Life in Balance

Exploring the Tandem Life Cycles of Brassica Butterflies and Wisconsin Fast Plants™

Grade Level: 5-12
Catalog Number:

*A Brassica Butterfly (*Pieris rapae*) dipping its proboscis into the nectar of a Wisconsin Fast Plants™ (*Brassica rapa*) flower.*

In this activity, students will have the opportunity to witness first-hand the dynamic relationship between Brassica Butterflies and Wisconsin Fast Plants™. Students are responsible for tending the butterflies and plants throughout the entire life cycles, while they **explore** and **explain** the changes that each organism goes through.

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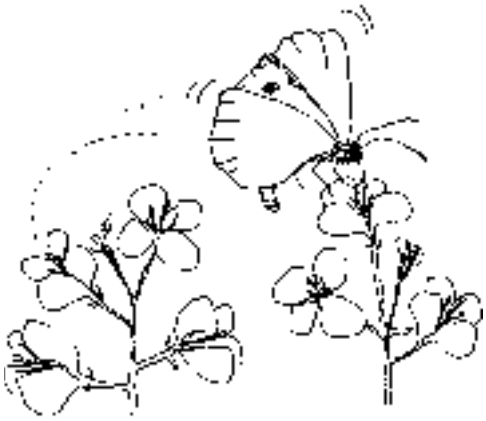
Life in Balance *was designed in collaboration with the Wisconsin Fast Plants Program at the University of Wisconsin - Madison. Special thanks to: Dan Lauffer, Paul H. Williams, and Coe Williams (Wisconsin Fast Plants Program); Lisa Darmo and Kathy Douglas (Carolina Biological Supply Company).*

Written by Sarah Lauffer and illustrated by Amy Kelley. For more information about Wisconsin Fast Plants™, go to www.fastplants.org or www.carolina.com/fastplants. See back page for ordering information.

Objectives of Life in Balance

At the end of this activity, students will be able to:

- Care for two organisms (Brassica Butterflies and Wisconsin Fast Plants™) through their entire life cycles
- Maintain a written log of observations, notes, and explanations
- Identify each organism's parts and structures, and relate form and structure to function at different stages in the life cycles
- Describe how butterflies and plants interact, and how the interactions change at different stages
- Predict how external stimuli may affect behavior and tropisms
- List what environmental conditions are necessary for growth, development, and reproduction
- Explain how resources (biotic and abiotic) can limit growth



Life Science Standards

Met by the Objectives of Life in Balance

Life Science Standards for Grades 5-8

- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Life Science Standards for Grades 9-12

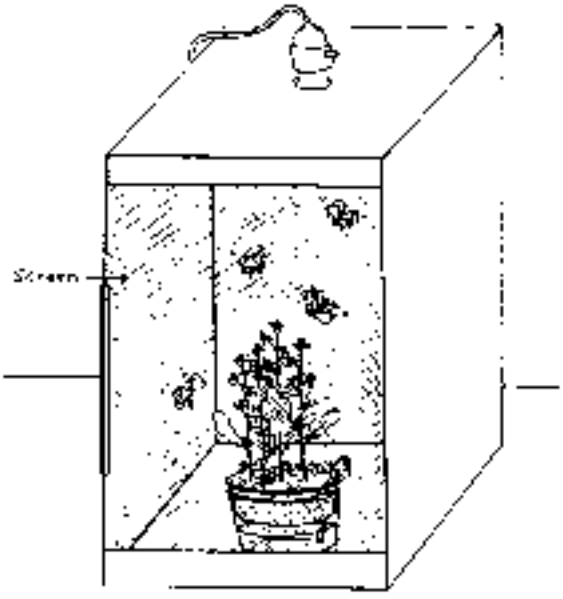
- Interdependence of organisms

Time Requirements

- **It is recommended (but not necessary) that you begin this activity on a Wednesday.** Order eggs the preceding Friday.

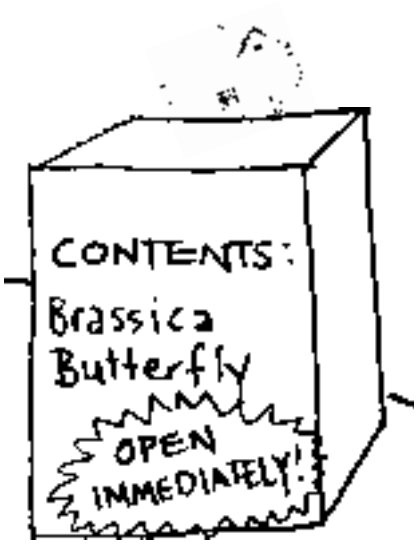
- **Total days to complete the activity: 35-56**
  The Brassica Butterfly life cycle is approximately 30-40 days, and the Wisconsin Fast Plants™ life cycle is approximately 40 days. The actual time of this exploration depends on: the number of larvae that survive and metamorphose into adult butterflies, the number of female butterflies that lay eggs, and whether or not students grow the plants until they produce seed.

