

Chapter **THREE**

Natural and Artificial Lighting

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What Plants Need

Plants are utterly amazing – they are the only living things on our planet that are able to generate growth directly from the energy they receive from the Sun. If you think about it, everything other than plants that is alive on Earth is dependent on second-hand energy from the Sun, which comes to us through plants. Plants form the foundation of the entire food chain.

Your plants need energy to grow, and if for all or part of the year, you cannot use the free energy from the Sun, you will need to provide the right amount of light for them to do well. However, if you give them too much light, not only are you wasting money on electricity, your plants will suffer, and not grow as well. This chapter will show you the options that are available for indoor lighting, and how to provide the right amount of light for optimum growth of the plants in your Aquaponic garden, and how to do so safely.

Plants and Light

Without light, your plants will not grow at all. Without the right kind of light, your plants will not grow well. It is our goal to show you how to put together a vegetable-growing machine, which will grow plants as efficiently as possible, with the least amount of work. If you're growing indoors, choosing the right indoor lights for your plants can be a bit overwhelming, as the choices are vast. To correctly choose, you need to know a few things.

How Much Light?

To know how much light your plants will need, consider how the plant grows in its natural environment. If you're not sure, just read the back of the seed packet, and you will almost always find light requirements; "full sun" or "partial sun", for example. As a general rule, most vegetable plants will need full sunlight, which means you'll have to provide quite a bit of light to your plants if you're placing your AquaponiGarden indoors for all or part of the year. However, it is also important to know that plants need darkness, just like the plant would have if growing outdoors.

In general terms, you will need about 30-40 watts per square foot of growing area (tomatoes and other fruiting plants will need more than this), and remember, you only have to calculate the size of your raft, NOT the whole room!

An easy way to tell if your plants are getting enough light – or too much – is to simply look at them. Some signs that your plants are getting too much light are leaves that look droopy or dried out, with curled leaf edges, or an entire plant that droops and looks weak. Your plant's leaves might also have dead, brown spots in the areas of the plant that is closest to the light, if the light is too close to the plant, if you're using lights that put out a lot of heat (plants under water-cooled lights have symptoms that look more like an iron deficiency, not like they're burned). However, it is rather uncommon to give an indoor garden too much light, unless you're using High-Intensity Discharge (HIDs) lights (metal halide or high-pressure sodium, more on these lights later in the chapter).

A far more likely scenario is plants that are not getting enough light. Signs of this include thin, uneven growth, with tall, spindly stems, and plants that lean toward the light. If this is what you notice, you'll either need to move your lights closer to the plants, if you can do so without burning the tops, or add another light.

Figuring out what plants need as far as light involves some trial and error, and lots of observation. The nice thing about your AquaponiGarden is that you are able to move the plants – if they're on the edge of your raft, and stretching toward the light in the middle, you can always move them to the middle, so they are directly below the light.

What Color of Light?

The color of the light is also important. When your eye sees sunlight, it is a mixture of many colors that looks white. Remember prisms from high school science, which breaks up white light into its different colors? "Cooler" light appears to the human eye to be more bluish, and "warmer" light appears more reddish. This does not have to do with the physical temperature of the light, but rather the **color temperature** of the light. Of all the colors in white light, plants use the red and blue wavelengths the most. Blue is what triggers the plants to make more leaves, and red is what triggers more flowering and fruiting. So, to give the plants the color of light that they can best use to make leafy vegetables, we want a cool color temperature around 6500°K, as this is where most vegetable plants grow best, or, if you want to grow fruiting vegetables (peppers, tomatoes, etc.),




Soft white (left) and daylight bulbs.

you'll want to provide a color temperature of around 2700°K, which is in the warm, red range. Most "plant lights" that you will find are in the 6500°K range. You can use bulbs of the same type (T12, T8, or T5 - more on this in the following sections) with both "warm" and "cool" bulbs in a multiple-bulb housing, to give plants both red and blue color temperatures.

about 10% useful light and 90% wasted in the form of heat! Incandescent bulbs last between 750-1000 hours.

