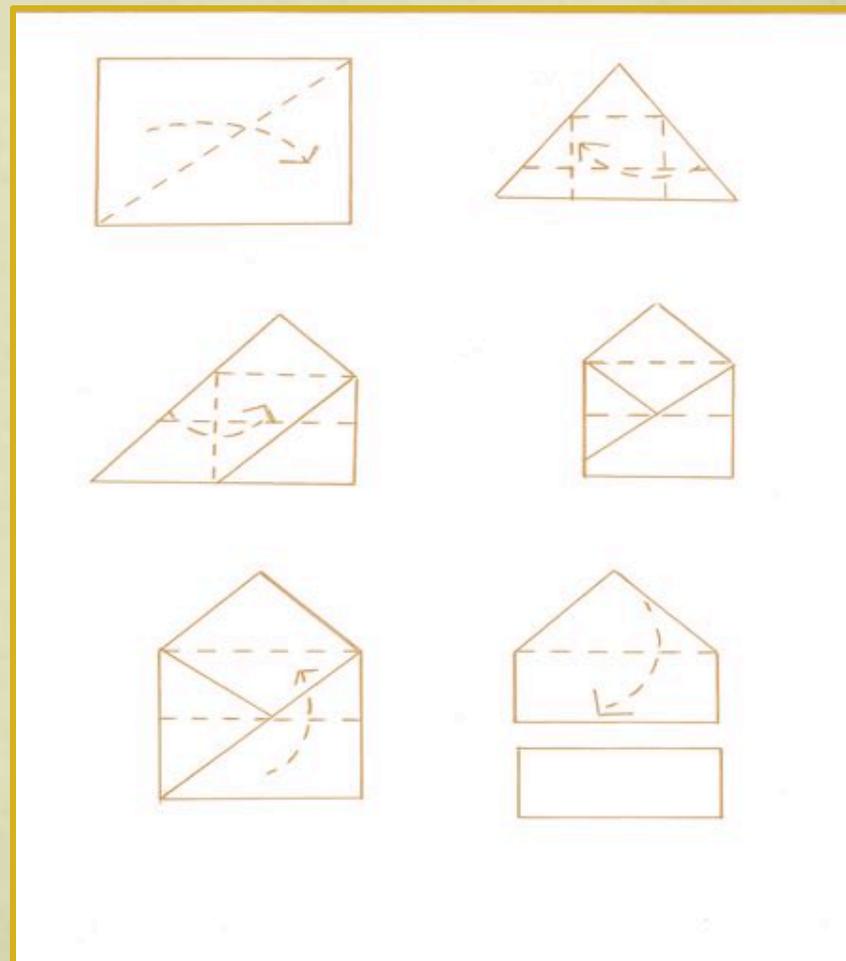
Now fold the left third to the right.

Tuck the left point between the sheets of the right point.

Fold the lower half of the square upwards.

Fold down and tuck the upper point between the double sheets to close.

Enter the genus and species name, date of collection, and source of spore on the packet.



Containers for disinfecting soil :

A lidded plastic or glass container or casserole dish which is about 4 inches tall that is microwavable and heat proof. This covered container will hold the soil to be disinfected. Once disinfected the soil is then spooned into smaller growing containers. Containers and lids must be microwavable and heat proof.

Bleach- dilute this with water to a 5 – 10% solution. Used as a disinfectant.

Soil mix- a fine textured mix that will drain well but yet hold moisture. (see slide 22)

Distilled, or cooled boiled water - which will be used to moisten the media.
(*never straight tap water*)



Microwave or oven - used as a means of heating to disinfect the soil mix. (see slide 23 for details.)

Growing area - scrubbed and cleaned, with a consistent temperature between 65-80 degrees F., and with indirect sunlight or artificial light providing 10 -16 hours of light.

Labels - to note name of fern, sowing date, source, and other information.





Sowing containers and utensils

The containers and their lids, utensils such as spoons, tweezers, and spray bottles, should be cleaned and soaked in a 5% bleach solution for a few minutes, and then drained; no need to rinse. Use new plastic wrap and rubber bands when covering the sowing container.

If the soil mix is to be disinfected directly in the sowing container, a glass or heat proof plastic container must be used.

Using sowing containers with drain holes make it easier to avoid overwatering or saturated soil. If outfitted with a saucer, they may also be watered from the bottom when needed. Types of sowing containers vary from plastic pots, to deli containers with clear lids, etc. It is essential that the containers be disinfected, that they allow light, and provide drainage.





Soil mix



It is important that the sowing media provides good drainage yet holds sufficient moisture.

