EXPERIMENT 4 - IDENTIFYING FEATURES OF MUTANT SEEDS USING NOMARSKI MICROSCOPY (GENE ONE)

**Purpose:** To introduce Differential Interference Contrast (DIC) or Nomarski Interference Contrast (NIC) microscopy technique as a tool to identify features of defective embryos in knockout mutants.

**Reference:** The protocol was written by Dr. Miguel Aguilar in Professor Robert L. Fischer’s laboratory at University of California, Berkeley.

**Materials Needed:**

- Siliques containing seeds with a wide range of embryo stages (globular to mature green) from Arabidopsis
  - wild type
  - homozygote or heterozygote mutant
- 100% ethanol
- Acetic acid
- Sterile water
- Chlroral Hydrate (Cat. #C8383, Sigma-Aldrich; should be fresh)
- Glycerol (Invitrogen)
- Double-distilled water

**Materials Needed:**

- Pipettes
- Pipette tips (regular, non-filter)
- 1.5 mL microcentrifuge tubes
- Microcentrifuge tube rack
- Black ultra-fine sharpie
- Rulers with METRIC scale (mm)
- Plant layout chart
- Phenotype observation chart
- Fine point forceps
- 30-gauge hypodermic needles
- Fine-point scissors or razor blades
- Coverslips
- Microscope Slides
- Double-sided tape
- Dissecting microscopes (borrowed from Dr. Pei Yun Lee)
- A microscope equipped with Nomarski optical parameter (Leica CTR5000)
- Microscope camera
PROCEDURE

Each student collects the following from wild type and his/her homozygous or heterozygous mutant:

a) 5 siliques containing seeds with embryo stages of globular to torpedo.

b) 2 siliques containing seeds with mature green embryos.

Note: Be sure to collect a wide range of stages. Do not collect yellow or brown siliques; these contain dry seeds.

I. Observation of Seeds Using Light Microscopy and Fixing Seeds for Observation with Nomarski Optics

1. Prepare 5 mL of a fixative solution of ethanol: acetic acid (9:1, v/v) in a 14 mL centrifuge tube using disposable 5 mL pipets.

   **FIXATIVE SOLUTION**

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% ethanol</td>
<td>4.5 mL</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>0.5 mL</td>
</tr>
<tr>
<td>Total volume</td>
<td>5.0 mL</td>
</tr>
</tbody>
</table>

   Tightly snap the cap on the tube. Invert the tube to mix the contents.

2. Pipet 1 mL of the **fixative solution** into **FOUR** 1.5 mL microcentrifuge tubes sitting on a microcentrifuge tube rack. Label each tube in step 2 with your **initials**, the **plant #** and the **plant genotype**. These tubes will be used in step 5.

3. Bring the following materials to the Plant Growth Center (PGC).
   - Bucket of ice
   - Twelve 1.5 mL microcentrifuge tubes
   - Microcentrifuge tube rack
   - Black ultra-fine sharpie
   - Ruler with METRIC scale (mm)
   - A pair of fine point forceps
   - Plant layout chart with information about plant number and the genotype of those plants
   - This protocol
4. Measure and collect siliques according to the chart below. Place each sique in a 1.5 mL microcentrifuge tube. Write your initials, the plant #, the plant genotype and the length on the tube. Keep the tube on ice. Note: Collect the same length of siliques for wild type and homozygous/heterozygous mutant so that you can compare them.

<table>
<thead>
<tr>
<th>Plant Genotype</th>
<th>Seed Stages Collected</th>
<th>Length of Siliques Collected</th>
<th>Number of Siliques Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild type</td>
<td>globular to torpedo</td>
<td>0.5 - 1.0 cm</td>
<td>5</td>
</tr>
<tr>
<td>Wild type</td>
<td>mature green</td>
<td>1.0 - 1.9 cm</td>
<td>2</td>
</tr>
<tr>
<td>Heterozygous or homozygous mutant</td>
<td>globular to torpedo</td>
<td>0.5 - 1.0 cm</td>
<td>5</td>
</tr>
<tr>
<td>Heterozygous or homozygous mutant</td>
<td>mature green</td>
<td>1.0 - 1.9 cm</td>
<td>2</td>
</tr>
</tbody>
</table>