Even though their color temperature is in the red color temperature range plants need to produce flowers, we do not recommend incandescent light for your AquaponiGarden. Most incandescent plant lights are really only good for spot lighting to showcase a beautiful houseplant, and have very little use to the plant, even those that are labeled "grow lights".

If you use an incandescent, never place it closer than 24" from the leaves of your plants, as any closer that greatly increases the likelihood of the leaves burning.



Definition

Scientifically, color temperature is measured by comparing the color of a light to something black, at a certain temperature. This color temperature is given in "degrees Kelvin", and is abbreviated "K", which is what you will see on the light bulbs you purchase at the store. When you see terms like "soft white" or "daylight", what they are talking about is the color temperature. For white lights, it tells you whether the light tends to be more yellow (on the lower end of the color spectrum), or more blue (on the high end).

Fluorescents- A Better Lighting Choice

Fluorescent lighting consists of bulbs or tubes that are filled with mercury vapor that emits ultraviolet (UV) light when electricity passes through them, with a phosphorus coating inside that converts the UV light into visible light. All these bulbs are by law labeled with a symbol that includes the letters "Hg" (the chemical symbol for mercury) inside a circle, both on the box and on the bulb itself, along with a warning. There are also very specific laws governing how to dispose of them.

Indoor Lighting Choices – Incandescents and T12/T8/T5 Fluorescents

There is an almost bewildering array of choices when you are in the lighting aisle of your local "Build-It-Yourself" Center. We know what we're looking for, and we still have to look to find what we want, and sometimes ask someone. Just relax, and know that it's easier than you think to find what you need. Below are some easy and affordable options .

Incandescents – NOT a Good Lighting Choice

Incandescent light bulbs have a filament that electricity passes through when turned on, that heats up to the point of glowing; this is what produces the bulb's light.

These are the standard, old-fashioned light bulbs, and are incredibly inefficient when it comes to energy use, providing



To the far right, you can see the chemical symbol for mercury, Hg, is printed on every bulb that contains mercury, which is very toxic.



WARNING!

It's critical to know that when a bulb that contains mercury breaks, it's not a small thing. There are very specific methods for safe clean-up, which are required to be followed according to Federal laws (seriously!). Mercury is a very dangerous chemical, and all the steps for safely cleaning up a break are covered at the end of this chapter. Remember, take care of your body! If you don't, where are you going to live???

Fluorescent bulbs are all labeled with the letter "T", followed by a number. The "T" stands for "tubular", which makes sense, since these bulbs are all, in fact, tubular. The number that follows the "T" tells you how the thickness of the bulb as measured in eighths of an inch. For example, a T12 is $\frac{12}{8}$ " inch around, or $1\frac{1}{2}$ "; a T8 is $\frac{8}{8}$ ", or 1", and a T5 is $\frac{5}{8}$ " around. As a general rule, the more narrow the bulb, the more energy-efficient it is, and the less mercury it contains. They also all have different expected life spans, (see the graphic in the right column).

There are many different kinds of fluorescent lights, with the output of light and color of light controlled by components called **ballasts**. A fluorescent light is comprised of several different components including the light fixture itself, internal wiring and the ballast. Many times, the ballast is built into the fixture, and you probably won't even notice it. The ballast is essentially what starts and illuminates the tube or bulb by creating the appropriate amount of voltage and current necessary. If you've ever seen a flickering fluorescent light, there's a good chance it was the ballast that was failing, rather than the bulb. It's a very small component difficult to replace and is best left to a professional, unless you have prior experience with wiring. It's usually just easier to buy a new fixture.

