How Does Light Affect Flowering?

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The bedding plant industry is being pressured to consistently produce blooming plants when marketed. Potted plant growers have scheduled flowering on crops such as potted chrysanthemums for decades using photoperiod (day length) control. We are only now beginning to understand how light and photoperiod affects flowering of many of the bedding plants we market today.

In general, the total daily light a plant is grown under affects seed-propagated bedding plant flowering by reducing the juvenile phase length and/or by inducing rapid flowering. What a juvenile phase is and how light can reduce it is discussed below. In addition, how day length or photoperiod manipulation can result in faster bedding plant flowering or flower induction is also discussed. Lastly, how this information can be used by growers to control flowering is summarized. Although this article provides a summary of light effects on bedding plant flowering, I would encourage those interested in this topic to read recent articles we wrote on our research results, as well as new articles that will be appearing over the next year in this magazine and in Greenhouse Grower.

Plant Age:

Animals and plants pass through phases as they mature and grow. With animals, phase changes occur throughout the whole body. In contrast, with plants, phase changes occur only in shoot tips, i.e. newly formed tissues. As plants grow, shoots pass through three phases: the juvenile phase, adult vegetative phase and adult reproductive phase. The difference between juvenile and adult phases is that plants can produce flowers only in the adult phases. The difference between the two adult phases is based on whether flower induction has occurred, i.e. a plant can be mature or adult but not flowering (adult vegetative phase), or not.

Conditions that slow growth (or leaf unfolding) can delay the change from the juvenile to adult phase in time. In addition, non-optimal growing conditions such as low light or lack of fertilizer can delay the change from the juvenile to adult phase developmentally. In other words, non-optimal growing conditions can result in more leaves below the first flower. However, there are rare cases (anecdotally impatiens and celosia) where stresses (such as water stress) are suspected to reduce juvenile period length and hasten flowering. In contrast to slowing of flowering by non-optimal conditions, conditions that promote growth and/or photosynthesis can hasten the change from the juvenile to adult phases. For instance, juvenile phase length can be decreased by increasing light intensity in seed geraniums, petunias and pansies (see following section).

Plants vary in juvenile phase length. In general, the ‘longer-lived’ a plant is, the longer the juvenile phase. For instance, some nut-trees, herbaceous perennials, and herbaceous annuals can have a 25-year, a 4-month, (14 leaves), and a 2 week (3-4 leaf) juvenile phase length, respectively. Some juvenile period lengths of herbaceous species are shown in Table 1.

Table 1. Juvenile period length based on node number of selected herbaceous species.

Species	Nodes When Plants Change From Juvenile To Mature Phase
Leek	>2 nodes
Onion	4-6 nodes
Celeriac	>2 nodes
Columbine ‘McKana’s Giant’	12 nodes
Columbine ‘Fairyland’	15 nodes
Cauliflower	4-12 nodes
Broccoli	>4 nodes
Cabbage	4-15 nodes
Kohlrabi	>2 nodes
Brussel Sprouts	>15 nodes
Kale	>4 nodes
Calceolaria	5 nodes
China Aster	4 nodes
Coreopsis ‘Sunray’	8 nodes
Gaillardia ‘Goblin’	16 nodes
Heuchera ‘Bressingham’	19 nodes
Lavandula ‘Munstead’	18 nodes
Tomato	>3 nodes
Parsley	>5 nodes
Rudbeckia ‘Goldstrum’	10 nodes

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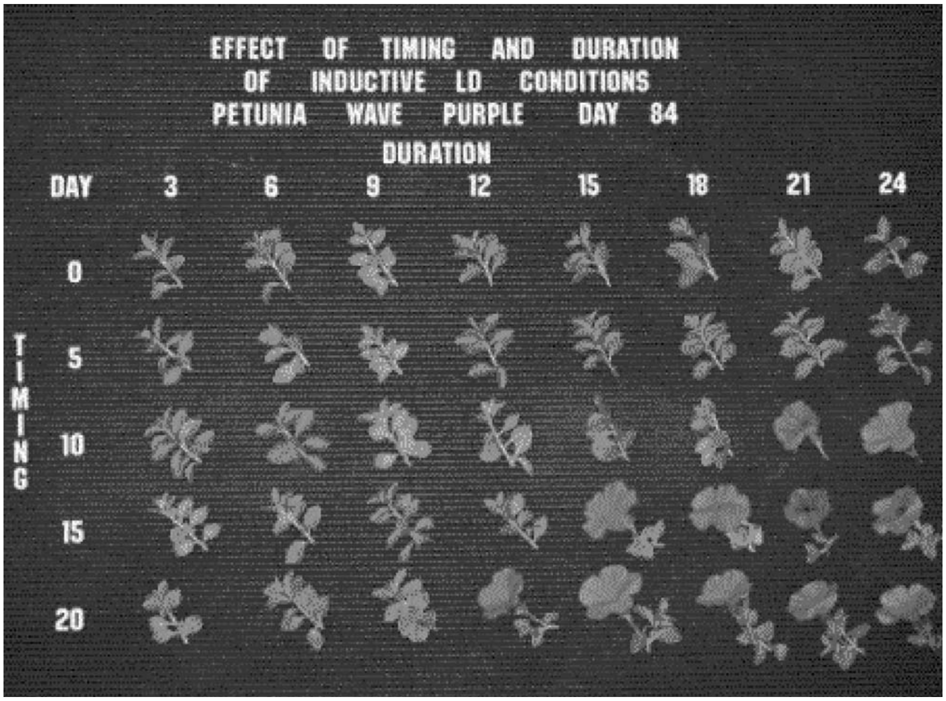