- **Twice a week** (or more)—Students observe the plants and butterflies and record their observations on new Student Notebook Pages. Verify that there is enough water or nutrient solution in the plant reservoirs (especially before a weekend), and that the plant tops are 10 cm below the lights. On these days, plan 10-30 minutes. See page 10 for a detailed **calendar**.



Materials

The following materials are included with the *Life in Balance* Kit. Each kit contains enough materials for 8 groups of 2–4 students.



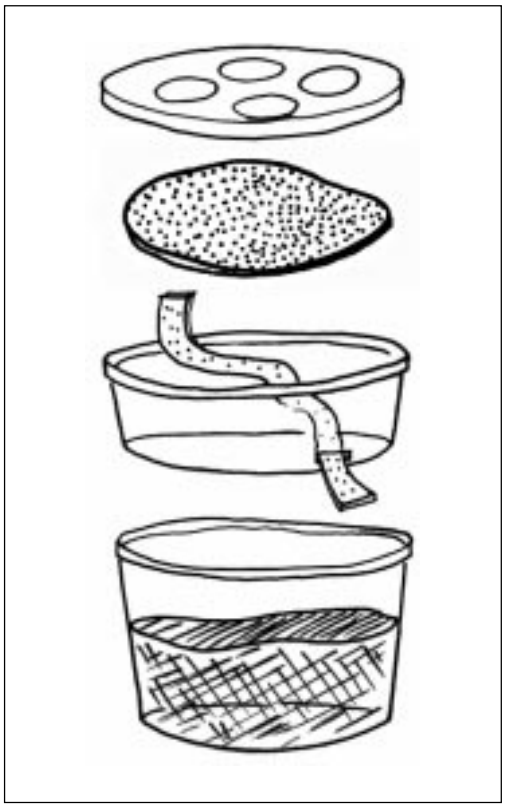
Written Materials

- *Life in Balance* Book, which includes: detailed life cycle descriptions (pages 6–9), a calendar of exploration days and plant care (page 10), and two student Notebook Pages (pages 14-15)
- Brassica Butterfly Care Instructions
- Wisconsin Fast Plants™ Growing Instructions
- CBSC Butterfly Order Card

Brassica Butterfly Materials

- Brassica Plant Mix seeds
- Butterfly "Nectar" Feeders and wicks
- Egg Collector (film can)
- 8 Broccoli Barns (large reservoirs with lids)

Growing System Assembly



Wisconsin Fast Plants™ Materials

- Wisconsin Fast Plants™ seeds
- 8 growing systems
  Each growing system includes:
  - 1 Circular watermat
  - 1 Long watermat wick
  - 1 Small container
  - 1 Large container (reservoir)
  - 4 Pots (holes in bottom)
  - 4 Small blue watermat wicks
- Potting mix
- Fertilizer
- Stakes and ties
- Labels

Materials that you may need to supply or order separately

- Butterfly Box (Purchase through Carolina Biological Supply Company, Catalog Number 15-8997) or make your own (see **www.fastplants.org** for instructions)
- Thumbtacks
- Broccoli or cabbage
- Automatic timer for light
- Sugar
- Yellow food coloring
- Wax paper
- Double-stick tape

Introduction to Life in Balance

Plants and insects boast fascinating relationships; their intricately woven life cycles encompass all aspects of life and death, from mating and reproduction, to growth and development, to evading disease and predation. In nature, the coevolution of plants and insects is riddled with elaborate interdependencies and exciting paradoxes that offer insight into how complex life is... and about how **no organism can survive alone**.

The ubiquitous Brassica Butterflies (*Pieris rapae*) have evolved closely with brassica plants, such as broccoli, cabbage, kohlrabi, turnips, their wild relatives, and Wisconsin Fast Plants™. At first glance, the **relationship** between the plants and butterflies appears **mutualistic** — or beneficial to both. Throughout their life cycle, Brassica Butterflies utilize virtually all parts of a brassica plant: as larvae, they forage on the leaves; as chrysalises, they are sheltered from predators; and as adults, they drink nectar and lay eggs on the leaves. In return, the butterflies pollinate the flowers of brassicas so the plants can produce seeds for another generation of life.

As any vegetable gardener can tell you, a closer look reveals that this **relationship can be less benign** (or more **antagonistic**) than it first appears. While the larvae thrive and grow into mature butterflies through the safety and nourishment provided by the plants, it is the larvae themselves that ultimately have the **capability to consume and destroy** the plants. Depending on their numbers and the proportion of butterflies to plants, they may even decimate an entire population of plants, a destruction that can be costly to gardeners and farmers as they attempt to combat the larvae with expensive pesticides and other means.

Life in Balance offers students a glimpse of the complex, ever-changing relationship between Brassica Butterflies and Wisconsin Fast Plants™ as the two organisms go through their life cycles together.