Bulb Life*



**Bulb life varies by wattage. See the package of the bulb you buy for specific product information regarding that bulbs expected life span.*



Definition

The purpose of the **ballast** is to start and maintain a steady flow of electricity through the bulb. In fluorescent lights, the ballast is built into the housing. In the much more expensive but also much more efficient High-Intensity Discharge (HID) lights, the ballast is separate, and can be either mechanical or electronic. Ballasts are NOT interchangeable between different types of fluorescent bulbs.

Still Not The Greatest Lighting Source – CFLs

Compact fluorescent bulbs (CFLs) are newer form of fluorescent lighting, which have almost entirely replaced incandescent bulbs. They are far more energy efficient, put out much less heat, and last 8 to 15 times longer, usually around 10,000 hours.

CFLs come in “warm” (2700-3000°K) and “cool” (5000-6500°K), with the cool being better for growing vegetables. Look for bulbs that are labeled “Grow Light”. They come in many different wattages; 42, 85, 105, 125, 150, 200, 250, and 300 watts. Plant growth is not very good under these lights, and they should be used as supplemental lighting when you get at least some sun on your AquaponiGarden each day.

They are a good choice in that they don’t require a separate ballast or any special wiring, but they’re far from ideal. Some of the lower wattage bulbs screw into a standard Edison light socket in the exact same manner as does an incandescent bulb, while the higher wattage bulbs have what is called a “mogul” base, which is larger, but can be used in standard Edison bases with an adapter. They’re very expensive - the 300-watt bulb costs about \$100, and they’re **very fragile** where the bulb is connected to the base.

No matter what kind of CFL grow light bulb you choose, just make sure you put a reflector behind the bulb, ideally reflective aluminum or painted white, as CFLs shine light in all directions, and unless you capture the light that shines away from your garden, light will be wasted. These bulbs don’t do very well in a tight horizontal reflector, especially the larger higher wattage bulbs, despite the fact that they

are often sold in tight horizontal reflectors! To take advantage of their light output, they are best used in a vertical umbrella-shaped reflector.

You might need to use two or three to get good light over your entire garden, and because they remain cool to the touch, they can also be placed quite near your plants, in the 6-8” range for the low wattage bulbs (40W), and 24” for the high wattage bulbs (250-300W).

Pay attention to how your CFL is shining – if the bulb starts to flutter or fluctuate, it means it needs to be replaced (see the next section on how to dispose of your CFLs properly).



CFL with a match (upper right) for scale. This kind of light would be used with a reflector, to direct all the light at your AquaponiGarden, and to prevent light from being wasted.

An Excellent Lighting Choice – T8 Fluorescents

There is another fluorescent light, introduced in 1981, called a T8, which has thinner ($\frac{8}{8}$ -inch, or one inch around) than the 1½” T12, about 40% more energy efficient than a T12, and with far less mercury in the tube. T8s are rated with the same 20,000-hour lamp life as T12 fluorescents. T8s should be placed a little bit higher than T12s above the top of your plants, because their light is stronger.

HINT

If the any of the different kinds of fluorescent lamps are installed where they are frequently switched on and off, they will age more rapidly. Put your lights on a timer, to come on in the morning and to go off in the

*evening. If you are only turning them on once per day, the bulbs will last a lot longer. **Turn the bulbs off and on as infrequently as possible!***



Three different kinds of fluorescents: the two on top are T12s, below that is a T8, and the one on the bottom is the skinny T5.

Another Excellent Choice, But a Bit More Expensive - The Skinny T5

Two newer types of fluorescent lights were introduced in the 1990s, called T5s. They come in two versions, the High Efficiency (HE - the lower power version), and High Output (HO - higher power, but lower efficiency) version. **Make sure to get the High Output kind!** HE saves power, HO gives more light. In this case, you want more light. There are also "Very High Output" (VHO) T5s, but they don't put out enough additional light per watt to make them worth the price. They also produce more heat, which is why VHO fixtures are sold with air-cooled capabilities. You really don't need these kind of lights for small AquaponiGardens.

