**Lesson: Do Fungicides Affect Bees?**

**Big idea**

Fungicides are meant for fungi, not insects—but they can still impact bees indirectly (e.g., gut microbes, larval development, navigation/foraging) and synergize with insecticides. [ScienceDirect](https://www.sciencedirect.com/science/article/pii/S0160412022002380?utm_source=chatgpt.com)[PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)

**Learning goals**

* Explain at least two ways fungicides can affect bees.
* Interpret evidence from a real experiment and from our class practical.
* Make a claim about risk vs. benefit of fungicide use, supported by data.

**Prior knowledge**

* Basic pollination and why plants need pollinators.
* What pesticides are (herbicide vs insecticide vs fungicide).

**1) Engage (5–8 min)**

**Prompt:** “If fungicides don’t target insects, should we worry about bees?”
Students do a quick **Think–Pair–Share** and post hypotheses on the board.

**2) Explore with a short video case (12–15 min)**

Show the **HHMI BioInteractive video case** *“The Effects of Fungicides on Bumble Bee Colonies”* (describes an experiment applying fungicide to flowers and tracking bumblebee colony outcomes). Use the student handout questions below as a viewing guide.
• Watch on HHMI/BioInteractive (teacher resource hub, with worksheets). [HHMI BioInteractive+1](https://www.biointeractive.org/classroom-resources/effects-fungicides-bumble-bee-colonies?utm_source=chatgpt.com)
• (Alt mirror link) YouTube copy of the same video exists if your school blocks BioInteractive. [YouTube](https://www.youtube.com/watch?v=Z0FB1PcRQ8k&utm_source=chatgpt.com)

**Viewing questions**

1. What was the independent variable?
2. What outcomes did the researchers measure?
3. Summarize the main result in one sentence.
4. What’s one limitation or follow-up question you’d ask?

**Key takeaways to highlight after viewing**

* Some fungicides on flowers were linked to **bumblebee colony declines** in the case study context. [HHMI BioInteractive](https://www.biointeractive.org/classroom-resources/effects-fungicides-bumble-bee-colonies?utm_source=chatgpt.com)
* Mechanisms proposed in current research include **microbiome disruption** and **increased larval mortality**, and **synergy** with certain insecticides (e.g., propiconazole with pyrethroids). [PubMed](https://pubmed.ncbi.nlm.nih.gov/35088523/?utm_source=chatgpt.com)[PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)[Wiley Online Library](https://onlinelibrary.wiley.com/doi/abs/10.1002/ps.2780390407?utm_source=chatgpt.com)
* Evidence is nuanced: some recent studies show **little effect under brief, field-realistic exposures**, so context (dose, duration, co-exposures) matters. [PubMed](https://pubmed.ncbi.nlm.nih.gov/38240563/?utm_source=chatgpt.com)[ASM Journals](https://journals.asm.org/doi/abs/10.1128/aem.01739-23?doi=10.1128%2Faem.01739-23&utm_source=chatgpt.com)

**3) Practical investigation (30–35 min in-class + 10 min follow-up)**

**Option A (most accessible): “Bee gut” proxy using baker’s yeast**

**What it shows:** Many fungicides suppress fungi. Bees rely on a community of microbes; if a fungicide reaching nectar/pollen also hits bee-associated fungi, it could indirectly affect bee health. Students test how a common garden fungicide affects **yeast growth** as a visible stand-in for a fungal microbe.

This is a **proxy** model to explore a mechanism—students interpret it cautiously and compare with real bee data.

**Materials (per group of 3–4)**

* Dried baker’s yeast, sugar, warm water
* Clear cups/test tubes (4–5), permanent marker
* Measuring spoons/syringes/pipettes
* A **ready-to-use garden fungicide** (choose the safest, school-approved option; check your policies).
* Gloves, eye protection, spill tray; waste container labeled “fungicide waste”

**Method (rapid starter)**

1. Label tubes: **Control (0×)**, **Low (0.5×)**, **1×**, **2×** (relative to bottle’s lowest garden-use rate).
2. Make a **standard yeast starter** (warm water + sugar + yeast). Split equal volumes into tubes.
3. Add fungicide dilutions to the treatment tubes (control gets water). Mix gently.
4. Start timer. Observe for **20–25 min**: look for CO₂ bubbling/foam height or turbidity (qualitative), and take a photo at 5, 10, 15, 20 min.
5. Quick-quant: use a ruler to record **foam height** (mm) at each time point.

