***What are the changes that take place in developing Clarkia unguiculata seedlings?***

***(Cultivating Clarkia unguiculata in the classroom)***

**Teacher’s Preparatory Guide**

**Overview -** Students will plant Clarkia seeds in petri dishes then transplant them to a cup with soil and grow them in a mini-greenhouse or in the classroom to their flowering stage and observe changes to the seedlings as the seedlings mature to a flowering plant. The reason we are using Clarkia is because it is a native California wild flower that can be easily grown and contains reproductive organs that are easily visible and manipulated.

**Purpose -** This lab teaches students the methods used in of growing plants in a greenhouse then how to transplant them to the field. It also teaches them about the changes that occur in the different stages of the plant cycle and how to record this data.

**Level -** High school (9-12)

**Time Required -** Two 55 minute student lab periods then 5-10 minutes per day for observations and weighing.

**The Next Generation Science Standards addressed**

[**LS1.A: Structure and Function**](http://www.nap.edu/openbook.php?record_id=13165&page=143%22)

[Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)](http://www.nap.edu/openbook.php?record_id=13165&page=143)

[All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1)](http://www.nap.edu/openbook.php?record_id=13165&page=143)

[Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)](http://www.nap.edu/openbook.php?record_id=13165&page=143)

[**LS1.B: Growth and Development of Organisms**](http://www.nap.edu/openbook.php?record_id=13165&page=145)

[In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the](http://www.nap.edu/openbook.php?record_id=13165&page=145)

**Teacher Background**

 The [**seed**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_seed.htm) of a [higher plant](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_seed_plant.htm) is a small package produced in a [flowering plant](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_F/dictionary_flowering_plants.htm) or [**gymnosperm**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_G/dictionary_gymnosperm.htm)containing an [embryo](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_embryo_embryonal.htm) and [stored](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_storage.htm) [food](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_F/dictionary_food.htm) [reserves](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_reserve.htm). The seed looks apparently [dead](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_death.htm). In fact, even with [biochemical](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_B/dictionary_biochemical.htm) tests for the [metabolic](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_M/dictionary_metabolism.htm) [processes](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_process.htm) we associate with [life](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_L/dictionary_life_living.htm) ([respiration](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_respiration.htm), etc.) the rate of these processes is so slow that it would be difficult to determine whether there really was anything [alive](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_L/dictionary_life_living.htm) in a seed. **Germination** is the resumption of [growth](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_G/dictionary_growth.htm) of the [dormant](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_dormancy_dormant.htm) [embryonic](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_embryo_embryonal.htm) [plant](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_plant.htm) inside the seed; it implies complex [physical](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_physics.htm) and [chemical](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_C/dictionary_chemical_compound.htm) changes that occur as the embryo begins to [develop](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_development.htm) into a young [shoot](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_shoot.htm) and [root](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_root.htm) ([**seedling**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_seedling.htm)). The germinating seed sends its first root ([**radicle**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_radicle.htm)) into the [soil](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_soil.htm) and the first [stem](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_stem.htm) with the first [leaves](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_L/dictionary_leaf.htm) ([**cotyledon**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_C/dictionary_cotyledon.htm)) toward the [sunlight](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_sunlight_solar_radiation.htm). In some definitions, the appearance of the [radicle](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_radicle.htm) marks the end of germination and the beginning of [establishment](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_establishment.htm), a period that ends when the seedling has exhausted the food [reserves](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_reserve.htm) stored in the seed. These are critical [phases](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_phase.htm) in the [life](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_L/dictionary_life_living.htm) of a plant. The [mortality](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_M/dictionary_mortality.htm) between [dispersal](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_dispersal.htm) of seeds and completion of [establishment](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_establishment.htm) can be so high, that many [species](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_species.htm) survive only by producing huge numbers of seeds. If a seed is not allowed to germinate within some certain length of time, the embryo inside will die. Each species of seed has a certain length of [viability](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_V/dictionary_viability.htm), varying from a few weeks up to 2000 years. A seed will germinate, or sprout, when conditions are right for [survival](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_survival.htm), some seeds require particular conditions before they will germinate, these conditions encompass adequate [moisture](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_M/dictionary_moisture.htm), [heat](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_T/dictionary_temperature.htm), and/or [light](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_L/dictionary_light.htm), also some species of seed have particular needs such as the heat of a [fire](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_F/dictionary_fire.htm), or [soaking](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_soaking.htm) in a [body of water](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_B/dictionary_body_of_water.htm) for a long period of time. When a [mature](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_M/dictionary_maturity.htm) seed is placed under favorable conditions and fails to germinate, it is said to be [dormant](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_dormancy_dormant.htm). The length of time plant seeds remain dormant can be reduced or eliminated by some simple seed [treatments](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_T/dictionary_treatment.htm) called [stratification](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_stratification.htm), [vernalization](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_V/dictionary_vernalization.htm) or [soaking](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_soaking.htm) ([**imbibition**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_I/dictionary_imbibition.htm)).