T5 fluorescents are very thin - only 5/8-inch thick, and produce almost twice as much light as standard T12 fluorescents, while still remaining very cool to the touch. They are available in "warm" (3000K) or "cool" (6500K) versions. Again, we recommend the cool type for your AquaponiGarden.

They are as long-lasting as standard T12s, with an average usable life span of around 20,000 hours. They contain even less mercury (only about 3mg per bulb) than T8s, because the bulb has a special coating in the inside that stops the glass and the phosphorus from absorbing mercury. This coating also makes the bulb remain more efficient over the course of its life.

High Output T5s are the best lighting source you can buy if you decide to go with fluorescents. However, they're not inexpensive - expect to pay about \$8.00 each for the bulbs.

More Excellent Indoor Lighting Choices - Metal Halide, High Pressure Sodium, and LEDs

There are three other categories of indoor lighting choices you could make, and we'll talk about them briefly. Two are in a category called "high-intensity discharge" lights (HIDs), and the third is in a completely different category called "light-emitting diodes" (LEDs). All are excellent choices, but HIDs are a bit more complicated, and LEDs are very expensive.



Definition

High-Intensity Discharge (HID) bulbs create more visible light per unit of electricity than incandescent or even fluorescent lights. There are two kinds of HID bulbs used for indoor growing, high-pressure sodium (HPS). To produce light, MH bulbs use a mixture of argon, mercury, and different kinds of metal halides, while HPS bulbs use mercury and sodium. **Light-emitting diodes, or LEDs,** are a type of tiny semi-conductor that emits light at a specific wavelength. LEDs for plant grow lights are made in the colors blue and red, which are the wavelengths that plants need most. These two colors combine to make a light that looks purple when it shines on your plants.

MH - Metal Halide

Metal halide lights come in a range of sizes, commonly 175 watts, 250 watts, 400 watts, and 600 watts. A 175 watt lamp will cover the 3.5 sq. ft. AquaponiGarden, and a 400 would cover the 12 sq. ft. garden. Two 250 watt lamps could be positioned properly to cover the three troughs of the 18. These lamps put out a lot of heat, you'll want to place them at least three feet above the tops of your plants, and keep an eye on your plants for signs that the light is too close (upper leaves wilting, edges curling, burning). Expect to pay about \$100 for a 175 watt lamp kit, including ballast and reflector.



Photo courtesy JoeX/Wikimedia Commons

A 400w metal halide bulb, with 100w incandescent bulb (top) for scale.

High Pressure Sodium

HPS lights emit a red color temperature, and are not ideal for growing leafy greens. They are also a bit expensive, though are very efficient, but they last about twice as long as metal halide lights. We do not recommend them for your aquaponics garden. HPS bulbs emit a very orange light, and you've probably seen them in use as streetlights, as that is a common application. Their light is very bright, and things illuminated by them look unnatural and very orange. They emit wavelengths better for flowering and fruiting plants.



A high pressure sodium bulb in a reflector., with ballast (foreground). Notice the opening at the top of the reflector, where a fan is meant to be installed for air cooling. A gallon jug is included, for scale.

LEDs – Light Emitting Diodes

LEDs offer distinct advantages over other lighting choices:

- Lack of heat – zero risk of fire, and you can put the light so close to your plants that they actually touch the tops of the plants, with no burning whatsoever
- They only emit light that is usable to the plant
- Energy efficient: 300W LED = 800W HPS
- No mercury
- Long life (100,000 hours!)
- The LED technology is improving rapidly
- Prices of LEDs are dropping fast (but they're still very expensive!)

However, they also have some real disadvantages:

- Expense, expense, expense! At least \$200 for a decent LED grow light, and up to \$1200!
- Growth is still not as good as HID's for most plants

We could write a whole lot more about this, but the price tag is enough to put most people off of LEDs. If you're not one of us, and you have a trust fund, and money to burn, do your research online, and be sure to read reviews written by someone other than the store selling the lights!