**Data table (per tube)**
Time (min): 0, 5, 10, 15, 20 | Foam height (mm)

**Graph & analysis (whole-class or homework)**

* Plot foam height vs. time for each dilution; compare slopes.
* **CER write-up** (Claim–Evidence–Reasoning): *Does the fungicide suppress fungal growth at these doses?* How might that relate to **bee gut microbes** or **larval development**? Compare to literature results. [PubMed](https://pubmed.ncbi.nlm.nih.gov/35088523/?utm_source=chatgpt.com)

**Safety & disposal**

* Wear PPE. Keep food away from lab area. Treat all solutions as chemical waste; decant to labeled waste per school policy.

**Option B (biology extension): Pollen germination under fungicide**

**What it shows:** Several fungicides inhibit **pollen germination/pollen tube growth**, which can lower floral rewards and indirectly affect pollinators. If you have microscopes, students can view pollen tubes. [NIAB](https://www.niab.com/influence-spray-chemicals-pollen-germination?utm_source=chatgpt.com)[ASHS](https://journals.ashs.org/view/journals/jashs/94/5/article-p558.pdf?utm_source=chatgpt.com)[International Scholars Journals](https://www.internationalscholarsjournals.com/articles/effects-of-fungicides-on-pollen-germination-peach-and-nectarine-in-vitro.pdf?utm_source=chatgpt.com)

**Materials**

* Fresh, **untreated** flower pollen (e.g., lily) or pre-bought pollen
* Simple germination medium (e.g., sucrose + boric acid solution; recipe per your syllabus)
* Slides, cover slips, droppers; compound microscopes
* Same dilution set of a school-approved fungicide

**Method (outline)**

1. Prepare drops of germination medium on slides: control and treatment dilutions.
2. Dust a tiny amount of pollen onto each drop; incubate 10–20 min (warm spot).
3. Examine under 100–400×. Count **% germinated** and average pollen tube length in control vs. treatments.

**Analysis**

* Bar chart of % germinated; short discussion on how reduced pollen viability might affect bee foraging success/colony nutrition, tying back to the video.

If chemicals aren’t permitted: skip wet lab and do the **data-analysis version** below using teacher-provided (realistic) datasets.

**4) Explain (10 min)**

Whole-class synthesis using three evidence streams:

1. **Video experiment** (colonies exposed via flowers). [HHMI BioInteractive](https://www.biointeractive.org/classroom-resources/effects-fungicides-bumble-bee-colonies?utm_source=chatgpt.com)
2. **Your practical** (mechanism proxy or pollen viability). [NIAB](https://www.niab.com/influence-spray-chemicals-pollen-germination?utm_source=chatgpt.com)[ASHS](https://journals.ashs.org/view/journals/jashs/94/5/article-p558.pdf?utm_source=chatgpt.com)
3. **Current research** (microbiome impacts and synergy; but also studies showing limited effects under short exposures). [PubMed+1](https://pubmed.ncbi.nlm.nih.gov/35088523/?utm_source=chatgpt.com)[PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)

Create a **concept map** linking: fungicide → pollen/microbes/larvae → bee health → crop pollination.

**5) Evaluate (Exit ticket, 5 min)**

* **MCQ:** Which statement best fits the evidence you saw today?
* **Short response:** “Under what conditions might fungicides pose the **greatest** risk to bees? Use at least two pieces of evidence.”
(Look for mentions of **dose**, **exposure duration**, **bloom timing**, and **co-exposure with insecticides**.) [PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)

**Differentiation**

* **Support:** Provide a word bank (fungicide, microbiome, synergy, germination, larva).
* **Stretch:** Have advanced students read a short summary/abstract and identify variables and controls from a recent paper. [ScienceDirect](https://www.sciencedirect.com/science/article/pii/S0160412022002380?utm_source=chatgpt.com)

**Homework / Extension (20–30 min)**

1. **Short reading carousel:**
	* 2022–2024 research snapshots on microbiome and larval effects; note contrasting findings and Why. [PubMed+1](https://pubmed.ncbi.nlm.nih.gov/35088523/?utm_source=chatgpt.com)[ASM Journals](https://journals.asm.org/doi/abs/10.1128/aem.01739-23?doi=10.1128%2Faem.01739-23&utm_source=chatgpt.com)
2. **Policy memo (150–200 words):** Recommend two farmer practices to reduce risk (e.g., avoid spraying during bloom or when bees are active; choose bee-safer modes of action; avoid tank-mixing with certain insecticides). Include one citation. [Xerces Society](https://xerces.org/sites/default/files/2019-09/Fungicide_Regular_Factsheet_Final_Web.pdf?utm_source=chatgpt.com)

