



STEMsational Ag: The Virtual Farm

MIDDLE TENNESSEE STATE UNIVERSITY



Module 11: My Own Garden UNIT 4: FROM SEED TO SPROUT Grades 9 – 12



National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE



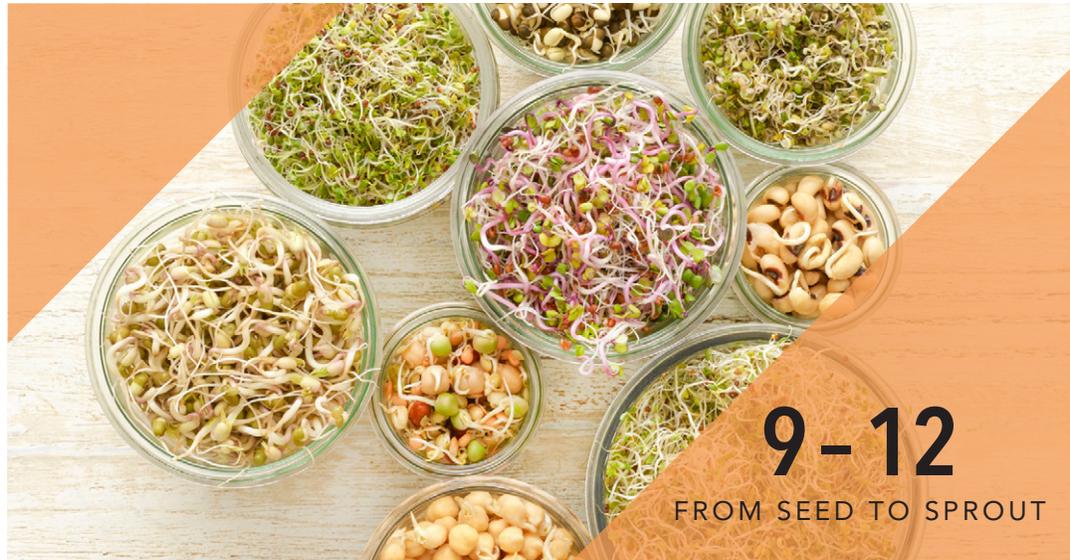
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Module 11: My Own Garden
UNIT 4: FROM SEED TO SPROUT
Grades 9 – 12



9th – 12th Grade:

Introduction to the Unit: This unit will review the benefits of sprouting, potential therapies, and include a science communications article to increase critical thinking and research/investigation skills among students.

Pre-assessment:

Write down your answers to the following questions.

1. What prevents seeds from germinating immediately?
2. Describe the environment required for a seed to grow.
3. At what stage of growth does a plant contain the most nutrients?
4. What are the macronutrients and building blocks required for a healthy diet?
5. What is a food desert?
6. Why is it important to purchase organic produce when possible?
7. Do you know of any health benefits from broccoli sprouts? If so, what are they?



Purpose:

- ▶ To educate students about sprouting, foundations of a healthy diet, biotechnology in sprouting seed production, food scarcity and how to improve nutrient accessibility in their communities. Students will also learn how to digest a research article and reflect on bigger picture, real-world applications from their reading.

Student Learning Outcomes for the Unit:

- ▶ Students will learn about the basic germination process.
- ▶ Students will explore how to structure a healthy meal.
- ▶ Students will practice how to sprout at home.
- ▶ Students will address the impact of food on our body and organs.
- ▶ Students will explore why food deserts exist and how to address them with sprouting.
- ▶ Students will learn about clinical applications of active compounds from broccoli sprouts.

National Agricultural Literacy Standards:

Science, Technology, Engineering & Mathematics Outcomes

- ▶ T4.9-12 C. Discuss population growth and the benefits and concerns related to science and technologies applied in agriculture to increase yields and maintain sustainability.

Food, Health, and Lifestyle Outcomes

- ▶ T3.9-12 A. Accurately read labels on processed food to determine nutrition content.
- ▶ T3.9-12 E. Explain food labeling terminology related to marketing and how it affects consumer choices (e.g., natural, free-range, certified organic, conventional, cage-free, zero trans-fat, sugar-free, reduced calorie).

Vocabulary Words:

- ▶ **Germination:** refers to the process by which an organism grows from a seed or a spore after a period of dormancy
- ▶ **Sprouting:** the process whereby seeds or spores sprout and begin to grow, and while synonymous with germination, typically refers to a sprouted seed or legume for food preparation
- ▶ **Food Insecurity:** a household-level economic and social condition of limited or uncertain access to adequate food
- ▶ **Sulforaphane:** a plant compound derived from cruciferous vegetables, such as broccoli and Brussels sprouts. It is known for its antioxidant, antimicrobial, and anti-inflammatory properties and is studied for its health benefits, such



as for cancer prevention, heart health, and as a potential treatment for autism

- ▶ **Food Desert:** the United States Department of Agriculture (USDA) defines a food desert when a census tract meets the following two criteria (USDA, 2014):
 - ▶ **Low-income community:** poverty rate of 20 percent or higher, or a median family income at or below 80 percent of the statewide median family income
 - ▶ **Low-access community:** urban census tracts with more than 33 percent living more than one mile from a supermarket or large grocery store or rural census tracts (geographical region containing 1,000 to 8,000 people) that are more than 10 miles from a supermarket or large grocery store.

Materials Needed:

- ▶ 1 Mason jar
- ▶ Cheesecloth or galvanized stainless steel screen
- ▶ Rubber band
- ▶ Bowl or dish rack (to set jar at angle)
- ▶ 2-3 tablespoons of organic sprouting seeds

Activity 1:

Read the handouts and exercises for this lesson on the following pages.

- ▶ Seed to Sprout
- ▶ Sprouting Guide for hands-on experience with gardening in the kitchen.
- ▶ How to Sprout EASILY for 25 cents a Day!