Three LED bulbs, with red spectrum on the left, both red and blue in the middle light, and blue only on the right.

So, After All That, What Exactly Should You Use?

There are so many variables that it's really difficult to give you a good recommendation, but here goes. High output T5s are bright enough to grow ALL types of plants. They are very versatile, because they're safe and cool, and do not have a hot, single blinding point of light as do H.I.D. lights. With a bulb shield and wire guard, they are very safe to use above the food you're growing to eat. They're far less expensive than LEDs.

We asked for the recommendation of a well-respected aquaponics lighting expert, Jesse Hull, Imagine Aquaponics, LLC, of Milwaukee, WI, and his recommendations are on the top of the next column. Thanks Jesse!

- A 3.5 AquaponiGarden would require a minimum of 175W for leafy greens and at least a 250W HID to produce tomatoes on a dwarf plant.
- For leafy green production, a 12 AquaponiGarden would require a 4 foot long, 6- or 8-bulb T5 fixture, or two 2-foot long, 6 bulb (OK) 8 bulb (better) fixtures.
- For tomato production, a 12 AquaponiGarden would require a 400 watt minimum, but preferably a 600 watt HID.
- For greens production, an 18 AquaponiGarden (36" x 72") would require three 2-foot long, 6 or 8 bulb fixtures.
- To grow tomatoes, an 18 AquaponiGarden would require two 400 watt HID's, preferably on a light mover, because 72" is a long area to cover, and the ends of that garden footprint will likely be too dimly lit without moving the lights.



An EASY solution: at bottom right is a compact fluorescent in a reflector, for supplement, spot lighting on a 3.5 AquaponiGardens. at the top is a SylverStar 2 Foot 4 Lamp High Output T5 fixture with four bulbs installed. About \$130, online at <http://www.htgsupply.com>, with numerous options such as light racks, reflector hangers, and timers.

How Much Does All This Lighting Cost?

All this information about lighting, efficiency, and energy usage is great, but you're probably wondering if you can afford to not only to purchase these lights, but also how much they'll add to your electric bill. Purchase prices vary around the country, as well as online, but we'll give you some general ideas of how much each type of lighting will cost. We'll also show you how to figure out how much that your lights will cost to run, wherever you are, once you've made your choice of what lights to buy.

How Much Can I Expect To Spend Buying Lights?

This question is a lot like asking "how far can I push a string?" or "how high is up?". There are so many variables! However, we will try to give you a general idea of what you can expect to find when you go to Lowe's, Home Depot, or shop online. Incandescent "grow lights" – though these are not recommended, you can try them if you like – remember, aquaponics is a lot of fun if you enjoy experimenting! – will run you \$12-15 each, for both the bulb and the housing. Replacement bulbs are less expensive, since you don't need to purchase the housing, around \$5-8, as of this writing.

Fluorescents have a wide variety, of sizes, shapes, and costs. We'll give you the general rule of thumb. Check prices online and locally.

- T12s – Lowest Efficiency / Lowest Cost
- T8s – 40% better efficiency than T12s and cost only you 20% more, so they're a pretty good deal
- T5s – 51% better efficiency than T12s but with 2-3 times the cost, so you may decide the extra cost is not worth it

And when you add the fixture (ballast and reflector), you'll find prices are even more all over the board. Expect prices for HIDs and LEDs vary widely as well.

How Much Will All These Lights Cost to Operate?

