2017

AP CollegeBoard

# AP Biology

## Sample Student Responses and Scoring Commentary

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# AP® BIOLOGY
# 2017 SCORING GUIDELINES

## Question 2

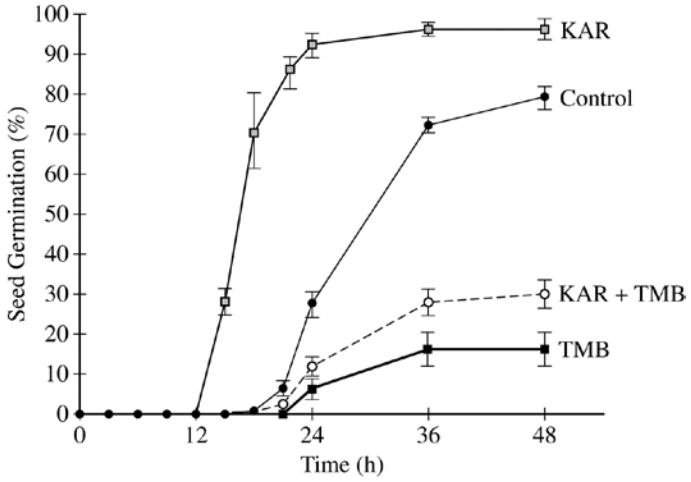


Figure 1. The effect of karrikins (KAR) and trimethylbutenolides (TMB) on seed germination in *Lactuca* plants. Error bars represent $\pm 2SE_{\bar{X}}$.

Fires frequently occur in some ecosystems and can destroy all above-ground vegetation. Many species of plants in these ecosystems respond to compounds in smoke that regulate seed germination after a major fire. Karrikins (KAR) and trimethylbutenolides (TMB) are water-soluble compounds found in smoke that are deposited in the soil as a result of a fire. KAR and TMB bind to receptor proteins in a seed. In a study on the effects of smoke on seeds, researchers recorded the timing and percent of seed germination in the presence of various combinations of KAR and TMB. The results are shown in Figure 1.

In a second investigation into the effect of available water on seed germination after a fire, researchers treated seeds with KAR or TMB. The treated seeds were then divided into two treatment groups. One group received a water rinse and the other group received no water rinse. The seeds were then incubated along with a group of control seeds that were not treated. The results are shown in the table.

EFFECT OF CHEMICAL TREATMENT AND WATER RINSE ON GERMINATION

| Treatment Group | Chemical Treatment | | Water Rinse | Germination Result |
|---|---|---|---|---|
| | KAR | TMB | | |
| 1 (control) | – | – | – | Control result |
| 2 | + | – | – | Different from control |
| 3 | – | + | – | Different from control |
| 4 (control) | – | – | + | Control result |
| 5 | + | – | + | Different from control |
| 6 | – | + | + | Same as control |

# AP® BIOLOGY
# 2017 SCORING GUIDELINES

## Question 2 (continued)

(a) The researchers made the following claims about the effect of KAR and the effect of TMB on seed germination relative to the control treatment.

- KAR alone affects the timing of seed germination.
- KAR alone affects the percentage of seeds that germinate.
- TMB alone affects the timing of seed germination.
- TMB alone affects the percentage of seeds that germinate.

**Provide support** using data from Figure 1 for each of the researchers' claims. **(4 points)**

| **Claim** | **Support (1 point each row; 4 points maximum)** |
|---|---|
| KAR affects timing | • germination starts earlier/sooner/faster/quicker |
| KAR affects percentage | • higher percentage of seeds germinate in the presence of only KAR |
| TMB affects timing | • germination starts later/slower |
| TMB affects percentage | • lower percentage of seeds germinate in presence of only TMB |

(b) **Make a claim** about the effect of rinsing on the binding of KAR to the receptor in the seed and about the effect of rinsing on the binding of TMB to the receptor in the seed. Identify the appropriate treatment groups and results from the table that, when compared with the controls, **provide support** for each claim. **(4 points)**

