

# STEM Utilizing Cactus Fruit

*Developing and Utilizing Science, Technology, Engineering and Math Knowledge and Skills*

## Tucson Cactus and Succulent Society

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## I. INTRODUCTION TO STEM UTILIZING CACTUS FRUIT



### Science - Technology - Engineering - Math

A Cactus Fruit can be utilized to provide many hands on and interesting activities to develop and utilize Science, Technology, Engineering and Math knowledge and skills. The Ferocactus Wislizenii (our native Fishhook Barrel cactus) has a good fruit to use. They are plentiful most if not all months, large, have no spines and have lots of seeds.

Each of the sections below can be very simple using math and others skills as appropriate for various grade levels. Some items, especially the more complex calculations, will not be appropriate for lower grade levels but certainly concepts can be introduced and simple math can be used. Students can work in small groups (2-4) with each group needing one barrel cactus fruit. If the opportunity exists, the students can observe fruits growing on available cactus and pick the one they would like to work with. You might want to write a number on the fruit skin for the cactus where they were picked to do plant comparisons. Comparing at least 7 or 8 fruits may be enough to provide statistically significant information, or is it?.

This material is organized so many of the sections can be used individually without following the entire document. Improve, improvise, amend and have fun. Share your suggestions and improvements with TCSS so we can share with others via our web site,

## II. VOLUME CONCEPTS AND CALCULATIONS



Before the cactus fruit is cut into pieces to count the seeds, the volume of the fruit can be calculated using a couple of different methods. The volume measurement, how much space an object occupies, is an important concept by itself and will also be used for exercises below.

There are two easy methods that can be used, one for simple shapes and the other for any shape including very complex ones. They are listed below. Try to do both and compare your answers. Which one is likely to be more accurate? Why? Which is faster to do?

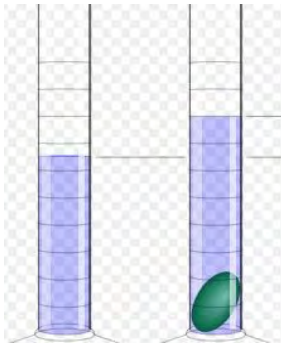
### A. Ruler Measuring Method



1. A ruler can be used to measure the fruit dimensions. Centimeters or millimeters may be easier to avoid using fractions for inches.
2. Visualize the fruit (just the yellow part, not the flower stem) as being a rectangle, measure each direction (length, width, thickness) but do not measure to the ends for the length as the fruit tapers off so stop at about half way on the tapered part. Write each number on a piece of paper including the units (mm, cm or inches).

3. Multiply your 3 numbers together to get your fruit volume in cubic millimeters, centimeters or cubic inches. Write this on the paper including the units.
4. Have each student in the group (suggest 1, 2, or 4 students per group) do their own measurements, then average them to get the most likely actual volume (law of averages).
5. A chart with student names on it can be created to visually show their measurements and answers.

## B. Volume Displacement Method



1. You need a glass or plastic container (that you can see a water level) with straight sides, about 3 to 5 inches tall and 1.5 to 2 inches in diameter. Place a narrow strip of masking tape on the container going from the top to half way down so you can mark water levels on it. Do one strip spaced apart for each student in the group, write a first name on the bottom part of each tape strip.
2. Fill the container with water about one inch from the top. Mark on the tape on the right edge the water level with the container sitting on a flat surface. You can add a drop or two of food coloring in the water if that helps view the level.
3. Take a small square or rectangular object (about 1 by 1 by 1 inches, like a wood block) and calculate the volume using method A. above. Write the answer on a piece of paper calling it the block volume, be sure and include the units for all measurements.
4. Do you think the object or the fruit will have the larger volume?
5. Take the block object and push it just below the water level, if it sinks that is OK.
6. On the other edge of the tape mark the water level with the block submerged below the water, this will be a higher level.
7. Measure the distance between the two marks, this is the displacement for your block.
8. Repeat steps 4, 5, and 6 above for the fruit, submerge the yellow part of the fruit only and mark the water levels on the opposite edge of the masking tape strip. Note, the second and other students do not need to start with the same water level, just mark the level where they start on their strip of tape.
9. Calculate the volume of the fruit by using ratios (or other math techniques). The displacement for the block divided by the volume of the block is proportional to the displacement of the fruit divided by the fruit volume. Document your work.

10. Take each of the students on a given team and average their fruit volume numbers to get an accurate number. How much do the answers vary? Can you plot it? Does that make the variance easier to see or understand?
11. Can you do a vertical bar graph showing the Ruler and Displacement results for each of the teams? How could you make the Displacement measurement more accurate?
12. Some really interesting and challenging things you can do regarding volumes after you cut the fruit in half are: calculate the volume of the seeds, the cavity inside the fruit and the walls of the fruit.

### III. FRUIT ANATOMY AND COUNTING SEEDS



These exercises will delve into the fruit to observe its structure and allow students to count seeds allowing many math calculations. Results can be compared with the other student groups since they have different fruits.

The Fishhook Barrel cactus (botanical name is *Ferocactus wislizeni*, note the botanical name is always in italics) fruit has larger seeds than many cactus hence the quantity that can be counted in a few minutes.