Overview of the Student Notebook Pages (pages 14-15)

The Student Notebook Pages are designed to promote **exploration** *and* **explanation** *of the interactions between Brassica Butterflies and Wisconsin Fast Plants™ throughout the tandem life cycles.*

On each day that they tend their butterflies and plants, students should receive two new Student Notebook Pages: one for butterflies and one for plants. Each page encourages students to make consistent observations, to answer inquiry-based questions, and to write their own notes and questions. At the end of the exploration, students will have a log that chronicles the intertwined life cycle of two organisms. (Alternative: Students maintain their own lab notebooks on blank pages.)

Division of Labor (Student Groups)

- Each student group should receive a copy of the Calendar (page 10), *Brassica Butterfly Care Instructions*, and *Wisconsin Fast Plants™ Growing Instructions.*
- When the eggs arrive, carefully cut the egg strip apart and distribute the eggs evenly among the student groups. Each group's strip should be placed egg-side-down on top of one pot of Brassica Plants. (The larvae will crawl to the other plants.)
- Each student group is responsible for its own reservoir of Brassica Plant Mix and Wisconsin Fast Plants™ (each reservoir holds 4 pots with 2 plants per pots).
- After day 19, the entire class is responsible for the chrysalises and butterflies.

The Life Cycle of Brassica Butterflies

Week 1 (0-3 days old)

Within 1-3 days after arriving, the eggs hatch. Once the young larvae chew their way out of a hole on the top side of the egg, they forage for food. If no food is available, the larvae may cannibalize adjacent eggs and unhatched larvae. Young brassica seedlings serve as the primary source of nourishment while the larvae grow and molt.

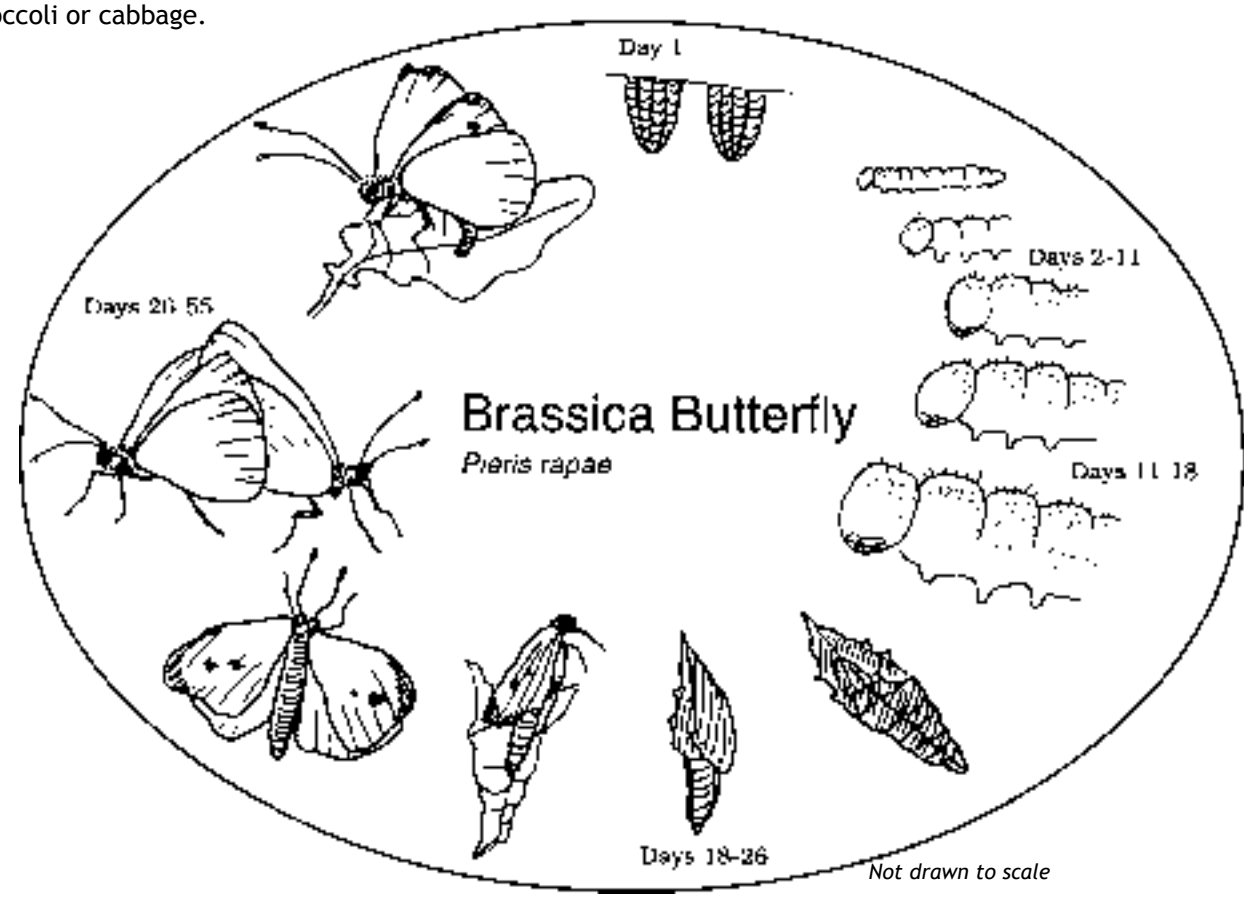
Week 2 (3-13 days old)