Fig.1 (Horticulture Science)

1. The [primary root](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_primary_root.htm) emerges through the [seed coats](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_T/dictionary_testa.htm) while the seed is still buried in the [soil](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_soil.htm).
2. The [hypocotyl](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_H/dictionary_hypocotyl.htm) emerges from the seed coats and pushes its way up through the soil. The two [cotyledons](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_C/dictionary_cotyledon.htm) protect the [epicotyl](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_epicotyl.htm) [structures](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_structure.htm) — the [**plumule**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_plumule.htm)— from mechanical damage.
3. Once the [hypocotyl](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_H/dictionary_hypocotyl.htm) emerges from the soil, it straightens out.
4. The [cotyledons](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_C/dictionary_cotyledon.htm) spread apart exposing the [epicotyl](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_epicotyl.htm), consisting of the [primary leaf](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_primary_leaf.htm) (or leaves) and the [apical meristem.](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_A/dictionary_apical_meristem.htm) In many [dicots](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_dicotyledon.htm), the [cotyledons](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_C/dictionary_cotyledon.htm) not only supply their [food](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_F/dictionary_food.htm) [reserve](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_reserve.htm) to the [developing](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_development.htm) plant but also turn green and make more food by [photosynthesis](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_photosynthesis.htm) until they drop off.

In this lab, students will plant seeds from Clarkia Unguiculata and record their observations of the changes that take place in the developing seedling.

**Sources**

1. Te Kura, ā -Tuhi, *Horticulture Science*. The correspondence School, 2010.

2. Maple Science TV “Germination of a seed”

http://www.youtube.com/watch?feature=player\_detailpage&v=R59vvt6aD6c

1. Cactus Art Nursery

www.ecolawnandgardensb.com

**Materials per class (36 students)**

* 18 Plastic cups
* 18 petri dishes
* 1 10 lb. bag of soil
* Electronic scales
* paper towels
* 18 squeeze water bottles
* 18 rulers
* 18 long wood stirring sticks
* 18 tweezers
* refrigerator
* Fertilizer pellets(optional)
* mini-greenhouse or rubber tub with transparent lid(optional)

**Materials per student group**

* 1 plastic cup
* Potting soil
* 5-10 Clarkia seeds
* 1long wooden stirring stick
* Ruler
* Squeeze water bottle
* petri dish
* paper towel
* masking tape
* pencil/pen
* one pair of tweezers

**Advance Preparation –** Purchase Clarkia seeds online from any vender including amazon.com, ebay.com or others.

 We obtained ours from amazon.com. Cups and soil can be of any brand and may be purchased at any super market. Cups can be filled to about ½ an inch from the top with soil before class or students can do it for themselves. 16 oz. cups are recommended as Clarkia has deep roots to grow tall.

**Instructional Procedure (Timeline)**

|  |  |  |
| --- | --- | --- |
| **Time** | **Activity** | **Goal** |
| **Day 1** |  |  |
| **15 min** | Introduce students to this lab by reading about seed germination. Show students YouTube videos and discuss with students the types of work being done in this field and the advances that this field has made possible. | To prepare student to appreciate the use of seed preparation techniques and in the lab they will do. |
| **10 min** | Students define terms (in the *Guided Dialog* section).Watch “Germination of a seed” video <http://www.youtube.com/watch?feature=player_detailpage&v=R59vvt6aD6c> and have students answer the questions in the *Guided Dialog* section. | To ensure students understand the process of seed germination.To prompt students to consider what they will do in this lab. |
| **20 min** | Distribute *Student Worksheets* to students. Students follow procedures 1–3. | To plant their seedling and allow students to write down a few observations |
| **5 min** | Clean up. | To prepare workspace for next class. |
| **Day 2-5** |  |  |
| **5-10 min** | Ongoing observation of student’s seedlings, this can be done at the beginning of the period or at some point when it is convenient to the teacher. | To take notes on the  |
| **HW** | Answer conclusion questions. Students may finish them for homework. | To wrap up the activity. |
| **Day 6** |  |  |
| **20 min** | Transplanting seedlings to a cup with soil as in procedures in step 4 and 5. | To place the seedling in a larger median to allow for proper growth. |
| **5 min** | Clean up. | To prepare the classroom for the next class. |

**Teaching Strategies -** This lab is best done individually or in groups of two students. Two 55-minute periods are recommended and will require 5 to 10 of ongoing data collection once seeds begin to germinate and grow.