<table>
<tr><th>Claim (2 points maximum; 1 point for KAR; 1 for TMB )</th><th colspan="5">Support (2 points maximum; 1 point for KAR; 1 for TMB)</th></tr>
<tr><td rowspan="2">• KAR remains (bound after rinsing)<br>• Rinsing does not affect KAR (binding)</td><td>KAR with no rinse</td><td>KAR with rinse</td><td rowspan="2">different than</td><td colspan="2">Controls</td></tr>
<tr><td>Group 2</td><td>Group 5</td><td>Group 1</td><td>Group 4</td></tr>
<tr><td rowspan="4">• TMB does not remain (bound)<br>• Rinsing affects TMB (binding)</td><td colspan="2">TMB with no rinse</td><td rowspan="2">different than</td><td colspan="2">Control</td></tr>
<tr><td colspan="2">Group 3</td><td colspan="2">Group 1</td></tr>
<tr><td colspan="2">TMB with rinse</td><td rowspan="2">same as</td><td colspan="2">Control</td></tr>
<tr><td colspan="2">Group 6</td><td colspan="2">Group 4</td></tr>
</table>

(c) There is intense competition by plants to successfully colonize areas that have been recently cleared by a fire. **Describe** ONE advantage of KAR regulation and ONE advantage of TMB regulation to plants that live in an ecosystem with regular fires. **(2 points)**

| **Description (1 point per row; 2 points maximum)** | |
|---|---|
| Advantage of KAR regulation | • Germination occurs at times of increased resources availability.<br>• Plants with KAR regulation can outcompete other plants (without KAR regulation).<br>• Germination occurs when fewer competitors are present/land is barren. |
| Advantage of TMB regulation | • Plants with TMB regulation do not germinate/can maintain seed dormancy until (enough) water is available.<br>• Plants with TMB regulation do not germinate in a dry environment. |

PAGE FOR ANSWERING QUESTION 2

a) KAR affects the timing of seed germination, as seeds germinate 12 hours sooner than the control group.
KAR also affects the percentage of seeds that germinate, as 20% more seeds germinate than the control group.
TMB affects germination time, as seeds germinate 7 hours later than the control group.
TMB affects the percentage of seeds that germinate, as over 60% fewer seeds germinate than the control group.

b) Rinsing doesn't affect the binding of KAR to receptors. Treatment groups 2 and 5 are both treated with KAR, and, though treatment group 5 is rinsed, both behave differently than the control groups 1 and 4.
Rinsing does affect binding of TMB to receptors. Treatment groups 3 and 6 are treated with TMB. Treatment group 3 is unrinsed and behaves differently than control group 1. Group 6 is rinsed and behaves the same as control group 4. This shows that Rinsing causes seeds with TMB to behave the same as the control group, showing that rinsing affects TMB.

c) One advantage of KAR regulation in plants is that seeds germinate and begin to grow quickly after a wildfire, giving them first access to nutrients. One advantage of TMB

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

regulation is that seeds grow again in the presence of water, so the seeds wait until a vital nutrient is present in order for them to grow better, is present.

PAGE FOR ANSWERING QUESTION 2

KAR alone affects the timing of seed germination. According to the graph, KAR seeds germinated about 3 hours earlier than the control seeds.

~~KAR~~ KAR alone affects the percentage of seeds that germinate. The graph shows ~~about~~ an almost 20% increase when compared to the control seeds.

TMB alone affects the timing of seed germination According to the graph, TMB seeds germinated about 6 hours later than the control seeds.

TMB alone affects the percentage of seeds that germinate. The graph shows an almost 65% decrease when compared to the control seeds.

When rinsing the experimental seeds in ~~water~~ water, TMB rinsed off while KAR didn't. In the first test, both ~~TMB and KAR~~ KAR(2) and TMB(3) differ from the control. In the second test however, TMB(6) results the same as the control, and KAR(5) differs from the control. TMB doesn't bind

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2B2

to the receptor proteins when rinsed. KAR still binds to receptor proteins even after being rinsed.

KAR regulation allows the seeds to grow more quickly, giving them an advantage when trying to spread and reproduce. TMB regulation conserves resources and energy for the ~~plant~~ seed, giving it a better chance of survival in harsh conditions such as after a fire.

PAGE FOR ANSWERING QUESTION 2

a) #1: when only KAR was present the seeds germinated at 12 hours which is almost half the time for control seeds (20 hours).

#2: when only KAR was present 100% of the seeds germinated when only 80% of the control seeds germinated.

#3: when only TMB was present, the seeds germinated 3 hours after the control seeds (at 24 hours instead of 21).