Larvae pass through five stages, called instars. The instars are numbered L_1-L_5. By the end of each instar, the larvae outgrown their exoskeletons and need to molt. They seek a dry site and weave a carpet of fine silk to secure themselves. (The silk is spun from silk glands, located in the anterior and posterior regions.) When the exoskeletons crack, the larvae crawl out and quickly pump their new exoskeletons with fluid before they harden. Larvae molt 2-3 times during the first week. As they grow and molt, larvae become voracious eaters. They quickly devour the plant leaves and begin to forage for heartier fare, such as broccoli or cabbage.

Week 3 (13-18 days old)

Once the larvae have grown to the final larval stage (L_5), they search for a suitable place to form a chrysalis. Most of them attach to the broccoli/ cabbage or to the side of the container where they are housed. Once settled, they weave silken carpets to anchor themselves in place, then spin silk belts around their middles. They attach their posterior ends to the carpet with minute hook-and-loop structures.

The pupae (chrysalises) form within the exoskeletons of the L_5 instars. As the pupae grow, the L_5 exoskeletons split beneath the head. Powerful elastic fibers contract and cause the old exoskeletons to slip over the new pupal exoskeletons, like pulling off a sock. The old, tightly condensed L_5 exoskeletons may be found at the posterior end of the pupa, or they may fall off. The pupae remain belted securely to the carpet in the middle and at the posterior end.



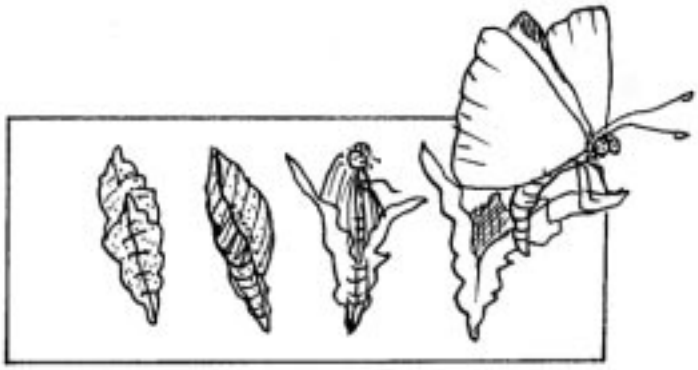
Not drawn to scale

Week 4 (18-26 days old)

To the outside observer, the next ten days appear to be quiet. Quite the opposite! Profound changes are happening inside the chrysalises as the pupae transform from larvae to adult butterflies during metamorphosis.

During the first few hours, the soft, green chrysalises harden and become a translucent brown. Over the next few days, the outlines of the newly formed wings appear. When two dark wing spots appear on each side of the chrysalises, the butterflies are within 24 hours of emergence.

Weeks 5-9 (26-55 days old)



After crawling out of their chrysalises (sometimes in just a minute or less), the butterflies pump up their new wings and begin to forage for food. This time, it's nectar from flowers that they crave. (Plan to have planted Wisconsin Fast Plants™ two weeks prior, so the flowers are in full bloom.) Seeking the sweet substance, the butterflies uncoil their proboscises and plunge them into the flowers. As they drink, the butterflies unwittingly pick up pollen from each flower and transfer it to the stigma of another flower, thus pollinating the flowers.

Within 2-3 days of emergence, mating ensues. Butterflies couple in the air or on plants for minutes at at time. A few days later, the female butterflies (two spots per wing, rather than one) deposit tiny eggs onto the undersides of the Wisconsin Fast Plants™ leaves or egg collectors, and the butterfly life cycles continue.

About The Butterflies...

Brassica Butterflies (*Pieris rapae*) are also known as Cabbage White Butterflies. In nature, they can be found virtually anywhere that brassica plants grow. The butterflies spend most of their short lives in fields of brassica crops such as broccoli or canola, or among the brilliant yellow, wild mustard plants that are common along roadsides and in woodlands.

These easy-to-rear insects have a short life cycle of about 40 days. In less than two months, students can observe all stages of the life cycle, from hatching eggs to laying eggs. Easily reared in the classroom, Brassica Butterflies require little more attention than a continuous supply of brassica plants to eat. Once laid, the eggs of the next generation can be left to hatch into more larvae, or terminated by placing them in a freezer overnight.

For details about rearing Brassica Butterflies, refer to the *Brassica Butterfly Care Instructions*. For classroom activities and investigations with Brassica Butterflies and Wisconsin Fast Plants™, go to *www.fastplants.org*.

The Life Cycle of Wisconsin Fast Plants™

Note: The age of plants listed here is calculated from the date that seeds are planted, so Day 0 here equals Day 12 on the Life in Balance Calendar.

Week 1 (0-6 days old)

Each seed contains a tiny, new plant, called an embryo. The outside of the seed is called the seed coat. A seed can remain quiescent (sleeping) for years, as long as it stays dry and cool.