SEED TO SPROUT

ADDRESSING FOOD INSECURITY

SPROUTING FOR CHANGE

RESTORING NUTRITION

HEALING THE GUT

PRACTICAL AND SUSTAINABLE



IN THIS LESSON

05 GERMINATION

06 PHOTOSYNTHESIS

08 SUGAR:FAT TRIGGER

09 HEALTHY CHOICES

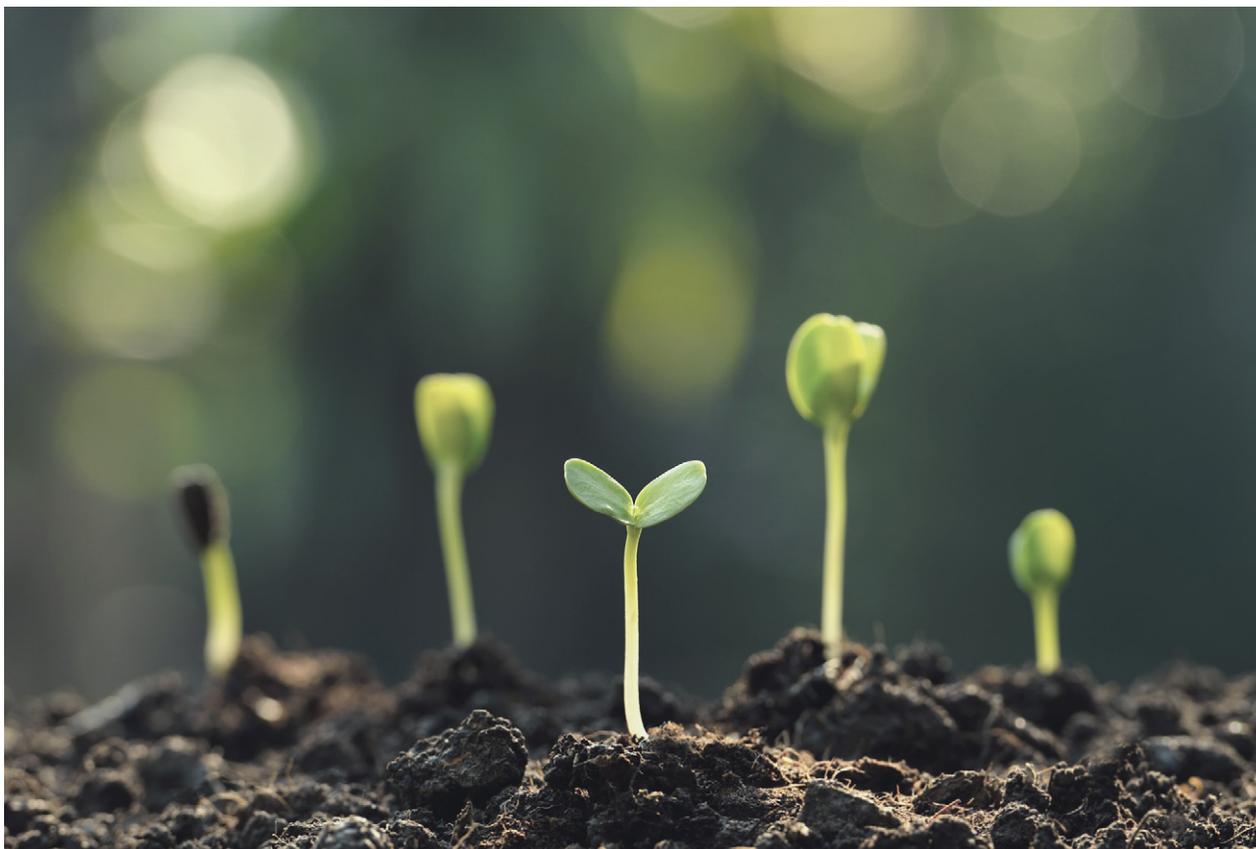
10 FOOD SCARCITY

**SOMETIMES THE
SOLUTION TO OUR
PROBLEMS IS
CLOSER TO THE
GROUND THAN WE
REALIZE.**



Pre-Assessment

1. How do plants grow from a seed?
2. Describe the environment required for a seed to grow.
3. What is produced by photosynthesis?
4. At what stage of growth does a plant contain the most nutrients?
5. What is required for a healthy diet?
6. _____ helps our gut function properly.
7. What is a food desert?
8. How can we improve the problem of food scarcity?
9. Why is it important to purchase organic produce when possible?



GERMINATION

FROM SEED TO SPROUT

Every plant begins its life when seed reaches water. With the right environment, this capsule of nutrients is unlocked to begin the process of producing roots and shoots.



When the seed is exposed to moisture and the right temperature, it begins to absorb water and the outer shell of the seed softens as the seed expands. A dark, warm environment is optimal for most seeds to begin their journey to becoming a full-grown plant.

As you can see in the picture to the left, the process of **germination** goes from seed to radicle, then a primary root develops before a plumule emerges from the ground and leaves are produced to begin the process of photosynthesis.

The beauty of sprouting is that it only takes 3-5 days for the sprout to be ready for consumption.

Sprouting seeds are unique in that they go through a screening process using technology to examine the germination rates for specific seed strains. They are also screened for cross-contamination with animal products that may leave behind types of E. Coli or other harmful bacteria. Organic sprouting seeds ensure that the seeds are free from harmful pesticides that can damage our brain cells and our reproductive and hormone systems.

PHOTOSYNTHESIS

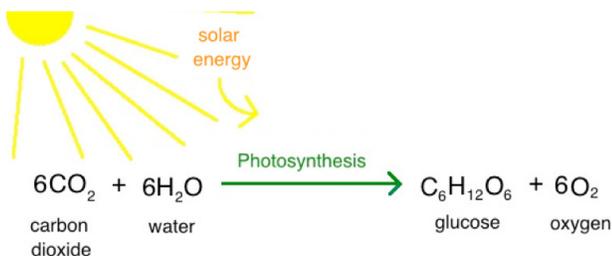
ENERGY CYCLING



All producers use **photosynthesis** to create their own energy. Using the sun, carbon dioxide and water, they harness this energy in little structures known as **chloroplasts** which are similar to the mitochondria within our cells.