Figure 1. The effect of long-days (18 photoperiod, ambient daylight plus 100 umol m-2 s-1 high pressure sodium lighting) for different durations (across the top) at different times after germination (down the left side) on flowering of Purple Wave petunia (long-day plant). Note that no duration of long days induced flowering when applied 0 or 5 days after germination suggesting that there is a juvenile phase. We determined Purple Wave petunia has a 2 week juvenile period and plants must have long-days for at least 3 weeks to induce complete flowering.

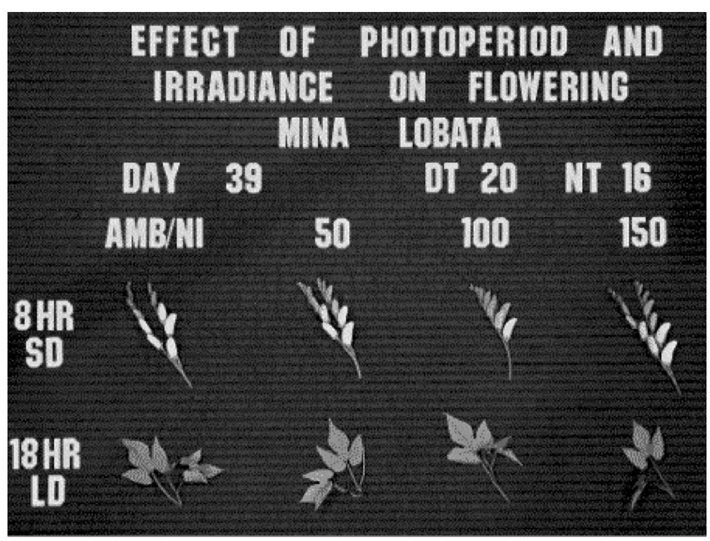
Day Length or Photoperiod Effects on Flowering

Plants time flowering during the year by measuring day and/or night length. Many bedding plants are induced to flower (once mature) when day length (actually night length) is less than or more than some critical length, i.e. they are photoperiodic. For instance, we know that African marigolds are short-day plants, i.e. plants will not flower unless the day length is less than night length. It is for this reason that African marigolds must be given short-days by pulling cloth to get them to flower if they are germinated and grown after March 21st when day length exceeds night length. In contrast, fuchsia will flower when day length is greater than the night length, i.e. fuchsia are a long-day plant. To get fuchsia to flower earlier than Mother's day, light in the middle of the night prior to March 21st! We conducted a series of lighting experiments supported by the Widmer Fund and F.I.R.S.T. on many of the current spring annuals and have found that many of them are photoperiodic.

Photoperiodic plants can be divided into the following groups:

1) Facultative Short Days Plants – plants flower eventually regardless of day length, but flower faster when the day is shorter than some critical length.
2) Obligate Short Day Plant – plants flower when day length is less than some critical length (Figure 2).
3) Facultative Long Day Plants - plants flower eventually, but flower faster when day length is longer than some critical length.
4) Obligate Long Day Plant – plants flower when day length is longer than some critical length (Figure 3).
5) Day Neutral Plants – plants flower regardless of the day length.