**Guided Dialog** *Before* beginning the lab, review the meaning of these terms:

**germination**  *is the* [*process*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_P/dictionary_process.htm) *of emergence of* [*growth*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_G/dictionary_growth.htm) *from a* [*resting stage*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_D/dictionary_dormancy_dormant.htm)*.*

**seed** *is a small package produced in a* [*plant*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_F/dictionary_flowering_plants.htm) *containing an* [*embryo*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_E/dictionary_embryo_embryonal.htm) *and* [*stored*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_storage.htm)[*food*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_F/dictionary_food.htm)[*reserves*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_reserve.htm)*.*

**seedling** *is a young* [*shoot*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_S/dictionary_shoot.htm) *and* [*root*](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_R/dictionary_root.htm)*.*

**radicle** *The first root.*

**cotyledon** *The part of seed that will develop into leaves and contains stored food.*

**plumule** The *young shoot of the seedling.*

[**imbibition**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_I/dictionary_imbibition.htm)*soaking a seed to stimulate germination*

[**gymnosperm**](http://www.cactus-art.biz/note-book/Dictionary/Dictionary_G/dictionary_gymnosperm.htm)*a flowering plants*

Watch “Seed germination in a petri dish” http://www.youtube.com/watch?feature=player\_detailpage&v=R59vvt6aD6c

Have students answer these questions:

1. What possible changes do you think will be observable in your seeds? *Students may response anything from start growing roots and leaves to we may not see any changes (won’t get any growth).*
2. Why do you suppose it is important to study the development of a seed? *Students may respond with learn more about the germination process itself, to develop better crop yield, or better more disease resistant crops.*
3. What conditions do you supposed will have an effect on the growth and development of your seeds? *Students may respond with things like amount of water, light and soil present.*

**Procedure**

1. **Preparing the petri dish**

Obtain a clean petri dish from your instructor. Using masking tape or a marker put your name and your partner’s name on both sides of your petri dish. Trace a circle the size of your petri dish on a folded paper towel and draw a grid on your towel with at least four sections. Place the towel in the bottom side of your petri dish.

1. **Planting your seeds**

Thoroughly wet the paper with a spray water bottle or squirt water bottle. Place one or two seeds in each of the grids that you drew on the paper towel. Place the cover on the petri dish. Place the petri dish where your teacher designated for your class.

* 1. **Observing your seedlings**

Each day from today forward you must observe you seeds and write down all your observations.

* 1. **Preparing a cup with soil**

Obtain a cup from your instructor and put your name and your partner’s name on it with masking tape. Fill the cup to about ½ an inch from the top with potting soil. Gently wet the soil with your water bottle. Take a pencil and make a hole about one inch in depth in the center of the potting soil.

* 1. **Transferring your seedling to a cup**

Once your seedling has reached an acceptable length it is time to transfer it to a cup with soil. It should be at least one to two inches in length and no longer able to fit in the petri dish. Carefully select one or two of your seedlings and using your tweezers pick up your seedlings from the stem. Place only the roots of your seedling inside the one inch hole (Be sure not to damage the roots). Now gently cover the roots with soil.

**Cleanup -** things should be thoroughly cleaned and students should wash soil or fertilizer from their hands.

**Going Further -** Students who have a good grasp of the content of the lab can be further challenged with these questions:

1. How do you think these techniques could be used to produce better crops?
2. How could these methods be used to grow more abundant crops?
3. Design your own experiment to test your ideas.

**Assessment**

The student will be able to:

1. Draw and label the different parts of seeds germination.
2. Plant and germinate seeds in a petri dish.
3. Transplants seedlings from a petri dish to container with potting soil
4. Maintain a suitable controlled environment for plants to grow and develop.
5. State the changes that take place in seeds as they grow and develop.
6. State the importance of seed germination technology to society as a whole.

**Resources**

1. Te Kura, ā -Tuhi, *Horticulture Science*. The correspondence School, 2010.
2. Maple Science TV “Germination of a seed”

http://www.youtube.com/watch?feature=player\_detailpage&v=R59vvt6aD6c

1. Cactus Art Nursery

[www.ecolawnandgardensb.com](http://www.ecolawnandgardensb.com)

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