5. Go back to the lab. Dissect the siliques and observe the seed phenotype using a dissecting microscope. Note: Work quickly so the seeds don’t dry out. You may also place a drop of water on the sique.

   a. Place a piece of double-sided tape on a microscope slide. Label the microscope slide with a small piece of white tape with your initials, the plant #, the plant genotype and the length.
   b. Carefully, use fine-point forceps to place a sique on the tape.
   c. Under a dissecting microscope, use fine-point forceps to carefully place a sique on the tape and arrange the sique such that the transmitting tract is facing you (see diagram below, NOT drawn to scale).
d. With your left hand, use forceps to hold the silique on the side closest to the stem.

e. With your right hand, use a 28G or 30G hypodermic needle attached to a 1 cc syringe to slice the carpels along each side of the transmitting tract.

f. Gently peel back the carpels and stick them to the tape to reveal the seeds.

g. Observe the phenotype. Note any phenotypes that you observe on your

**Screening Seeds Using Light Microscopy** chart.

*In what stage of development are the seeds?*

*How many seeds are in the silique?*

*How many are green?*

*How many are white?*

*How many are brown?*

*What is the expected ratio of wild type seeds to mutant seeds if the mutation is seed lethal?*

*What is the observed ratio of wild type seeds to mutant seeds?*

*Are the observed results significantly different from the expected results?*

*Use a Chi-Square test.*

\[
\chi^2 = \sum \frac{(observed - expected)^2}{expected}
\]
### Probability that the deviation is due to chance alone

<table>
<thead>
<tr>
<th>Degrees of Freedom</th>
<th>0.5</th>
<th>0.1</th>
<th>0.05</th>
<th>0.02</th>
<th>0.01</th>
<th>0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.455</td>
<td>2.706</td>
<td>3.841</td>
<td>5.412</td>
<td>6.635</td>
<td>10.827</td>
</tr>
<tr>
<td>2</td>
<td>1.386</td>
<td>4.605</td>
<td>5.991</td>
<td>7.824</td>
<td>9.210</td>
<td>13.815</td>
</tr>
</tbody>
</table>

What is your null hypothesis?

How many degrees of freedom are there?

(The degrees of freedom is one less than the number of different phenotypes possible.)

What is your chi-square value?

(The chi-square statistic is a probability that indicates the chance that, in repeated experiments, deviations from the expected would be as large or larger than the ones observed in this experiment)

What is the probability that the deviation of the observed values from the expected values was a chance occurrence?

(Look up your degrees of freedom in the table. Find where your chi-square value falls in that row.)

Can you reject the null hypothesis?

If the probability is less than 0.05 (5%), reject your null hypothesis.

If the probability is 0.05 (5%) or greater, then you cannot reject your null hypothesis.

h. Ask your TA to take pictures of the seeds within the siliques.

i. **Immediately**, use the fine-point forceps to transfer the cut siliques into the tube with fixative solution from **step 2**.

j. Repeat steps a-i for the other siliques. **Note**: You collected an excess of siliques so that you would have some to practice dissecting and to have a
range of developmental stages for each genotype. However, you only need to fix FOUR siliques.

i. Wild type, early development  
ii. Heterozygous (or homozygous), early development  
iii. Wild type, late development  
iv. Heterozygous (or homozygous), late development

6. Fix seeds and siliques in the fixative solution for at least 2 hours. **Note:** It is recommended to fix the siliques overnight to ensure that the fixative solution penetrates the seeds and their embryos. It is okay to leave siliques in the fixative solution for up to 3 days.

7. Carefully, pipet off 900 µL of the fixative solution using a P-1000 pipette and discard into a beaker labeled “acetic acid waste.” Then remove the remaining volume with a P-200 pipette. **Note:** Do not let the seeds and siliques dry out, and do not pipet up your seeds.

