ANSWER KEY.

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Genes, Light, and Ratios: A Fast Plants Lab

Biology | ANSWER KEY

Sample answers and data. Accept answers that match the group's own data and reasoning.

Draft lab. This lab has not been tested in a classroom yet. Your teacher may change some steps, times or amounts.

The Puzzle

Wisconsin Fast Plants are a fast-growing relative of turnips. One gene controls purple stem color. The allele for purple (**P**) is dominant over the allele for non-purple (**p**). Your seeds are the **F_2 generation**: their parents were both **Pp**. But purple color is a pigment the plant makes more of in bright light. Can the environment hide a genotype?

Question

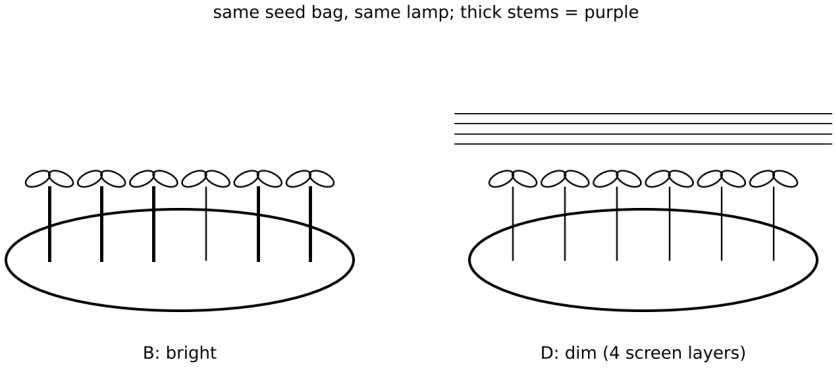
Does the ratio of purple to non-purple seedlings match 3:1, and does dim light change the ratio you observe?

Safety

- Do not eat seeds. Wash your hands after the lab.
- Lamps get hot. Do not touch them.

Materials (per group)

- About 60 F_2 Fast Plants seeds
- 2 petri dishes or flat containers with wet paper towel, labeled B (bright) and D (dim)
- 4 layers of window screen for dish D
- Hand lens, toothpick, color card



Same seeds, two light levels. Score stem color on day 4 or 5.

Before the Lab

1. Use a Punnett square for Pp × Pp to predict the ratio of purple to non-purple seedlings.

PP, Pp, Pp, pp. 3 purple : 1 non-purple (3/4 purple, 1/4 non-purple).

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Procedure

1. Place 30 seeds in rows on the wet towel in each dish. Keep them a few millimeters apart.
2. Cover dish D with 4 layers of window screen. Put both dishes under the same continuous light.
3. Keep the towels wet. On day 4 or 5, look at each seedling's stem just below the seed leaves with a hand lens.
4. Score each seedling as purple (any pink or purple) or non-purple (all green). Use a toothpick to move each seedling as you count it.
5. Add your counts to the class table.

Data

Table 1. Stem color counts

Dish	Purple	Non-purple	Total	Ratio (purple ÷ non-purple)
B: bright, our group	**23**	**7**	**30**	**3.3 : 1**
D: dim, our group	**18**	**12**	**30**	**1.5 : 1**
B: bright, class total	**228**	**72**	**300**	**3.2 : 1**
D: dim, class total	**190**	**110**	**300**	**1.7 : 1**

Analysis

2. For 300 seeds, how many purple and non-purple seedlings does a 3:1 ratio predict? Compare with the class bright and dim totals.

   Expected: 225 purple and 75 non-purple. Bright (228 and 72) is very close. Dim (190 and 110) has far more non-purple than expected (sample).

3. Your group's bright ratio was probably not exactly 3:1. Why is the class total a better test of the prediction?

   Each seed's genotype is a matter of chance, like a coin flip. Small samples vary a lot by chance; a large sample averages out the chance variation and gets closer to the true ratio.

4. The seeds in dishes B and D came from the same bag, so their genotypes should follow the same 3:1 ratio. Why did dish D seem to have more non-purple seedlings?

   In dim light, some PP and Pp seedlings made too little pigment to see, so they were scored as non-purple. Their genotype did not change; the environment reduced the expression of the purple trait.

5. Which dish gives the better estimate of the genotypes? Explain.

   Dish B (bright). In bright light, seedlings that carry P make enough pigment to see, so phenotype matches genotype more closely.

6. Honors: a chi-square test with 1 degree of freedom rejects a 3:1 ratio when χ^2 is greater than 3.84. Calculate χ^2 for the class bright and dim totals.

   Bright: $(228 - 225)^2/225 + (72 - 75)^2/75 = 0.04 + 0.12 = 0.16$, fits 3:1. Dim: $(190 - 225)^2/225 + (110 - 75)^2/75 = 5.44 + 16.33 = 21.8$, does not fit 3:1.

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7. Claim, evidence, reasoning: Can the environment change the phenotype ratio we observe without changing the genotypes?

Claim

Yes. Dim light lowered the observed purple ratio even though the genotype ratio stayed 3:1.

Evidence

Bright light gave 228 purple : 72 non-purple (3.2 : 1), close to 3:1. Dim light gave 190 : 110 (1.7 : 1) from the same seed (sample).

Reasoning

Genes set what a plant can make, but light affects how much pigment is produced. In dim light, some plants with a P allele did not show purple, so the observed ratio shifted.

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