**Materials list (quick order/checklist)**

* Baker’s yeast, sugar, cups/tubes, droppers/pipettes, markers
* School-approved garden fungicide (ready-to-use)
* PPE: gloves, goggles; spill tray; chemical waste container
* (Option B) Pollen, slides, cover slips, basic reagents, microscopes

**Misconceptions to address**

* “Fungicides can’t affect insects.” → Indirect and synergistic effects are well documented. [PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)[ScienceDirect](https://www.sciencedirect.com/science/article/pii/S0160412022002380?utm_source=chatgpt.com)
* “One study proves the whole story.” → Effects depend on **exposure route, dose, timing, and mixtures**; evidence includes both harmful effects and null results under certain conditions. [PubMed](https://pubmed.ncbi.nlm.nih.gov/38240563/?utm_source=chatgpt.com)[ASM Journals](https://journals.asm.org/doi/abs/10.1128/aem.01739-23?doi=10.1128%2Faem.01739-23&utm_source=chatgpt.com)

**Assessment rubric (10 pts)**

* **Claim** (2): Clear, defensible.
* **Evidence** (4): Uses video + practical + at least one study.
* **Reasoning** (3): Correctly links mechanism(s) to outcomes.
* **Communication** (1): Graph/figure is labeled and legible.

**Teacher background (optional quick notes)**

* **Microbiome & larvae:** Chlorothalonil has been linked to altered bee gut communities and reduced larval survival in lab contexts. [PubMed](https://pubmed.ncbi.nlm.nih.gov/35088523/?utm_source=chatgpt.com)
* **Synergy:** Certain azole/DMI fungicides (e.g., propiconazole, prochloraz) can **increase** pyrethroid toxicity to bees—orders of magnitude in some tests. Emphasize that **tank mixes** and **during-bloom sprays** are riskier. [PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)[Wiley Online Library](https://onlinelibrary.wiley.com/doi/abs/10.1002/ps.2780390407?utm_source=chatgpt.com)
* **Nuance:** Recent work shows **resilience** under brief exposures without other stressors; this is great for discussing experimental design and external validity. [PubMed](https://pubmed.ncbi.nlm.nih.gov/38240563/?utm_source=chatgpt.com)
* **Bloom/pollen angle:** Fungicides can inhibit pollen germination/tube growth in some crops, potentially reducing floral rewards and plant set—an indirect path to pollinator impacts. [NIAB](https://www.niab.com/influence-spray-chemicals-pollen-germination?utm_source=chatgpt.com)[ASHS](https://journals.ashs.org/view/journals/jashs/94/5/article-p558.pdf?utm_source=chatgpt.com)

**Slide/handout snippets you can paste into your deck**

* **Driving question:** “When is a fungicide *bee-safe*?”
* **Key terms:** fungicide, DMI/azole, microbiome, synergy, pollen germination, sub-lethal effect.
* **Graph template:** Foam height (mm) vs. time for 0×, 0.5×, 1×, 2×.

**Quick links (for you)**

* Video case + teacher resources (HHMI BioInteractive). [HHMI BioInteractive+1](https://www.biointeractive.org/classroom-resources/effects-fungicides-bumble-bee-colonies?utm_source=chatgpt.com)
* Research snapshots on bee health mechanisms (microbiome, larvae, exposure nuance). [PubMed+1](https://pubmed.ncbi.nlm.nih.gov/35088523/?utm_source=chatgpt.com)
* Synergy overview (open-access review). [PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC10926390/?utm_source=chatgpt.com)
* Practical extension context—pollen germination effects. [NIAB](https://www.niab.com/influence-spray-chemicals-pollen-germination?utm_source=chatgpt.com)[ASHS](https://journals.ashs.org/view/journals/jashs/94/5/article-p558.pdf?utm_source=chatgpt.com)
* Farmer guidance factsheet (Xerces Society). [Xerces Society](https://xerces.org/sites/default/files/2019-09/Fungicide_Regular_Factsheet_Final_Web.pdf?utm_source=chatgpt.com)

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