8. Immediately, pipet 1 mL of 90% ethanol solution into the tube using a P-1000 pipette. **Note:** The 90% ethanol solution will remove chlorophyll from the embryos.

**90% ETHANOL SOLUTION**  
<table>
<thead>
<tr>
<th>Component</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute ethanol</td>
<td>4.5 mL</td>
</tr>
<tr>
<td>Double-distilled water</td>
<td>0.5 mL</td>
</tr>
<tr>
<td>Total volume</td>
<td>5.0 mL</td>
</tr>
</tbody>
</table>

9. Incubate seeds and siliques in the 90% ethanol solution for **0.5 - 1 hour.** **Note:** It is safe to store the materials in the ethanol indefinitely.

10. Replace the 90% ethanol solution with 70% ethanol as in steps 7 & 8.

**70% ETHANOL SOLUTION**  
<table>
<thead>
<tr>
<th>Component</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute ethanol</td>
<td>3.5 mL</td>
</tr>
<tr>
<td>Double-distilled water</td>
<td>1.5 mL</td>
</tr>
<tr>
<td>Total volume</td>
<td>5.0 mL</td>
</tr>
</tbody>
</table>
11. Incubate seeds and siliques in the ethanol solution for **0.5 - 1 hour**. *Note: It is safe to store the materials in the ethanol indefinitely.*

II. Observation of Seeds and Embryos Using Nomarski Optics

*Note:*
- *Before observation of the seeds and their embryos, seeds must be submerged in the clearing solution. For young seeds, clearing is usually fast (~5 minutes). The older the silique, the longer it takes to clear (~1 hour). Seeds are ready for observation after they sink in the clearing solution.*
- *Tissues CANNOT be stored in the CLEARING solution for more than TWO days because they will lose their structures quickly.*

1. Prepare a *fresh* clearing solution of chloral hydrate/glycerol/water (8:1:2, w/v/v) in a 14 mL centrifuge tube. *Note: The TAs will prepare this solution before the lab class begins.*

   **CLEARING SOLUTION**
   
   Chloral hydrate    | 8 g |
   Glycerol          | 1 mL |
   Water             | 2 mL |
   Total volume      | ~7 mL |

2. *Carefully*, pipet off **900 µL** of the 70% ethanol solution using a P-1000 pipette and discard into a beaker labeled “ethanol waste.” Then remove the **remaining volume** with a P-200 pipette. *Note: Do not let the seeds and siliques dry out, and do not pipet up your seeds.*

3. Replace the 70% ethanol solution with **100 µL of clearing solution**.

4. Incubate seeds and siliques in the clearing solution for **5 min - 1 hour**. Wait until the seeds **sink** to the bottom of the tubes. You may lay the tube on its side so that the
silique is immersed in the clearing solution. *Note: Tissues CANNOT be stored in the CLEARING solution.*

5. Set a new glass microscope slide on the bench. Label it with your initial(s), the *plant* #, the *plant genotype* and *silique length*.

6. Use forceps to remove a siliques from the clearing solution and place it on the labeled glass slide.

7. Pipet the remaining clearing solution and seeds onto the slide with the siliques.

8. Carefully, place two square coverslips, one on each side of the solution. Then, place a third coverslip over the clearing solution. Avoid trapping bubbles in the solution (see diagram below).

9. Observe the seeds under Nomarski optics using the Leica CTR5000 microscope.

10. Take pictures of the embryos.

   *In what stage of development are the seeds?*

11. Repeat steps 2-10 for the remaining 3 fixed siliques.
Screening Seeds Using Light Microscopy

AGI# ________________ SALK # ________________ Plant # _____ Genotype __________

Silique # _____ Length of Silique (cm) _____ Total Seeds _____ Total Mutant Seeds _____

Instructions: The grid represents the layout of the silique. Put a number in each square that corresponds to a mutant seed. Describe the seed phenotypes in the chart below. The base of the silique is defined as the region closest to the pedicel and main stem, which is at the left of the grid.

<table>
<thead>
<tr>
<th>Seed</th>
<th>Seed Coat Color</th>
<th>Embryo Color</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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