#### A. Opening the Fruit

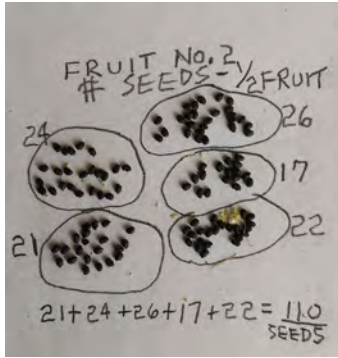
1. The barrel cactus fruit is easy and safe to handle, no spines or glochids which are very small reddish stickers, always found on Prickly Pear and Cholla. Sometimes there will be a small hole in the bottom when you pull it off so place a small piece of masking tape over the hole to keep the seeds inside.
2. Lay it on a flat surface on a letter size piece of paper and cut it long ways, from the top flower stem to the bottom of the fruit. Cut each half to be of approximately equal size. Try not to loose any of seeds that might fall out.

#### B. Observing

1. Look at the structure inside the fruit. What do you see? Is it totally full of seeds? Why or why not? What is the pulp/goo inside? What purpose does the it serve?
2. Look at it with a magnifying glass or other device to see more detail. Can you make a sketch of the parts (this is what botanical art is all about) and maybe take a close-up photo or two and view on a large tablet or computer screen.

#### C. Counting Seeds

1. Each person on a team should have a piece of letter size paper. Remove the seeds from the fruit and give each person about the same quantity. Students should write their name and date on their sheet of the paper and the fruit number if assigned one.



2. Take a pencil and start separating the seeds into small groups, about 20 to 30 per group, best to have various quantities. Once you have all the seeds into small groups, draw a circle around each group, count them and write the number next to the circle.
3. On the side of your paper, write each of the circle's numbers and add. On one of the sheets write each person's total number and now add to get the total fruit number of seeds. On all numbers add the units or description so you document what the number represents. This is critical for any Engineering or Science work. Without units, the numbers are meaningless and may be interpreted incorrectly.
4. If the goo makes it too hard to remove the seeds, you can wait a couple of days for the fruit to dry out a bit. If you do this, the fruit will shrink so additional volume measurements will not be accurate unless you want to measure the volume change as the fruit dries.

#### D. Other Seed Activities and Calculations

What else can you measure or discover about the seeds. Can you calculate the weight of a seed? How? Can you calculate or measure the volume of a seed and how many seeds would occupy one cubic inch of space? How much do the seed sizes vary in a given fruit? Does the color vary from seed to seed? Are all the seed shapes the same? Can you calculate the average seed density for a given fruit? What is the density after the seeds sit out for a week or two? Why did it change or did it?

### IV. MATH CALCULATIONS, CHARTS AND GRAPHS



There are many calculations that can be performed. Grade level will obviously influence the choices but observations and discovery may lead to interesting discussions.

#### A. Basic Arithmetic

Addition and Subtraction. Adding seeds in the groups, adding the total seeds of a fruit. Subtracting seeds in groups to see which is larger and by how much. Simple graphs and tables can be created to present the results visually. You could glue the seeds on a thin white glue line to make the graph or ?.

#### B. More Math

Multiplication and Division. Calculating percent and ratios of about anything that is interesting. Calculating averages or mean, median, mode, range, etc. values. Don't forget about creating word problems.

#### C. Advanced Math

Some statistical analysis might be appropriate for higher grade levels.

## V. PLANTING AND CALCULATING SEED GERMINATION YIELDS



There are many ideas, guides and documents on ways to plant and grow cactus seeds. Now that you have hundreds of Barrel cactus seeds, you may want to plant them.

This document will not cover this topic but we recommend going to our web site. Our information will be updated from time to time so it is best to use our web site. There is an easy Red Cup Planting Seeds method on our web site.

See our [Education Materials Section](#) or go to our web and click on Education on the left side navigation links.

## VI. COMPARING HEALTH AND GROWTH RATES



If you want to go beyond the germination activities, there are many more things that can be done in all the STEM areas. Once the plant pops through the soil, that is only the beginning of raising a healthy and viable plant. What percent of seeds germinated in a controlled environment survive or produce health and viable plants versus a native location like the desert?

Again, this document will not cover this topic but recommend going to our web site where our documents and suggested links will be updated from time to time so it is best to use our web site.

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## VII. PHOTOS AND SUGGESTED MATERIALS FOR EXERCISES

### Displacement Container and Measurements



Starting water level - Block Displacement - Fruit Displacement

### Special Items for activities above, need one each per student group:

- 1) Clear glass or plastic cylinder, about 1.5 inches diameter, 4 inches tall that you will be able to see a water level inside the container
- 2) Wood block or other solid rectangular object about one cubic inch in volume, or use a square or rectangular wood stick about 1x1x3 inches and mark a line on it about mid way to know how deep to submerge and to calculate the volume.

### Other items needed that are commonly available:

- 1) Paper, graph paper, clipboard, pencil, ruler (cm and inches)
- 2) Plastic utensil knife, one per group to cut the fruit open (may need metal knife)
- 3) Strips of masking tape, half or three quarter inch wide by 3" long, 2 for each student.
- 4) Magnifying glass, one per group or share
- 5) Digital Camera, can use a cell phone camera that takes close-ups
- 6) Calculator if allowed for some of the calculations, one per group