Through the process of photosynthesis, producers such as broccoli sprouts convert six molecules of carbon dioxide and six molecules of water into one molecule of glucose and six molecules of oxygen.



Other organisms receive oxygen to breathe and energy from consuming producers like plants and animals. It takes many producers to feed one consumer, and this is why global organizations for climate change recommend lowering intake of meat and animal products to reduce the strain on our ecosystems.

Plants also help to filter the underground water supply and prevent soil erosion and nutrient depletion when grown in complimentary and diverse groupings. Soil erosion, made famous in the dust bowl era, occurs when land is overfarmed and not allowed to rest properly between harvests. Monocropping is also a huge concern, and can lead to nutrient depletion of the soil and food we consume.

CO-EVOLUTION

why our gut health relies on diversity of plant fibers

Vegetable fiber in particular is essential for our epithelial cells in our gut to function properly. Our gut cells evolved with our microbiome, the bacteria, fungi, and viruses that live in our intestines. The cells responsible for moving food through our gut for proper digestion rely on the microbiome to break down this vegetable fiber so that they can use these products for energy.

In order to have an efficient and anti-inflammatory microbiome, we need to consume a variety of vegetables and fruits to provide different types of fiber for a balanced community of microbes.

The inflammatory colonies that are present in small amounts within our microbiome do not consume vegetable fiber. In fact, they feed off of sugars and fats.



OPTIMAL GUT HEALTH IS FOUND IN DIVERSITY OF PLANT FIBERS

When we eat too many ultra-processed foods, such as candy bars, chips, processed red meats and fried foods, we are encouraging the bad, inflammatory bacteria in our gut to multiply in numbers while our good, anti-inflammatory bacteria is starved off because they have no vegetable fiber to feed on. As a result, we are more prone to constipation, because now our gut cells are not able to function optimally due to a lack of the by-products of vegetable fiber broken down by our microbes.

Even the small spaces between our gut cells can become wider as tight junction proteins lose their ability to keep food particles and proteins from entering the bloodstream, whereby autoimmune conditions arise as antibodies are made against these particles.

Needless to say, the food that we choose to eat has a MASSIVE impact on how good we feel, how much energy we have, how well our body can eliminate toxins and waste, our immunity, and the quality of our gut health.



THE SUGAR:FAT TRIGGER

why our food choices matter

Have you ever thought about why candy bars are so addicting? We certainly all love the rush of energy from eating sugar, but there is actually a certain ratio of fat to sugar that our brains are addicted to consuming. Companies such as donut shops and candy bar companies have made sure to include this level of fats and sugars in their products to make bigger sales.

So why are our brains addicted to sugar and fats? In part, it is due to our survival instincts developed from the evolutionary process. Long before the industrial age, food supplies were scarce. Knowing how to hunt and scavenge for food was essential to survival. Our brain prioritized high fat and high starch foods because these contained the most energy to fuel long hunts and the hours or days inbetween the next meal.

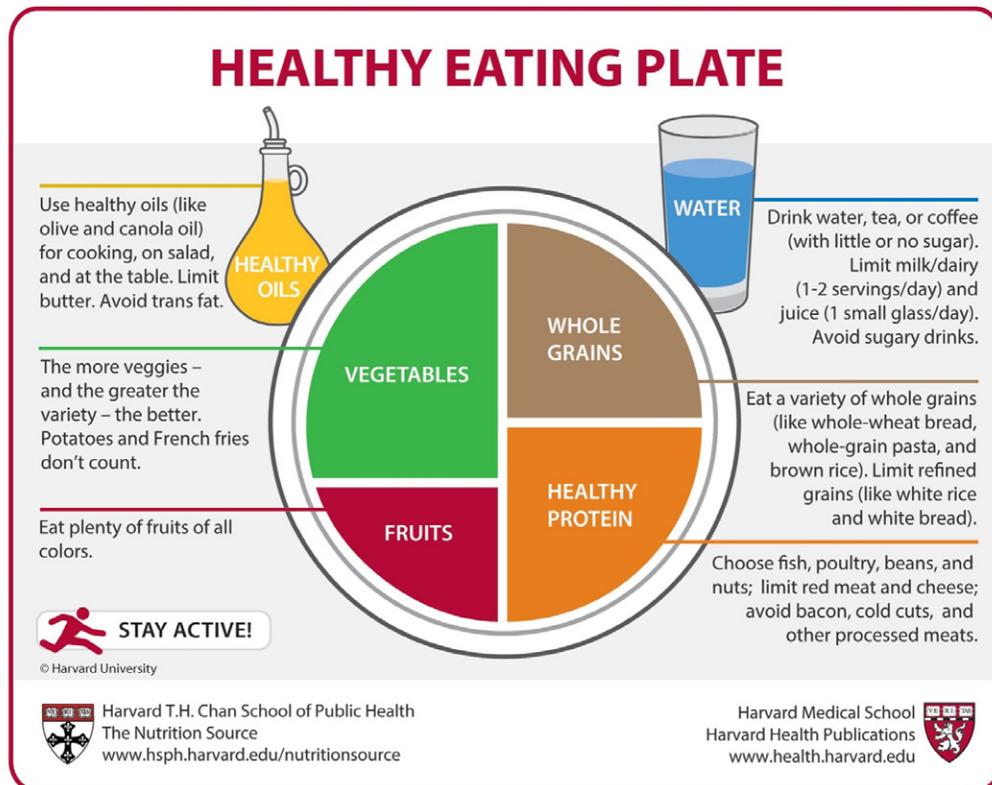
We now live in the age of convenience and industrialization where food is always available to grab off a shelf, drive-through, or gas station. This early survival adaptation no longer serves us, and it is used by food corporations to sell their products.

Whole, organic foods do not share this brain excitation pathway; however, they are essential for our gut health, brain health, energy, and lowering inflammation in the body. With this in mind, we can make informed choices about what we choose to eat each day.