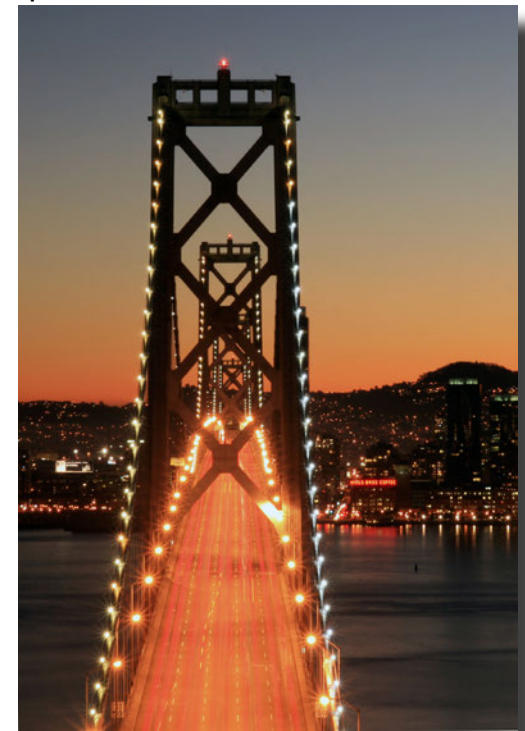
A tiny bit of very simple math (ACK! We know, but we promise it's really, really easy!) will tell you how much your

lights cost to operate, no matter how many lights you have, or what kind of lights you choose.

1. Add up your light's combined wattage.
2. Divide that number by 1000. This gives you the total kilowatts that they use.
3. Multiply that number by the amount your electric company charges per kilowatt hour (you can find this out by looking at your electric bill).
4. Multiply that number by the hours you use them per day.
5. Multiply that number by 30 to get the amount you pay to the electric company per month, OR multiply that number by 365 to get the amount you'll pay in a year.

Example: Say you're using four T5 Fluorescents, each using 24 watts, and you want to know how much the electricity you will use will cost in a month. You know your electric company charges 22 cents per kilowatt hour.

1. $4 \times 24 = 96$. You have a combined 96 watts from your four T5s.
2. Divide 96 by 1000, and you get .096 kilowatts used per hour.
3. $.096 \times .22 = .021$, or 2.1 cents per kilowatt hour (.096 multiplied by 22 cents per kilowatt hour), so the lights cost you a little bit over 2 cents per hour to use.
4. You have your lights on a timer, and use them 12 hours per day, so, in a month's timer, your total cost is about \$7.60 per month. ($.021 \times 12 \times 30$). Annually, in this example, you would pay \$91.98.



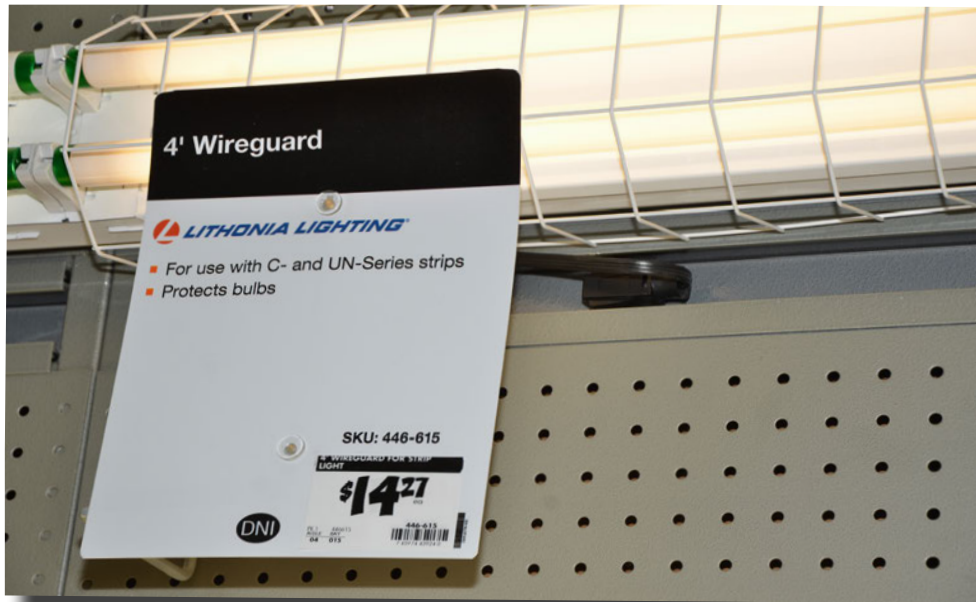
High pressure sodium lights on the San Francisco Bay Bridge.