Below Figure 2. The effect of daylength on flowering on Mina Vine (Mina lobata). Light levels increased from left to right from ambient daylight (8 hour) to ambient daylight plus 150 *u*mol m^{-2} s^{-1}. The top row represents plants grown under an 8 hour photoperiod. The bottom row represents plants grown under an 8 hour photoperiod plus a night interruption (2 *u*mol m^{-2} s^{-1}; 2200-0200 HR) or an 18 hour photoperiod (daylight plus high pressure sodium lighting from 0600-0000 HR. Note that Mina vine only flowered when grown under short days, i.e. it is an obligate short-day plant.



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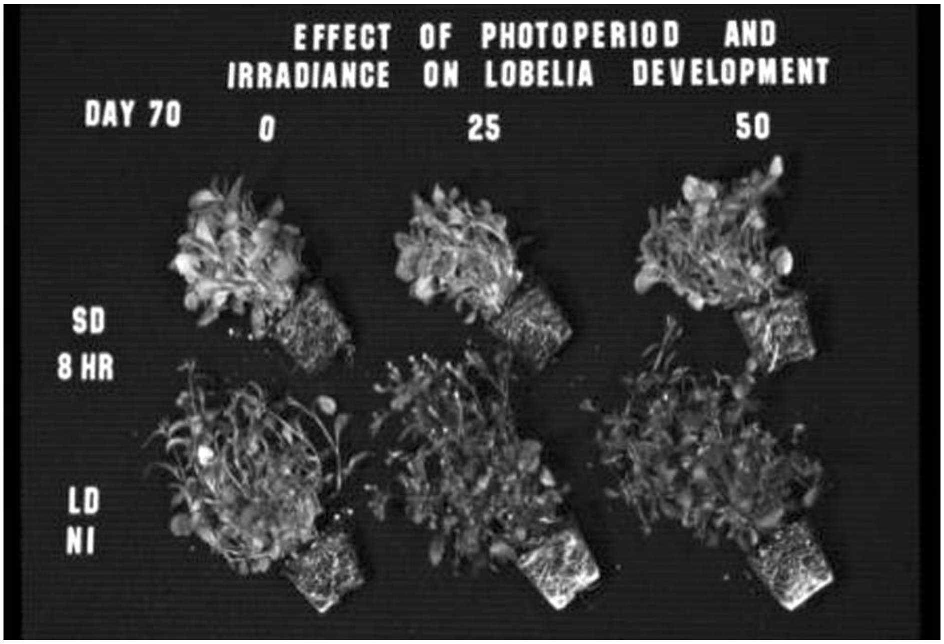

Figure 3. The effect of daylength on flowering on lobelia (Lobelia erinus). Light levels increased from left to right from ambient daylight (8 hour) to ambient daylight plus 150 *u*mol m^{-2} s^{-1}. The top row represents plants grown under an 8 hour photoperiod. The bottom row represents plants grown under an 8 hour photoperiod plus a night interruption (2 *u*mol m^{-2} s^{-1}; 2200-0200 HR) or an 18 hour photoperiod (daylight plus high pressure sodium lighting from 0600-0000 HR. Note that lobelia only flowered when grown under long days, i.e. it is an obligate long-day plant.

<u>Flower Development:</u>

Once a crop is induced to flower, some plants have a day length requirement for flower bud development. An example of this occurs on chrysanthemum, where flower development requires a shorter day length than flower induction/initiation. Chrysanthemums naturally induce flowers in July as day length gets shorter (after June 21st) and flowers continue to develop as day length gets shorter as fall approaches. If day length gets longer after flower bud initiation, development can stop and a 'crown bud' can form. Crown buds can be seen when growers are using black cloth to schedule flowering and stop pulling black cloth too early when plants might naturally get long days such as late spring and summer.

Light Intensity (Irradiance)

Increasing the light a plant is exposed to over a 24-hour period can hasten flowering of some plants. For instance, lighting seed geranium seedlings results in earlier flowering of the finished plant. The 'rule-of-thumb' is every day of supplemental lighting in the seedling stage with seed geraniums results in one day less time to flower.

We know that increased lighting results in earlier flowering usually because the length of the juvenile phase is reduced, and/or increased lighting heats the plant that causes more rapid growth (leaf unfolding and flower development). If earlier flowering is because of heating only, it is cheaper to turn the thermostat up rather than providing heat using lights! If lighting is resulting in quicker flowering because it is shortening the length of the juvenile phase, that's a different story because the lights are causing the plants to mature quicker and likely have more rapid leaf unfolding.

We recently found that extra lighting reduces the juvenile phase length on about 1/3 of the bedding plant species we grow (about 55 species studied). We divided bedding plants into two groups with respect to the flowering response to light:

1) Facultative Irradiance Plants - Plants where increasing light results in earlier flowering developmentally (reduced leaf number below the first flower) (Figure 4).
2) Irradiance Indifferent – Plants where increasing light does not result in earlier flowering developmentally (reduced leaf number below the first flower).