HEALTHY CHOICES

Fundamentals of nutrient density

As scientists learn more about how food affects our health and the quality of our mood and energy, these findings influence recommendations for how to structure our plate. An easy way to reach the goals for nutrient density, or achieve multiple types of vegetable fiber, vitamins, and minerals is to start the meal with vegetables or fruits as the base and build up from there with healthy protein sources, whole grains, and omega-3 rich fats like avocado.



A good rule of thumb is to start with two fistfuls of fruits and/or vegetables, then one fist of protein, one fist of complex carbohydrates like whole grains or potatoes, and one thumb-sized serving of fats. Always remember to switch up the types of whole foods you consume, and eat the rainbow!

Eating whole sunflower seeds can be a healthy snack, but when converted to an oil, we lose a lot of the benefits from the rest of the seed and the energy content becomes highly concentrated.

The closer to the ground that we eat, the better. When food is processed, fiber and nutrients are lost and many have an excessive amount of omega-6 rich oils such as sunflower, palm, vegetable, and rapeseed oil, which promote inflammation in the body.

Thankfully, sprouts are rich with nutrients, flavor, and fiber. When sprouting beans, we get all the benefits of complex carbohydrates and proteins and with broccoli sprouts we receive antioxidants.



FOOD SCARCITY

barriers to healthy food

When it comes to finding food to eat, America is one of the top countries for fast food and quick, junk food snacks. However, many of us live in food deserts, and we may not even know it.

What is a **food desert**? It is an area (community, neighborhood, etc.) that is surrounded by fast food restaurants and gas station markets, in which there is a lack of stores selling affordable and fresh, whole foods and groceries. Often food deserts encompass neighborhoods and communities where the nearest grocery store is over a 30-minute drive away. For many without transportation, accessing healthy lifestyle behaviours like eating fresh vegetables and even small amounts of meat can be nearly impossible. For many reasons, these community members often have higher rates of disease risk than their counterparts who have easy access to healthy choices.

It is hard to imagine why there are still so many barriers to accessing healthy food in the age of industrialism and technology. Thankfully, there are many ways to improve community access to fresh produce. Can you think of some ways to help your neighbors get fresh food?

A few ways to improve access to fresh food include sprouting, community gardens, and farmers markets. Sprouting is an easy way to access healthy choices without needing garden space, dirt, or sunlight. Community gardens can easily be organized and seasonal; local produce can produce an astounding harvest. Farmers markets exist in many communities and provide wonderful, affordable options for communities.

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Image: "Copyright © 2011 Harvard University. For more information about The Healthy Eating Plate, please see The Nutrition Source, Department of Nutrition, Harvard T.H. Chan School of Public Health, <http://www.thenutritionsource.org> and Harvard Health Publications, health.harvard.edu."



SPROUTING GUIDE



This guide will help you learn how to sprout in a few simple steps!

Materials Needed:

Mason Jar

Cheesecloth and rubber band or Screw on sprout lid ([link](#))

OR

Sprouting jar ([link](#))

Organic sprouting seeds ([link](#))

Instructions:

1. Pour 2-3 tbs. of sprouting seeds in your glass jar along with 2 cups of water.
2. Cover the jar with cheesecloth and secure with a rubber band, or place sprouting lid on jar and allow seeds to soak overnight.
3. In the morning, drain out the water with the cheesecloth/lid still on. Place the sprouting jar upside down tilted in a bowl to allow air flow and water drainage.
4. Rinse seeds every morning and evening (think of it as giving them a shower and draining out the water).
5. Within 1-2 days, you will see the seeds opening up and little shoots sprouting.
6. By day four or five of the rinsing process, you are ready to harvest!
7. Enjoy your sprouts with tahini and liquid aminos/soy sauce, sprinkle on a salad, or blend in a smoothie! Store in the fridge tucked in a paper towel or keep in your jar. Can freeze for adding to soups or smoothies.



Soaking Set up (overnight)



Sprouting Set Up (Prop up in a bowl next day)



Root hairs on broccoli sprouts are not mold!



Review this Exercise on Jar Growing Methods for Beginners.

Sprouting does not require soil or sunlight and can be an easy and fun way to help students engage with the plant growth process and cooking at home.

How to Sprout EASILY for 25 Cents a Day!

Also available online at: www.youtube.com/watch?v=qynti1u9ywE



Hey you guys!

It's Kristina. I am so happy to have you back in the kitchen today, because we're going to be sprouting and talking all things sprouts.



Sprouts are quick and easy to do. Anyone can sprout. It's super affordable, and you don't need much equipment to do it - just a jar or a sprouting tray.



You can sprout seeds, beans, legumes, or grains; and the nutritional value is increased when you sprout a seed. And because it releases enzyme inhibitors, it also helps to make the digestion process a little easier for you.



Because the sprouting process also increases nutrient levels, you're able to consume plants that are even richer in protein, folates, magnesium, phosphorus, manganese, and vitamins C and K.



For instance, there have been several studies released that showed that sprouting helps to actually increase the protein content of those plants. I thought that was pretty cool.



Sprouts are a great food to consume, especially for vegans because they're high in protein.



And so, when anyone ever asks you (if you're a vegan) where you get your protein... you can say sprouts, because it is a great source of protein.



And, because sprouts do not require any sunlight to grow, sprouts are amazing to grow any time of the year - especially during winter when less is available.



There's more interest now than ever to grow one's own food, and to practice more sustainability. So, I'm really happy to share with you what I've been sprouting at home; and I'm really excited to share my tips with you!



So, I'm gonna take you through the process today and we are going to have a lot of fun sprouting.



We're gonna have a little sprout party...



a little sprout party!!



So today is day 1, and usually, sprouting is a ...



four-day process from beginning to end.



What you will need is a sprouting tray or a jar. I have both, and I prefer sprouting via jars because not only is it easier, but also, there's less risk of your sprouts getting moldy. So I have some jars that I'll be sharing with you today.