A day or two after planting and watering, the tiny seeds germinate. During germination, the seed takes up water and swells until its seed coat cracks. The radicle (embryonic root) comes out first, followed by the hypocotyl (stem) and two cotyledons (seed leaves). A few days later, the hypocotyl pushes through the soil, pulling the seed leaves along with it.

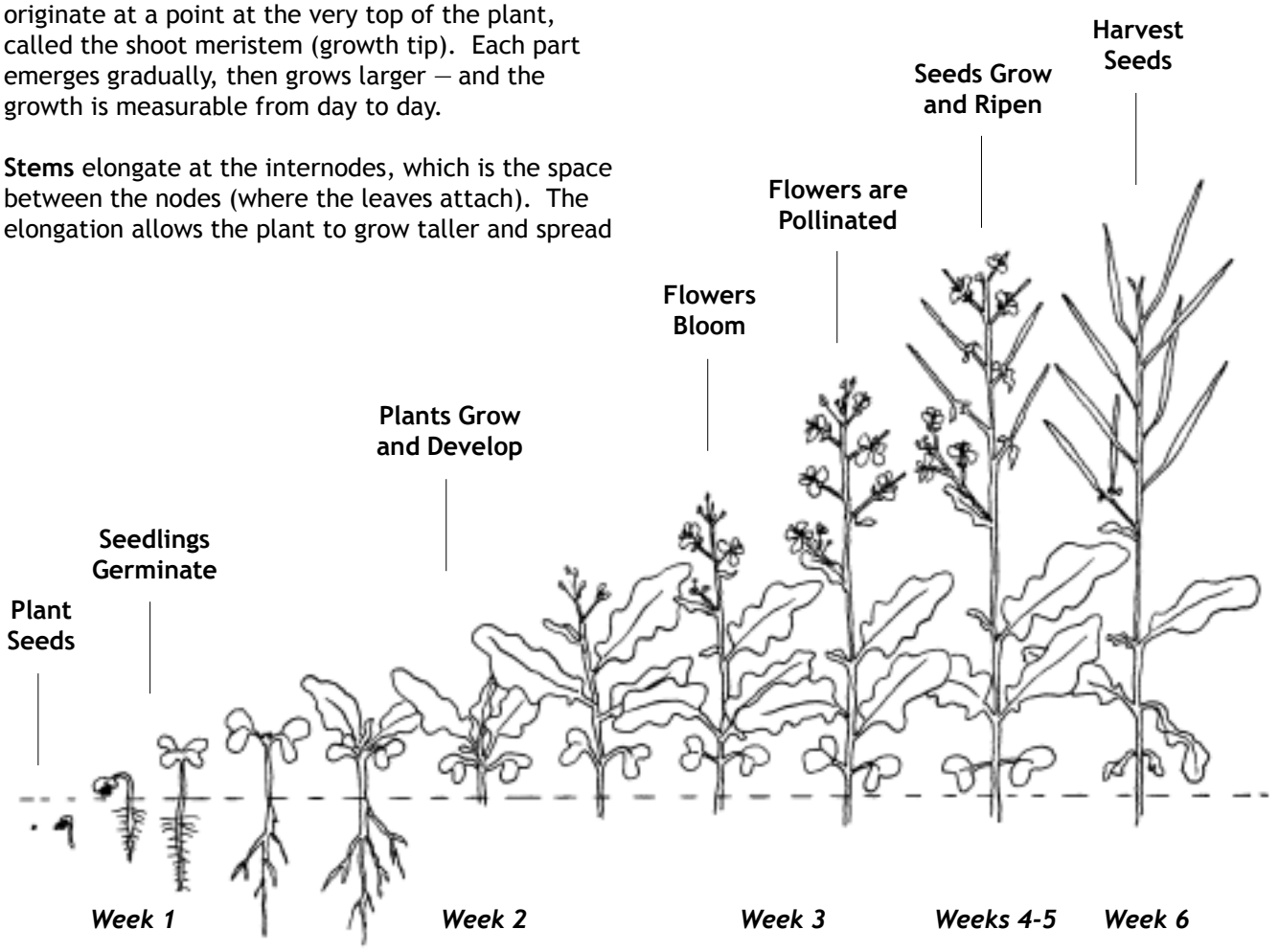
Week 2 (7-14 days old)

Above ground, the true leaves, stems, and flowers originate at a point at the very top of the plant, called the shoot meristem (growth tip). Each part emerges gradually, then grows larger — and the growth is measurable from day to day.

Stems elongate at the internodes, which is the space between the nodes (where the leaves attach). The elongation allows the plant to grow taller and spread out the leaves and flowers so they are in the best position to do their jobs. Stems allow food, water, and minerals to move throughout the plant.