Soil mix for spore may be commercially prepared potting mixes (such as Supersoil or Black Gold) that are sifted to remove large pieces of the mix. You may make your own mix by sifting together 1 part soil, 1 part sand, and 2 parts of peat moss.

Soiless mixes, if preferred may be made by using milled sphagnum or peat mixed with 2 parts fine perlite along with micronutrients.

Preparing the media

Disinfecting the soil may be done in the oven, or microwave, or by using boiling water. Place the moist (not soggy) soil into a 1-2 qt. glass casserole when disinfecting with the oven, or microwave.

For oven: bake for 2 hours at 300°F. *The rule of thumb is to maintain the soil temperature between 160° to 180° F. for half an hour.*

For microwave: set at high and bake for 10 minutes. *(Use the rule of thumb as mentioned above.)* Repeat sessions as needed to maintain temperature.

Boiling water method: place moist soil mix into a clay pot with drain holes. Very gently pour the boiling water over the soil until it drains out. Then apply the second portion as before. Let soil in pot drain before applying the next portion of water.





Keep the disinfected soil covered until cool and ready to be spooned into the sowing containers.. it should still be moist.

If the soil is too dry it may be moistened with distilled or boiled water.

If it is too wet or saturated allow it to dry out, or drain the excess water off.

Spoon the moist soil into the sowing containers to about $\frac{1}{2}$ to $\frac{2}{3}$ " from the top.

Gently level and firm the surface, cover immediately.

Surplus soil may be stored in disinfected cans or large zip lock bags.



Sowing the spore

Now that you have gathered the materials and prepared them, you are ready to sow the spore.

Find a draft free place to sow the spore as they are very small and may easily float away.

The work surface should be clean; wipe with 5% bleach solution.

Avoid sowing different species consecutively to avoid cross contamination.



Uncover the spore container, check to see that the disinfected soil is cool enough and moist.

Place the paper or packet holding the spores above the soil and very gently tap the paper so the spore is dusted over the soil surface as evenly as possible.

Avoid sowing the spore too densely.

After sowing, secure the lid and label the container giving the name of the fern, the date sown, and the origin of the spore. The containers are now ready to be moved to their growing area.



Growing place - a large to medium size north or east window receiving indirect sunlight and warm enough to reach 65-80 degree F. will do. Any well lighted room with natural or artificial light will work.

Optional light - additional light will hasten growth but is not necessary if adequate light is present. For fluorescent lights, place the fixture about 1 ft. above the containers. If the fixture is set on a timer the light may be kept on for 16-18 hours daily. Light tubes especially designed for plants will hasten growth.



Optional heat- Heating cables are optional but will speed up the growth process. Some protection between the cable and the planting containers (such as a layer of perlite) should be used to prevent excessive heat, and rapid drying of the soil. If possible set the thermostat for the heating cables between 68-72 degrees (depending on the species of fern).

The benefits of using heating cables is that a consistent temperature is maintained.



Trays are stacked only to show the heating mat.



Germination : Your first sign of success

When the spore germinate, a greenish film on the soil surface will slowly appear in about 4 weeks or more, depending on the species of fern.

The green color gradually intensifies in the weeks ahead and the mat will eventually be seen as a mass of filaments.

Each filament then grows into tiny bits of flat green tissue or a young gametophyte.

Because of the danger of airborne contamination, avoid frequent opening of the sowing container.





Watering needs

If the sowing container is well sealed, the soil usually remains moist during the weeks after sowing and watering is not necessary.

However, in the weeks ahead if there are signs of the soil drying or the gametophytes appear on the verge of shriveling, gently spray with distilled or boiled and cooled water. Water only to restore moisture to the soil.

When watering containers with drain holes, set the container in a saucer and water from below.

If you have inadvertently overwatered place the edges of pieces of clean paper towels into the soggy soil to absorb the extra water.

Constantly wet to soggy soil leads to contamination by algae and fungi.



Seeing the mature gametophyte plant

The flat bits of green tissue mentioned above will continue to grow larger and when mature will be seen by the unaided eye as a flat, heart-shaped plant with a fuzz of white root-like hairs on the underside near the notch. This is the mature gametophyte and measures about $\frac{1}{4}$ to $\frac{1}{2}$ the size of the nail on your little finger.



Young gametophyte

If the sowing of spores was too dense, the typical crowded gametophytes may become noticeably distorted; an irregular tangle of narrow ribbons in the earlier stages, and irregular heart shaped in later stages. If this is the case thinning should be done.

Gametophyte with first frond



Appearance of the sporophyte

The next milestone of success will be indicated by the appearance of a small leaf from the gametophytes. This is the first visible sign that fertilization has taken place.