Other than a jar or a sprouting tray, you will need to get some high quality seeds.

The quality of your seed matters. I cannot stress this enough.



You want to get organic non-gmo seeds. I got my seeds from True Leaf Market. (This is not sponsored; I'm just sharing what's in my kitchen.)



And, I got the 12 pound pack - which is my favorite one to get - because it's an amazing variety for beginners and for medium to advanced sprouters.



For those of you who are interested in their beginners set, I have it linked at the end for you. You can check it out. It's amazing. It has everything from mung beans, alfalfa, broccoli sprouts, salad mixes, protein mixes, and more. It's just a great variety to begin with.



I also love this 12 pound set because it can last you for up to a year. That's right, I said a year!

And it will save you a lot of money.



I did the math on this 12 pound seed set and each bag (each one of these bags) will yield you 8 half cups servings of seeds.



1/2 cup of seeds will yield you approximately 4 cups of grown sprouts at a minimum. Some will yield up to 7 cups.



This means that you will get approximately thirty two cups of fully grown sprouts per each pound bag.



That's three hundred and eighty four cups of sprouts total, which is enough to feed you at least one cup of sprouts [a day] for an entire year.



That breaks down to twenty-five cents a day for 1 cup of grown sprouts. For a year this is a huge savings, considering you can pay up to...



\$5 at the grocery store for...



a container of sprouts. (I've been guilty of it.)



These are the seeds that I'm using. Of course, you can find whatever seeds that you feel most comfortable with. I just highly recommend that you find the highest quality seeds organic and non-gmo. I love this set because of the variety, because it saves you so much money. If you're interested in it, it's linked below. No, it's not sponsored. I'm simply sharing what I use, and love; and I hope that you love it too.



So, when I'm sharing with people the importance and the nutritional value of consuming sprouts most people will roll their eyes at me and say, "Oh, one cup? That's not very much!"

Well, guess what? One cup of sprouts is filled with **so many** nutrients!



Imagine if everyone consumed just one cup of sprouts in their daily routine how much more nutrients they would get into their diet!



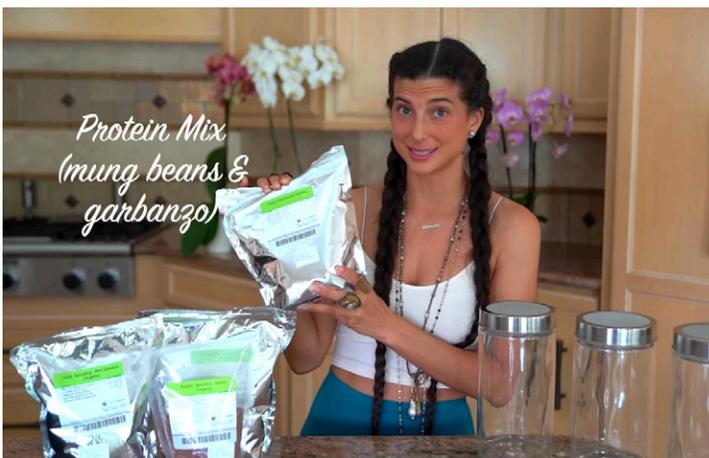
And usually one cup depending on what kind of sprout you're using can be very filling. I typically won't do more than two cups of sprouts on my salad, because they are very satiating.



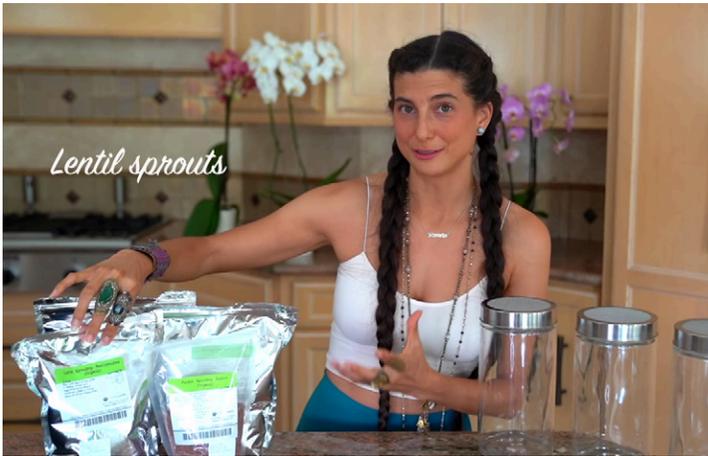
They're very, very filling, and you can get a lot in that little amount of sprouts. Sprouts are a great way to increase your nutritional intake. You get so much for so little. And, it's so easy to do at home!



So today, I'm gonna show you how I sprout three kinds of seeds from beginning to end.



I've got here a Protein Powerhouse Pack. It has mung beans and garbanzo beans. These are really easy to sprout for beginners.



I've also got lentil sprouts which are very hardy for a salad and some other recipes that I'm gonna be sharing with you at the end of this video.



I've also got broccoli sprouts. These are said to be one of the most nutritionally dense sprouts, and they taste amazing pretty much on anything you put them on.



So, I'm going to be showing you these three sprouts today.



So, as you can see here, I have three sprouting jars in front of me. Each of these is a half-gallon jar that I bought online.



I will also link these at the end for you if you're interested in buying some quality sprouting jars.



So into each of these (3) jars, I'm gonna add 1/2 a cup of each of the seeds that I want to sprout.



After your seeds are in your jar, you will fill up each jar with 3 cups of purified water, and then screw on the lid.



Purified water is really important here because the sprouts are soaking up your water - so you don't want to use non-filtered water.



You'll see that this lid has a sieve on it which allows water and air to come through. If you don't have one of these, you can also use a cheesecloth and tie it over with a rubber band. You can also use the top of a regular strainer throughout your daily process.



Ok, so this is it for day 1. After this, all you have to do is place them on your countertop somewhere away from the direct sunlight, and let them soak for about 12 hours.



I usually start this process at night, so when I wake up the next morning, I can begin the phase 2 component. I'll see you in the morning!