Safe Handling of Mercury-Containing Bulbs

Since all fluorescents, metal halide, and high-pressure sodium bulbs contain a small amount of mercury gas, if they break, it is something you need to pay close attention to. The good news is, according to the Environmental Protection Agency, the amount of mercury in a fluorescent bulb is less than 1/100th of what is found in the old-fashioned mercury thermometers. It's around 5mg, or 0.00017637 ounces. To put this in perspective, one Tylenol tablet is 375-500 milligrams, and a teaspoon is about 5000 milligrams. So, we are talking very small amounts.

Nonetheless, even small amounts of mercury are a known health risk, so a broken bulb should be taken very seriously. The mercury in fluorescent lights is in the form of elemental mercury, which is a heavy metallic liquid, which can be absorbed through your skin if you touch it, or inhaled if it becomes vaporized, as unfortunately can happen rather easily.

Of course, the very best way to never have mercury exposure is to make sure they don't break at all, however, if they do break, it's important that you know what to do. It's also important to know how to dispose of them properly, broken or whole.



A wire bulb guard will help prevent your bulbs from breakage.

Ways to Prevent Fluorescent Bulb Breakage

- Always handle the bulbs like they're newborn babies! Pay attention every moment, and work in an area that has no distractions.
- If bulbs have been turned on, turn them off and allow them to come to room temperature (at least 20 minutes) before handling them.
- When taking out a bulb, never unscrew CFL bulbs or remove tubular bulbs by exerting pressure on the glass. Use the base or the ends of the bulbs to gently screw them into place.
- When putting a bulb in, gently screw or tap in the bulb until it's seated snugly in the base. DO NOT over-tighten CFL bulbs, or strongly tap in fluorescent tubes.
- No matter what, never force anything!
- Whenever possible, shield your light fixtures with wire guards (see photo at left) and tubular bulb guards.

Rather than simply replacing bulbs in their fixtures directly over your aquaponics garden, unplug the entire fixture and move it away from your garden. Set up a drop cloth before you take out the bulb, in case it breaks.

Safe Clean-up If a Bulb Breaks

As quickly as possible, safely evacuate the room (including pets). Turn off air-conditioners, or heaters. If bulb break occurs over your aquaponics garden, immediately turn off the water pump to stop circulation of water.

Open windows and doors to air out the room, preferably to the outdoors, and let the room air out for at least 15 minutes.

While you're out of the room, gather the materials you will need to safely clean up the broken bulb. The list follows, on the next page.

Before returning into the room, gather the following materials:

1. Disposable gloves
2. Hand broom
3. Stiff cardboard or a dust pan (see "Hint", opposite)
4. Masking tape or packaging tape
5. Damp paper towel or disposable baby wipes
6. Glass jar (preferably) or other hard plastic container that can be sealed with a lid, or Ziplock bag or other bag you can seal.



WARNING!

Unless you have a HEPA filter on your vacuum, **DO NOT** vacuum!

Please know that the air flowing through the vacuum could spread mercury vapor through the room! If you must vacuum, put the vacuum outside, and run the hose inside where the break occurred.

If the break was over a hard surface:

Use the hand broom and the stiff cardboard or dustpan to carefully sweep up as much of the glass debris that you can. Use damp paper towels, baby wipes, and sticky tape to get the remainder of the glass shards off the hard surface.

Put all debris and cleaning materials into the glass container (preferably), or the hard-sided plastic container, or as a last resort, the plastic bag. Seal the lid. Be aware that if you use plastic, mercury vapors can still seep out through the plastic, whereas with glass, it cannot (this is why these bulbs are perfectly safe to use, unless they break!), so take it out of your house immediately, to a safe place outside, until you can dispose of it properly (see the following section).