This tiny leaf is the first frond of the familiar fern plant (the sporophyte generation). If all is well other fronds will follow, each subsequently larger than the last.



(This first frond typically looks nothing like the frond of the mature plant. Terms such as: “mature gametophyte” and “young sporophyte” are often interchanged).



As the sporophyte grows larger, the gametophyte plant will slowly deteriorate and disappear.

Young sporophytes grow up and when mature produce spores, thus completing the fern's life cycle. This may take 1 year or less for fast growing ferns and 3 years for most ferns; some ferns may take many years.



The first thinning and transplant

Plantings often need to be thinned to allow room for development of the gametophytes.

The extra gametophytes may be discarded or transplanted.

To prevent drying, remove each clump one at a time and immediately transplant.



The gametophyte clumps (not individuals) are lifted out with tweezers. The clumps that are taken out and those remaining are about 1/3 inch in diameter.

The transplants are replanted about one inch apart and the clumps in the thinned culture are also kept about 1 inch apart.

The removed clumps are planted in soil treated as for the original sowing.

To insure that there is good contact between the clump and the soil, place the clump very slightly below the soil level and gently firm the soil around the clump with a tweezers.

*In the first transplant some growers dispense with using disinfected soil or water. For beginners it is better to stay with disinfected soil and water for one or two transplants.





During the transplanting process, guard against drying out of the soil or plants.

Keep a spray bottle handy and gently water transplanted clumps as you go along (instead of waiting to transplant a large batch and risk drying the clumps out).

Covering the unplanted exposed clumps with moistened clean newspaper will also protect plants which are waiting to be transplanted.



Container choices

The transplants can be moved into flats, trays, or shallow containers that may be covered with glass or plastic.

Containers provided with drain holes will allow extra water to flow out and help prevent over watering.





After transplanting

Cover and place the thinned cultures and transplants under the same original growing conditions.

Watch the leaves at this stage very carefully for over or under watering and correct immediately.

Water logged soil will cause death of the roots and the leaves will wilt (absorb the extra water with pieces of paper towel).

Soil and humidity that is too dry will also result in wilted plants, use a spray bottle with distilled or cooled boiled water to remoisten the soil mix. Use a gentle spray.



Second transplant

As the cultures grow and become crowded or when most of the gametophytes have produced leaves, another thinning and transplant may be made.

Longer roots may appear, so use care in removing and planting the transplants. Keep the roots pointing downwards in the transplant and the crown of the plant just above the soil.

Gently firm the soil around the transplant to keep it in place, especially when watering. Follow the directions as for the first transplant.



Clumps of vigorous growing gametophytes with attached sporophytes may need to be divided and transplanted a few more times before they are moved into two and half inch sized pots.

If the transplants grow vigorously, they may be weaned away from distilled or cooled boiled water, and disinfected soil.



Hardening Off

Once healthy sporophytes have reached one inch tall or more they need to be acclimatized to the outside environment. This process is called hardening off and involves gradually exposing the plants to drier humidity and more light.

Hardening off will take longer in more arid climates, 1 to 2 months, and be quicker in humid climates as there is less adjusting needed. This takes patience and watchfulness.





Common problems

Need Nutrients? If the gametophytes or sporophytes seems very slow to grow or become pale green, check first to see that the culture is not over-watered.

If that is not the case dilute a solution of complete liquid fertilizer and gently spray the culture. Start with $\frac{1}{4}$ the recommend concentration and test apply to a few clumps to see if damage occurs. If burning or shriveling of the culture occurs reduce the concentration further. Most plants will respond with deeper greening within a week.

Sporophytes sparse -The sporophyte leaves typically appear about 16 weeks or more after sowing the spores. If they are slow to appear, or very uneven in distribution this may be due to: lack of nutrients, sperm in need of more water, or insufficient eggs.





Sperm need water- The gametophytes are healthy and not crowded but the sperm may lack enough water to swim to the egg. Gently spray enough water on the gametophytes to form a film of water on their surfaces or saturate the culture with water for about 10 hours, and then drain. Sporophyte leaves should appear in a week or two.

Insufficient eggs- When the gametophytes are too crowded, they produce many sperm but few or no eggs. Severely crowded gametophytes appear like a tangle of narrow threads or ribbons or are distorted. Thinning clusters of the gametophytes even at this late stage may allow them to produce eggs.



Fungus gnats

These tiny gnats seem to appear from nowhere and their larvae can quickly destroy young gametophytes and even young sporophytes.

The fungus gnat larvae are white and very small though they can be seen by the naked eye as they eat their way through the culture. With fine tweezers they may be picked out and destroyed if not too abundant.