So it's day 2, and the seeds and beans have been soaking overnight.



And as you can see, they have soaked up a significant amount of water.



All we need to do today is rinse and drain them, and I will do this once in the morning and once in the evening.



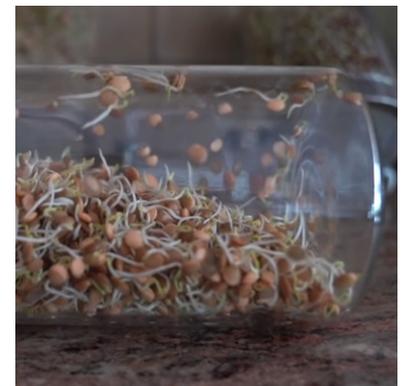
So I rinse and drain them twice a day, and I usually repeat the rinse and drain process twice.



Once they are rinsed and drained, you can lay them on your counter. I like to lay mine sideways or flat so that the seeds can lay out. They have more room to grow, and then you can just get on with the rest of your day!



Day 3: Look at the difference between Days 2 and 3! As you can see, the seeds have sprouted significantly. They've grown tails. They're starting to look like real sprouts.





We will follow the same process that we did yesterday: rinsing twice and draining twice, twice a day.



The only difference I'll do today is to be sure to mix the seeds around a little bit in the jar so that they don't clump together.



And, I will make sure that they're well-rinsed. Now you can use any kind of a long spoon here or a chopstick or any kind of tool to make sure that these seeds are broken up.



Just make sure that they are well-rinsed and drained. This will also help to eliminate or reduce any molding that might be happening.

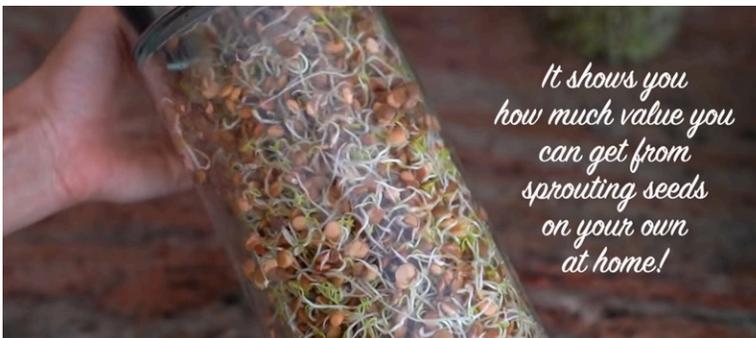


It is day four. Wahoo!

Typically your sprouts should be ready by day four.



And as you can see from these jars, they have expanded significantly. They look amazing!



We went from half a cup of seeds to nearly filling up a half-gallon jar.



You can see how much these seeds have sprouted. They look delicious.



So what we want to do now is we want to remove our seeds from their jars and put them each into their own separate bowls.

Fill each bowl up with water not only to give them one final wash or rinse, but also because during this process you'll see that the unsprouted seeds will float to the top.



This is a great way to separate the seeds that have sprouted from the few that didn't. The seeds that don't sprout will usually just float to the top with their shells and you can simply remove them by scooping your hand at the surface of the water.

Those seeds that didn't sprout are still good. you don't have to throw them away. You can begin the sprouting process with those again if you'd like. It's optional.



From here, we're gonna pour everything into a larger strainer. One at a time, I will strain my protein mix, my lentil sprouts, and my broccoli sprouts.



I'll give them one final wash in the strainer, and then you can place each of these either into a tray or bowl of choice.



I like to line the bottom either with a cloth or a towel or paper towel and from this point on - Voila! You have sprouted seeds!



These look fresh and ready to eat. You can store them just like this (or you can place them in a container of your choice), and they will last in the refrigerator for three to seven days.



How amazing do these look, and how easy was this process?!



Sprouting is so much fun - not just for us adults - but also for kids too!



There are three different ways that I love to enjoy at my sprouts. The first way is on a salad. Sprouts will make any salad more hearty, especially a rainbow salad. They just have this delicious crunch, and this ... just juiciness to your salad.



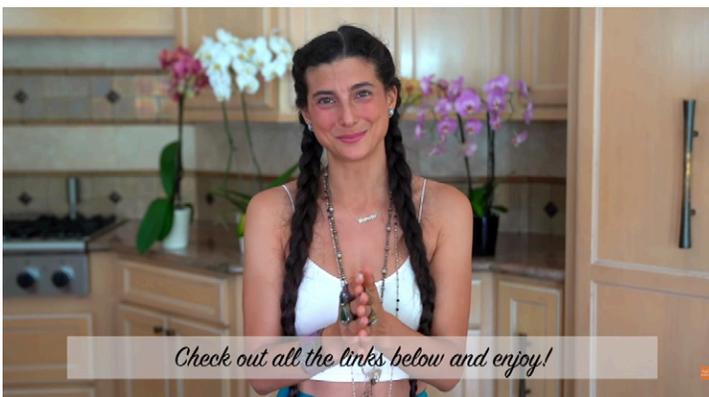
I also love to enjoy my sprouts on a flax cracker with some avocado and tomato. It's like a mini sandwich. It's a raw vegan sandwich!



I also love to enjoy my sprouts on top of a raw vegan soup. When you mix them in, the texture is just perfect and it just adds this different consistency to it that I really love.



So those are three different ways I love to enjoy my sprouts.



If you're interested in sprouting seeds or any of the jars or trays that I've talked about in this video, definitely check the links below. They're waiting for you.