#4: when only TMB was present, only 20% of the seeds germinated versus 80% in the control.

b) seeds that had KAR present and were rinsed began germinating very quickly (faster than control), water present sends a signal which removes the inhibitor and allows the KAR to bind to the receptor and start germinating. Seeds that had TMB present and were rinsed began germinating at the same time as the control. The water present also sends a signal for germination to begin and for the inhibitor to stop binding to the active site (receptor) so TMB can bind and initiate germination.

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2C

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

C) an advantage to KAR regulation is that the seeds germinate faster and more of them germinate. In the race to take over space this is an advantage bc they germinate faster/grow faster than other seeds w/o KAR regulation. an advantage to TMB regulation is that it prevents the seeds from growing when there is not enough water/nutrients present for the plant to survive.

# AP® BIOLOGY
# 2017 SCORING COMMENTARY

## Question 2

### Overview

This question was based on a laboratory experiment to determine the effect of compounds found in smoke water on germination of seeds in areas that experience frequent forest fires. Two types of compounds, karrikins (KAR) and trimethylbutenolides (TMB), bind to receptor proteins on Lactuca seeds and affect two aspects of germination. Students were presented with a line graph describing the timing of germination and the percent of seeds that germinated in various treatments (a control treatment and treatments with KAR alone, TMB alone, or KAR and TMB together). Students were asked to use the data to provide support for the claims that KAR alone and TMB alone affect both timing and percent of seed germination. Students were provided with data that described the results of a second investigation to determine the effect of a water rinse on seeds after exposure to KAR and TMB. Students were then asked to interpret the data to make a claim about the effect of rinsing on the binding of KAR and TMB to the protein receptors in the seeds. Students were also asked to support their claims by comparing the appropriate control and treatment groups. Finally, students were asked to describe a competitive advantage for plants that use KAR regulation and for plants that use TMB regulation in an area prone to fires.

**Sample: 2A**
**Score: 10**

The response earned 1 point in part (a) for providing support that seeds treated with KAR germinated 12 hours sooner than the control. The response earned 1 point in part (a) for providing support that 20 percent more seeds germinated when treated with KAR compared to the control. The response earned 1 point in part (a) for providing support that seeds treated with TMB germinate 3 hours later than the control. The response earned 1 point in part (a) for providing support that 60 percent fewer seeds germinated when treated with TMB compared to the control. The response earned 1 point in part (b) for claiming that rinsing doesn't affect the binding of KAR to the receptor. The response earned 1 point in part (b) for identifying that treatment groups 2 and 5 produced different results than the control groups 1 and 4. The response earned 1 point in part (b) for claiming that rinsing does affect the binding of TMB to the receptor. The response earned 1 point in part (b) for identifying that treatment group 3 produced different results than control group 1 and treatment group 6 produced the same results as control group 4. The response earned 1 point in part (c) for describing that one advantage of KAR regulation is that it gives plants the first access to nutrients. The response earned 1 point in part (c) for describing that one advantage of TMB regulation is that it allows the seeds to grow again when water is available.

**Sample: 2B**
**Score: 8**

The response earned 1 point in part (a) for providing support that KAR seeds germinated about 3 hours earlier than the control seeds. The response earned 1 point in part (a) for providing support that KAR alone caused a 20 percent increase in the seed germination compared to the control seeds. The response earned 1 point in part (a) for providing support that TMB alone caused seeds to germinate about 6 hours later than control seeds. The response earned 1 point in part (a) for providing support that TMB alone caused an almost 65 percent decrease when compared to the control seeds. The response earned 1 point in part (b) for claiming that TMB rinsed off the seeds. The response earned 1 point in part (b) for claiming that KAR did not rinse off the seeds. The response earned 1 point in part (b) for identifying that KAR (2) differed from the control and KAR (5) differed from the control. The response earned 1 point in part (b) for identifying that TMB (3) differed from the control while TMB (6) did not differ from the control.

## Question 2 (continued)

**Sample: 2C**
**Score: 6**

The response earned 1 point in part (a) for providing support that seeds treated with KAR alone germinated sooner than the control seeds. The response earned 1 point in part (a) for providing support that a higher percentage of seeds germinated when treated with KAR alone compared to the control. The response earned 1 point in part (a) for providing support that seeds treated with TMB alone germinated later than the control seeds. The response earned 1 point in part (a) for providing support that a lower percentage of seeds germinated when treated with TMB alone compared to the control. The response earned 1 point in part (c) for describing that an earlier germination allows them to outcompete other plants for space. The response earned 1 point in part (c) for describing that TMB regulation prevents seeds from growing when there is not enough water present.