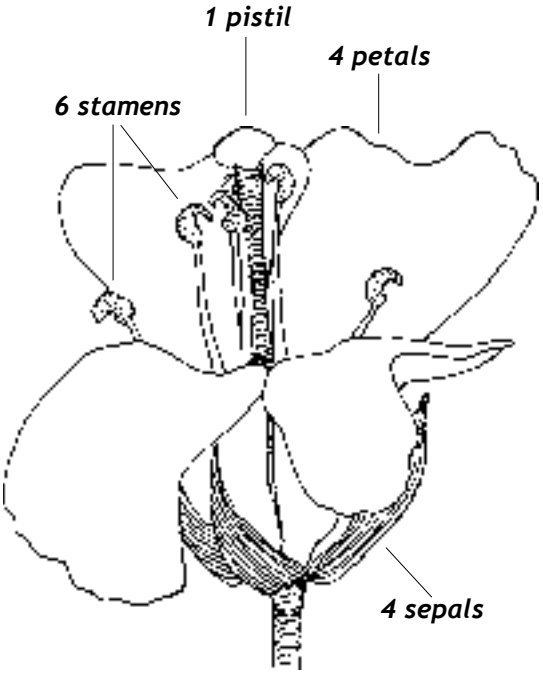
Leaves contain many pores (called stomata) on their surfaces that allow the plant to "breathe" by uptaking carbon dioxide (CO_2) from the air, and then expelling oxygen (O_2). A green pigment, called chlorophyll, causes the leaves to appear green and captures energy from light. When CO_2 and water are combined in the presence of light, the plant makes its own food, called carbohydrates (or sugar). This amazing process is called photosynthesis.

Under the soil, the **roots** grow downward. Roots anchor the plants into the soil so they don't blow or wash away. Root hairs absorb water and nutrients from the surrounding soil and bring them to the rest of the plant. Most of the absorbed water is used to cool the plant as water evaporates from the leaves; some is used for cellular processes, such as photosynthesis.



Week 3 (14-20 days old)

The **flowers** bloom. At the growth tip, new flower buds begin to appear. Each bud is protected by four green sepals. Once a flower opens, the sepals are hidden beneath four bright yellow petals. The flower's center boasts a single pistil, which is the female part of the flower. The pistil is surrounded by six yellow stamens, which are the male parts of the flower. Each stamen is covered with lots of powdery, yellow pollen.



The bright yellow petals may catch your eye — and the eye of insects. The petals form a beacon that lets insects know that there is food available. Hidden deep inside the flower are nectaries, which produce nectar. Nectar is a sweet, sugar-rich substance that insects love to eat. That's why bees and butterflies are attracted to flowers — they're hungry!

In exchange for food, insects pollinate flowers. When an insect moves from flower to flower looking for nectar, pollen from each flower gets caught in the insect's body hairs and is transferred to other flowers. After pollen has landed on the tip of another flower's pistil, it grows a tube down into the pistil, where the eggs are housed. Sperm (from inside the pollen) are then able move down the tube until they reach the eggs and fertilize them. The fertilized eggs then become the embryos of new seeds.

Weeks 4, 5, and 6 (21-40 days old)

As the seeds mature and ripen, the outside of the pistil swells to become the **seed pod** (or **fruit**) that encases several seeds. The leaves and flowers slowly wilt and fall off, one by one.

After the seeds have dried out completely, they are ready to be planted or stored. Inside each seed is a tiny **embryo**, waiting for water and warmth so it can germinate into a new plant, and another life cycle can begin.

About Wisconsin Fast Plants™...

Wisconsin Fast Plants ™ (*Brassica rapa*) are rapid-cycling brassicas. They are members of the crucifer family of plants, closely related to cabbage and turnips that have been bred over 30 years at the University of WIsconsin - Madison.

These petite plants (~20 cm tall at maturity) whiz through an ultra-short life cycle in about 40 days. In just over a month, students can plant seeds, tend plants, pollinate flowers, and harvest new seeds. The seeds can be immediately planted or stored for up to 10 years. Easily grown in the classroom, Wisconsin Fast Plants™ require little more attention than continuous fluorescent light, water, and fertilizer.

For details about growing Wisconsin Fast Plants™, refer to the *Wisconsin Fast Plants™ Growing Instructions*. For classroom activities and investigation ideas, go to *www.fastplants.org*.

Calendar

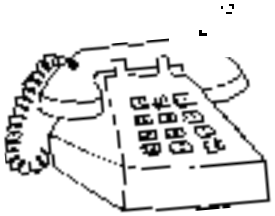
Monday	Tuesday	Wednesday	Thursday	Friday	Sat.	Sun.
				-5 Order eggs Construct Butterfly Box Plant Brassica Plant Mix	-4	-3
-2	-1	0 STARTING DAY Place egg strips on plants	1	2 Eggs hatch between days 2-4 Check nutrient solution	3	4
5 Larvae grow and molt	6	7	8	9 Transfer larvae to broccoli* Clean up plant materials	10	11
12 Plant Wisconsin Fast Plants™	13	14	15 Larvae pupate and form chrysalises	16 Thin plants to 2 per pot Check water levels	17	18
19 Pupae undergo metamorphosis Plants grow and develop; check nutrient solution regularly	20	21	22	23	24	25
26 Butterflies emerge, feed, mate, and lay eggs Flowers begin to bloom and are pollinated by butterflies	27	28	29	30	31	32
33 Eggs hatch and larvae feed on post-flowering Wisconsin Fast Plants™ Plants begin to produce seeds in seed pods.** Will both the butterflies and the plants survive?	34	35				

* If larvae are too small to handle easily, wait until day 12 to transfer them to broccoli.