Sprouting Seeds I LOVE (12 lb. Bulk Set): <https://bit.ly/trueleafsprouts>
Easy Sprouting Starter Kit (Jars Included): <https://bit.ly/sproutingstarterkit>
More Sprouting Jars: <https://amzn.to/37vEqvQ>

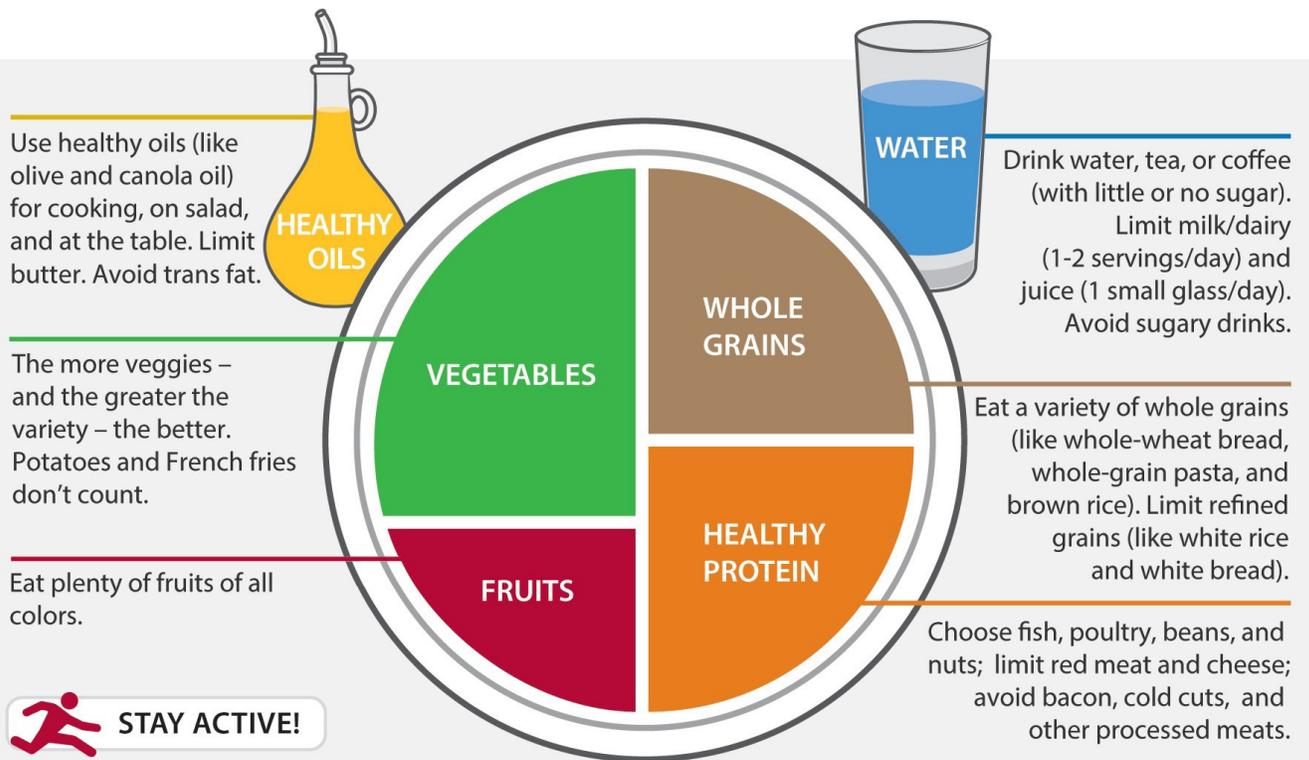


Activity 2: Review the diagram below

Answer the following questions:

- ▶ What changes would you be interested in making?
- ▶ What new foods would you like to try?
- ▶ How can you promote health?

HEALTHY EATING PLATE



STAY ACTIVE!

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The Nutrition Source
www.hsph.harvard.edu/nutritionsource

Harvard Medical School
Harvard Health Publications
www.health.harvard.edu



Copyright © 2011, Harvard University. For more information about The Healthy Eating Plate, please see The Nutrition Source, Department of Nutrition, Harvard T.H. Chan School of Public Health, www.thenutritionsource.org, and Harvard Health Publications, www.health.harvard.edu.



Activity 3: Broccoli Benefits – Secrets of Sulforaphane

While we have looked at many of the benefits of sprouts, such as fiber and nutrients, broccoli sprouts have a superpower that boasts the ability to improve the expression of our longevity genes, specifically increasing translation of our heat shock proteins. Read the article below from Johns Hopkins to unpack the researchers' findings and how they can impact future medical treatments and therapies. Then, respond to the questions after the article.

• • •

Johns Hopkins article: October 13, 2014

https://www.hopkinsmedicine.org/news/media/releases/chemical_derived_from_broccoli_sprouts_shows_promise_in_treating_autism

Chemical Derived from Broccoli Sprouts Shows Promise in Treating Autism

Improvements were seen within four weeks and generally persisted during treatment duration

FAST FACTS:

- ▶ Forty boys and young men, ages 13 to 27, with moderate to severe autism, were treated for 18 weeks with a daily dose of either a placebo or sulforaphane, a plant chemical derived from broccoli sprouts.
- ▶ Researchers say that many of those taking sulforaphane substantially improved in several aspects of their behavior during treatment.
- ▶ In contrast to most previously tested remedies that work to ameliorate the behavioral manifestations of autism, sulforaphane seems to target the basic mechanisms of the disorder.

Results of a small clinical trial suggest that a chemical derived from broccoli sprouts — and best known for claims that it can help prevent certain cancers — may ease classic behavioral symptoms in those with autism spectrum disorders (ASDs).

The study, a joint effort by scientists at MassGeneral Hospital for Children and the Johns Hopkins University School of Medicine, involved 40 teenage boys and young men, ages 13 to 27, with moderate to severe autism.



Photo: Johns Hopkins Medicine

In a report published online in the journal *Proceedings of the National Academy of Sciences* during the week of Oct. 13, the researchers say that many of those who received a daily dose of the chemical sulforaphane experienced substantial improvements in their social interaction and verbal communication, along with decreases in repetitive, ritualistic behaviors, compared to those who received a placebo.

“We believe that this may be preliminary evidence for the first treatment for autism that improves symptoms by apparently correcting some of the underlying cellular problems,” says Paul Talalay, M.D.,

professor of pharmacology and molecular sciences, who has researched these vegetable compounds for the past 25 years.