Keep containers covered. A ring of Vaseline or strip of cotton placed on the edge of the container and the lid will act as a seal to keep the gnats out.

Hanging sticky traps (yellow or blue) within the growing areas will trap some of the gnats. Empty yellow plastic oil containers that are split open can also be used to attract fungus gnats.



Adult fungus gnats

Contamination

This simply happens!

Contamination may appear as a patch of white or gray mold filaments that grow on the soil surface and kill the gametophytes and young sporophytes.

Other contaminants are so small that they are not seen, resulting in dead and dying mats of gametophytes and sporophytes.

Unchecked the contaminants may continue to grow and destroy the entire culture.





At early stages of contamination the contaminants and dead plants may be removed with a small clean spoon taking some of the healthy looking gametophytes around the edges as well.

Contaminants forming small dense filamentous mats adhere readily to toothpicks and may be thus pricked out. This seldom removes the contaminant completely, but slows its growth. Use clean spoons or toothpicks on each pricking to avoid spreading the filaments or its spores.

Avoid overwatering!



Healthy gametophytes might be saved by moving them out of the contaminated container and replanting them into new disinfected media. (Take only healthy gametophytes about ½ to 1 inch away from the contaminants)

Gametophytes can be “bathed” in a 5% bleach solution and then repeatedly rinsed with disinfected water, and planted into fresh soil. If the contamination is not out of hand this effort can sometimes save the young plants, although it may sometimes also damage them.

(“Bathing” should be roughly 3-5 minutes.
Rinse thoroughly)



Notes on contaminants

Water molds - Generally too fine to see. Plants wilt and die. Appears with infected soil and wet conditions. Prevention is best, infected soil should not be reused.

Botrytis - Visible white mold filaments which may bear spores at the tip of the filaments. Appears when weather is cool. Place culture in a warmer place.

Blue-green bacteria - The common species is *Oscillatoria* and it appears as a grey or darker patch of very fine filaments. If the patch is small, physical removal will retard its growth. Avoid use of tap water.



Botrytis



Oscillatoria

Algae - Most appear as green scum and may grow over the gametophytes . Avoid use of tap water, use only water which has been purified by boiling, or is distilled.



Algae

Moss contamination- This tends to appear when the light is low, they crowd out the gametophytes, with tweezers pick out the moss and move the culture to more light.

Liverworts - These might be mistaken for gametophytes, they are thicker with tiny holes on their surface. Prick out and discard.



Liverworts



When contamination is rampant it is simply best to discard the sporing container and start all over.

Even if great care was given to disinfecting the container, soil, water, and utensils contamination may still happen.

Sources of contamination could be from many sources such as watering cans, spray bottles, airborne contaminants (keep containers covered), improper disinfection of soil, use of tap water, surfaces of the spores, or other unknown factors.





The waiting game

This process takes patience and attentiveness to how the culture is growing. Does it need more or less water? Is it draining well? Does it need nutrients to give it a boost? Should it be forming sporophytes by now? Is the humidity too low, too high? Is the light level sufficient? Are the sporophytes hardening off sufficiently?

There is a wealth of information available from fern societies, and the stages of propagation become more familiar with each sowing of spore, along with recognizing specific needs of the young plants.





Calendar of growing stages

Here is a calendar for the growing of average species under optimum conditions.

Remember some ferns are much faster and others very slow. The timing depends on the species, the time of the year, the freshness of the spore, available nutrients and even unknown factors.

From sowing to seeing the green film over soil surface 3-5 weeks.

Green film continues to grow thicker 5-8 weeks .

Gametophytes form and mature. 8-20 weeks.

The first thinning if culture is crowded.

Apply nutrients if growth is slow or the culture is pale green.

Sporophytes leaves appear at 18-27 weeks

If growth becomes crowded again, thin.

Transplant to 2 ½ inch pots when sporophytes are sturdy with several fronds. 28-36 weeks.



We do hope you have succeeded in growing ferns from spores. Like most projects, when repeated it becomes easier and the results are usually better.

Eventually the process may seem routine, but there are always challenges to grow other ferns...

If you lost your culture at one stage or another, take heart, learning takes practice, try again with an easier to grow species.





In closing

Whether you succeed or not, you have learned about the unique life cycle of ferns and know more about that fascinating tiny plant, the gametophyte. May the thrill of growing that first sunflower be rekindled to growing ferns from spore.





This has been presented by: the American Fern
Society's Outreach Program

For more information visit the following websites:

The American Fern Society: amerfernsoc.org

The AFS Outreach Program:
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