** To continue the life cycle of the Wisconsin Fast Plants™ and harvest seeds (if the plants survive the larval devastation): Remove plants from the nutrient solution on day 50 and let the plants dry out for one week until they are brown and crispy. For details, see the *Wisconsin Fast Plants™ Growing Instructions*.Reminder: Day 12 on this calendar equals Day 0 in the *Wisconsin Fast Plants™ Growing Instructions*.

Getting Started

In this activity, students will have the opportunity to witness first-hand the dynamic relationship between Brassica Butterflies and Wisconsin Fast Plants™. The students are responsible for tending the plants and butterflies throughout the entire life cycles, and for recording their observations in Student Notebook Pages.



Five days prior to starting this activity:

1. **Call 1-800-334-5551 to order your Brassica Butterfly eggs.** It is recommended that you call on a Friday, so you can begin the activity when the eggs arrive the following Wednesday. Refer to the number on the CBSC Butterfly Order card (enclosed).

2. **Assemble the Butterfly Box** according to the instructions.

3. **Plant seeds of the Brassica Plant Mix** following the *Brassica Butterfly Care Instructions* (not the *Wisconsin Fast Plants™ Growing Instructions*), so that the plants will be 4–6 days old when the eggs arrive.

Starting the Activity (Day 0)

- **Open eggs immediately upon arrival**, and place the egg strip (egg side down) on the five-day-old Brassica Plant Mix. If your students can't observe the eggs immediately, t's ok to remove the strip briefly for observation later.

- **Follow the calendar** on page 10 of this manual.

- For tending butterflies and growing plants, refer to:
  Brassica Butterfly Care Instructions
  Wisconsin Fast Plants™ Growing Instructions

- For details about the stages in the life cycle of the butterflies and plants, refer to pages 6–9.

- **Keep the light on 24 hours a day** in the Butterfly Box for the plants until day 19. After day 19, reduce the light to 18 hours a day with a timer.

- **Prop the plants up on books** so that the top of the plants is only about 10 cm from the light at all times. Remove books to lower the plants as they grow taller.

Days 1 through 35: The Tandem Life Cycles

When is life "in balance?"

During the next five weeks, students will have the opportunity to care for their butterflies and plants, witnessing first-hand how butterflies and plants grow, develop, mature, and reproduce. Chronicling the tandem life cycles will reveal a confounding biological dilemma: while the butterflies and plants depend on each other for survival, the butterfly larvae have the capability of destroying an entire population of plants. Are the two populations (butterflies and plants) really living in balance?

Exploring and Explaining

Exploring and **explaining** are the two key components of *Life in Balance*. In many ways, students are responsible for their own learning as they explore and explain "life in balance." Their own observations, explanations, and questions will guide their exploration of the life cycles.

The students are responsible for tending both the butterflies and the plants through the entire activity. (For details, see the enclosed flyers: *Brassica Butterfly Care Instructions* and *Wisconsin Fast Plants™ Growing Instructions.*) When students observe their butterflies and plants, they should record their observations, notes, and questions on the **Student Notebook Pages**, then explain how the organisms are growing, developing, and interacting by answering the questions provided.

As they go through their tandem life cycles, the petite, rapid-growing plants and their hardy, natural predators engage in raw, dynamic interactions that are impossible for even the most apathetic student to ignore.

For more in-depth explorations:

- Ask some of the **Discussion Ideas and Questions** (page 13) during the life cycles.
- Design your own questions, tailored to your grade level and curriculum.
- Let the students develop their own list of challenging questions.
- Try some of the **Extension Ideas** (page 16) that are geared toward designing experiments and gathering evidence.
- Visit ***www.fastplants.org*** for more ideas about how to use Brassica Butterflies and Wisconsin Fast Plants™ in the classroom. This comprehensive website includes in-depth information on the life cycles and many **color photographs**!

Culminating Activity

When students **compile their Student Notebook Pages** at the end of the exploration, they will have a chronicle of butterfly and plant lives. The detailed descriptions, drawings, and explanations about growth, development, maturation, reproduction, and interactions can serve as **evidence** to claim whether or not the two populations were able to live in balance.

Discussion Ideas and Questions

Encourage students to:

1. Propose answers to the questions below (or your questions). The questions can serve as a way to guide observations throughout the life cycles, with answers written on the back of the Student Notebook Pages. Or, the questions can be used as pre- and post-test questions.

2. Ask their own questions about the growth, development, and reproduction of their butterflies and plants at different stages in the life cycles.