“We are far from being able to declare a victory over autism, but this gives us important insights into what might help,” says co-investigator Andrew Zimmerman, M.D., now a professor of pediatric neurology at UMass Memorial Medical Center.

ASD experts estimate that the group of disorders affects 1 to 2 percent of the world’s population, with a much higher incidence in boys than girls. Its behavioral symptoms, such as poor social interaction and verbal communication, are well known and were first described 70 years ago by Leo Kanner, M.D., the founder of pediatric psychiatry at The Johns Hopkins University.

Unfortunately, its root causes remain elusive, though progress has been made, Talalay says, in describing some of the biochemical and molecular abnormalities that tend to accompany ASD. Many of these are related to the efficiency of energy generation in cells. He says that studies show that the cells of those with ASD often have high levels of oxidative stress, the buildup of harmful, unintended byproducts from the cell’s use of oxygen that can cause inflammation, damage DNA, and lead to cancer and other chronic diseases.



In 1992, Talalay's research group discovered that sulforaphane has some ability to bolster the body's natural defenses against oxidative stress, inflammation and DNA damage. In addition, the chemical later turned out to improve the body's heat-shock response — a cascade of events used to protect cells from the stress caused by high temperatures, including those experienced when people have fever.

Intriguingly, he says, about one-half of parents report that their children's autistic behavior improves noticeably when they have a fever, then reverts back when the fever is gone. In 2007, Zimmerman, a principal collaborator in the current study, tested this anecdotal trend clinically and found it to be true, though a mechanism for the fever effect was not identified.

Because fevers, like sulforaphane, initiate the body's heat-shock response, Zimmerman and Talalay wondered if sulforaphane could cause the same temporary improvement in autism that fevers do. The current study was designed to find out.

Before the start of the trial, the patients' caregivers and physicians filled out three standard behavioral assessments: the Aberrant Behavior Checklist (ABC), the Social Responsiveness Scale (SRS) and the Clinical Global Impressions-Improvement scale (CGI-I). The assessments measure sensory sensitivities, ability to relate to others, verbal communication skills, social interactions and other behaviors related to autism.

Twenty-six of the subjects were randomly selected to receive, based on their weight, 9 to 27 milligrams of sulforaphane daily, and 14 received placebos. Behavioral assessments were again completed at four, 10 and 18 weeks while treatment continued. A final assessment was completed for most of the participants four weeks after the treatment had stopped.

Most of those who responded to sulforaphane showed significant improvements by the first measurement at four weeks and continued to improve during the rest of the treatment. After 18 weeks of treatment, the average ABC and SRS scores of those who received sulforaphane had decreased 34 and 17 percent, respectively, with improvements in bouts of irritability, lethargy, repetitive movements, hyperactivity, awareness, communication, motivation and mannerisms.

After 18 weeks of treatment, according to the CGI-I scale, 46, 54 and 42 percent of sulforaphane recipients experienced noticeable improvements in social interaction, aberrant behaviors and verbal communication, respectively.



Talalay notes that the scores of those who took sulforaphane trended back toward their original values after they stopped taking the chemical, just like what happens to those who experience improvements during a fever. “It seems like sulforaphane is temporarily helping cells to cope with their handicaps,” he says.

Zimmerman adds that before they learned which subjects got the sulforaphane or placebo, the impressions of the clinical team — including parents — were that 13 of the participants noticeably improved. For example, some treated subjects looked them in the eye and shook their hands, which they had not done before. They found out later that all 13 had been taking sulforaphane, which is half of the treatment group.

Talalay cautions that the levels of sulforaphane precursors present in different varieties of broccoli are highly variable. Furthermore, the capacity of individuals to convert these precursors to active sulforaphane also varies greatly. It would be very difficult to achieve the levels of sulforaphane used in this study by eating large amounts of broccoli or other cruciferous vegetables.

These studies were designed at The Johns Hopkins University by Andrew Zimmerman in collaboration with Paul Talalay and Kirby Smith. Jed Fahey prepared the sulforaphane-rich broccoli sprout extract that was administered in capsules to patients. The clinical studies were done at the Lurie Center in Lexington, Massachusetts, which is dedicated to the study of autism and is a satellite of Massachusetts General Hospital’s Department of Pediatrics. Other authors of the report include Kanwaljit Singh, Eric Macklin and Susan Connors of Harvard Medical School.

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U.S. patent applications have been filed by The Johns Hopkins University for inventors Smith, Talalay and Zimmerman. Talalay and Zimmerman have divested themselves from all potential financial benefits. The sulforaphane-rich broccoli sprout extract is not a commercial product. Broccoli sprouts and seeds rich in glucosinolates have been licensed by Johns Hopkins to Brassica Protection Products LLC; Antony Talalay, son of Paul Talalay, is chief executive officer. The university owns Brassica Protection Products stock, which is subject to certain restrictions under university policy. This arrangement has been reviewed and approved by the Johns Hopkins University in accordance with its conflict of interest policies.

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Questions:

- ▶ What are some of the most interesting benefits of broccoli sprouts in the article you read?
- ▶ Who were involved in the study as subjects? How were they chosen (i.e. What was the selection criteria)?
- ▶ What did the researchers say were found in cells of ASD patients?
- ▶ The researchers mentioned that the active compound in broccoli sprouts that bolsters immunity within the body was [fill in the blank].
- ▶ What response does sulforaphane induce in the body?
- ▶ In what way do you think broccoli sprouts or their active compound could be used in modern medicine?

Post Assessment

Refer to your pre-assessment answers. Would you now answer any of these questions differently?

1. What prevents seeds from germinating immediately?
2. Describe the environment required for a seed to grow.
3. At what stage of growth does a plant contain the most nutrients?
4. What are the macronutrients and building blocks required for a healthy diet?
5. What is a food desert and how have you seen this problem in your community or state?
6. How can we improve the problem of food scarcity?
7. Why is it important to purchase organic produce when possible?
8. What are some of the most interesting benefits of broccoli sprouts in the article you read?