Wash the hand broom (and the dustpan, if you used one instead of a piece of stiff cardboard) with soap and water before you take off your gloves.

If possible, continue to air out the room for several hours.

Wash your hands with soap and water!



If you use a piece of stiff cardboard instead of a dustpan, you can just throw it away with the rest of the debris and clean up materials, so it's a little easier. If you use a dustpan, you will have to wash it off with soap and water, while still wearing the disposable gloves, when you are finished.

If the break was over carpet:

If you absolutely must vacuum, keep windows and doors open, but unless you have a HEPA filter on your vacuum, put it completely outside the room (outdoors, if you can) and bring the hose in through a window or door. Use the longest attachment you have, and keep the actual vacuum body outside. Throw away the bag (or clean out the Shop-Vac canister and wipe it out with gloves on). Then, follow disposal instructions given previously.

The next several times you vacuum this area, open doors and windows before you begin, and dispose of the bag immediately afterwards, in the same manner. Leave the room open to air out for as long as possible after vacuuming.

Remember to wash your hands with soap and water after proper disposal of all the cleaning materials, and the jars or plastic bags of debris.



You can also purchase a tubular plastic bulb guard that fits tightly over the bulb, and contains glass in case of breakage.

If the break occurred over any of the plants in your aquaponics garden:

Determine which plants have had exposure to the glass shards. These plants need to be thrown away, roots and all.

***THIS IS CRITICAL:
If in doubt, throw it out.***

Examine the raft carefully for glass shards, and use the damp paper towels, baby wipes, and sticky tape to get the remainder of the glass shards.

With the water pump and aeration in the trough turned off, remove the raft to look closely into the water to determine if any debris fell into the grow bed. If you are not certain about this, bail out some water until you can see the bottom of your trough. If there is glass, you will need to throw all the water in the plant trough into your toilet or down the sink, scrub out the trough with mild soap and water, rinse well, and refill.

If you were not able to turn off the water pump immediately, or if in the unlikely event that debris fell into your fish tank (which should not happen, because of course you have a cover on your fish tank, right?), you will need to throw away the water in your fish tank as well, following the instructions given for starting your system in Chapter 12).

Proper Disposal of the Bulbs

Whether your bulbs are broken or still whole but have burned out, you will need to dispose of them properly. You will need to check with your local state or county government to find out what the rules are in your area. This is very important, as these bulbs are not the same as the old incandescent bulbs (remember them?), and must be disposed of in a manner consistent with the local laws. Call your garbage company, or your check with your local dump if you're in a rural area.

Check the Warranty

Many energy star-rated bulbs have a two-year warranty. If the bulb has burned out within that two-year period, you will be able to return it to the manufacturer for a replacement. Of course, this means you need to be able to locate your receipt, which indicates an incredible level of organization, which we admire greatly, and hope to someday emulate!

Pack the Bulb

If the bulb is unbroken, place it in a container so that it won't break during handling and transport. If you do not have a container available, or if the bulb is too long for a container, as a last resort, use two plastic bags, and seal the end. To always have packaging available for disposing of long tubes, it's an excellent idea to save the packaging that the bulbs came in when you purchased them originally. If you are replacing the bulb, you can use the packaging from the new bulb to dispose of the old bulb.

Recycle – If Possible

To find a local disposal site, go online to Earth911.com, or call 1-800-CLEAN-UP or 1-800-RECYCLE. Some local retailers, such as Ace Hardware, IKEA, and Lowe's, supply collection areas at their stores.

If Nothing Else, Throw it Away

If there is absolutely no recycling available where you are, as a last resort, you can put well-sealed bulbs into your regular trash, as long as it is not incinerated. If your garbage is burned, you must not do this, as burning the bulb will release the mercury into the atmosphere. It must be disposed of as hazardous waste.

Remember, these steps represent the highest safety levels you can provide, when dealing with what is actually a tiny, tiny amount of very hazardous material. Relax, but still be very careful.