3. Develop an experiment to do with the butterflies and plants, based on their observations and questions.

4. Try some of the investigation ideas (see page 6).

Butterfly Questions

- How do the larvae hatch from the eggs?
- What clues indicate that larvae are present?
- What do larvae eat?
- Where would you expect to find the larvae?
- What do the larvae excrete?
- Each larvae has an exoskeleton; how does it grow larger? What is the function of the exoskeleton?
- How do larvae become butterflies?
- What indicates that a larvae is ready to form a chrysalis?
- What indicates that a butterfly is ready to emerge from a chrysalis?
- Where do female butterflies tend to lay their eggs? Why?
- What do larvae and butterflies eat in the natural world?
- Plot the size of the larvae/butterflies on a graph over time.
- Will the larvae have enough food to become butterflies?
- Will the butterflies have enough food to mate and reproduce?

Plant Questions

- How does a seed germinate?
- What environmental conditions do seeds need for germination?
- Where do new plant parts (stems, leaves, flowers, and roots) develop?
- How do plants get carbohydrates for energy to grow?
- What is the purpose of each structure: stem, leaf, flower, and root?
- Why are insects attracted to flowers?
- Do all seeds on a plant have the same mother? Same father? Explain.
- Are seeds alive?

Life in Balance: Student Notebook Page for Brassica Butterflies

Name:

Observation Date:

Answer each question for this stage in the life cycle only. Use a new page on each observation day.
Use the back side of this sheet for notes, observations, drawings, questions, or ideas.

1. **Structure**: Draw a Brassica Butterfly here, to scale. Label the parts or structures.

Size: _____ cm

2. **Function**: Describe what function each structure serves.

3. **Environmental Effects** (at this stage in the life cycle)
   (a) What environmental conditions do the Brassica Butterflies need to survive?

   (b) What resources might limit their growth?

   (c) How did you tend the Brassica Butterflies?

4. **External Stimuli and Behavior**: What external stimuli might the Brassica Butterflies be responding to? Describe the Brassica Butterfly's behavior (eating, growing, mating, sleeping, excreting, moving, etc.).

Life in Balance: Student Notebook Page for Wisconsin Fast Plants™

Name:

Observation Date:

Answer each question for this stage in the life cycle only. Use a new page on each observation day.
Use the back side of this sheet for notes, observations, drawings, questions, or ideas.

1. **Structure**: Draw a Wisconsin Fast Plant™ (or seed) here, to scale. Label the parts or structures.

Height: _____ cm

2. **Function**: Describe what function each structure serves.

3. **Environmental Effects** (at this stage in the life cycle)
   (a) What environmental conditions do the plants need to survive?

   (b) What resources might limit their growth?

   (c) How did you tend the plants?

4. **External Stimuli and Tropisms**: What external stimuli might the plants be responding to? Describe what tropisms they are exhibiting.

5. **Interaction**: How are the plants and butterflies interacting? Is the interaction mutualistic, antagonistic, or both? Explain why.

Investigation Ideas: Gathering Evidence for Explanations

Note: It may help to have an extra Butterfly Box or two so the students can test more than one treatment (Catalog Number: 15-8997). For more information, see **www.fastplants.org**.

1. What does it take to achieve "Life in Balance?"
How many larvae and plants can live together so that both can produce fertile offspring?

As a class, students design an experiment to determine:

(a) how many larvae can survive and reproduce in the presence of a finite number of plants
(b) how many plants need to be present in order to survive the hungry larvae's devastation so the plants can produce viable offspring (seeds)

How will students measure their results?
Measurement ideas: Number of eggs or seeds; number of eggs that hatch or seeds that germinate.

2. Brassica Butterfly Buffet
Will different food sources affect the larvae or butterflies?

Each student group designs an experiment to determine how different food sources affect larvae or butterflies. Some food sources that students may want to try:

- Instead of Brassica Plant mix, try rearing the larvae on different types of brassica seedlings, such as broccoli, cabbage, cauliflower, chinese cabbage, turnip, etc. (Plant the same way as Brassica Plant Mix.)
- Instead of broccoli, try rearing the larvae on chunks of other brassica plants from the grocery store, or try non-brassica plants, such as lettuce, spinach, or carrots.
- Compare organic versus conventional broccoli. Students are often surprised to find that organic produce often causes larval death, due to the presence of an organic pesticide called Bt.

How will students measure if the larvae are affected by a different food source?
Measurement ideas: Larval length, days to chrysalis formation, frass color, or behavior.

3. Experimenting with Environmental Effects
How does the environment affect plant growth or butterfly behavior?

Each student group designs an experiment to determine how the environment affects the plants, the butterflies, or both. Some environmental parameters that students may want to vary:

- temperature
- the amount of time the light is on (photoperiod)
- the amount of food available (number of sugar feeders or flowering plants for butterflies; amount of water or fertilizer for plants)
- the presence of toxins in the soil (too much salt, bleach, etc.)

How will students measure any changes in butterfly behavior or plant growth?
Measurement ideas: Monitor habits of eating, flying, resting, mating, or egg laying; plant height.