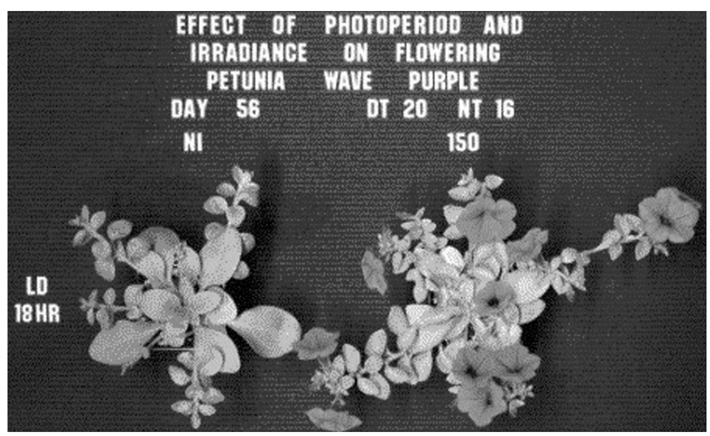

Figure 4. Purple Wave petunia is a 'facultative irradiance response' plant. The plant on the left received ambient daylight plus night interruption lighting (2 *u*mol m^{-2} s^{-1} (10 footcandles) from 2200-0200 HR) and the plant of the right received ambient daylight plus 150 *u*mol m^{-2} s^{-1} for 18 hours (0600-0000 HR). Note that supplemental high pressure sodium resulted in hastened flowering that resulted from a decrease in the juvenile phase length (fewer leaves below the first flower) and plant heating by the lights (+4°F).

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Examples from each lighting response groups are found among common bedding plants. For instance, Purple Wave petunias are induced to flower earlier when given long days, however, days to flower can be reduced still further when they are given long days using supplemental high pressure sodium lighting as opposed to night interruption lighting (more total light per day; Figure 4). Increasing total daily light with the facultative long-day and facultative irradiance plant Blue salvia 'Strata' decreased the time to flower because node number below the flower decreased from 24 to 18 (and because the lights increased plant temperature by approx. 2°F) and days to flower from 98 to 66 days.

In contrast to Purple Wave petunias and Blue Salvia, Blue Moon lobelia and Sorbet viola are long-day plants categorized as 'irradiance indifferent' plants because additional light does not reduce leaf number below the first flower (leaf number below the first flower was unchanged at 8 nodes when comparing night interruption lighting to day extension lighting using HPS lamps). In other words, using high pressure sodium lights to induce flowering compared to night interruption lighting gives no benefit with respect to time to flower. Any hastening of flowering of viola or lobelia was due to plant heating.

Temperature Interaction with Light

Growing bedding plants too cool or warm will reduce flower number, or eliminate flowering entirely, even when plants are under a photoperiod that induces flowering. For instance, the optimal temperature for inducing flowering on fuchsia is around 68°F when grown under long-days (inductive). If plants are grown warmer or cooler, flower number decreases. This is also the case with geraniums where flower number per inflorescence (flower head) decreases as average daily temperature plants are grown at increases from 50 to 86°F.

With some short-day plants, night temperatures over 72-74°F (especially 8 hours after the onset of darkness) will delay flowering (increase leaf number below the first flower) of many plants. High night temperature inhibition of flowering is called 'heat delay'. Heat delay is common during summer with garden mums, during early fall with poinsettias, and in the spring with African marigolds. Gomphrena (facultative short-day plant) flowering is also delayed if night temperatures are warmer than 74°F.

Application:

As mentioned before, seed-propagated plants have a juvenile phase. After seed germination, plants are in the juvenile phase and after a period of time which is affected by total daily light with some plants, seedlings transition from the juvenile to adult phases and are then capable of flowering if grown under inductive conditions. Of those species that have a facultative irradiance response, increasing light during the day in early spring in Minnesota (to about 15 moles day^{-1}) will hasten flowering by reducing the leaf number below the first flower.

Once a plant is mature, you can induce consistent and complete flowering on plant species that are photoperiodic by providing the appropriate photoperiod. For plants such as gomphrena, zinnia, mina vine, morning glory and hyacinth bean induce earlier flowering by providing short days. In general, we deliver short day treatments by pulling black cloth over plants from 1600-0800 HR; 8 hour day length). In the summer the black cloth schedule can be shifted to 1800-0800 or 1000 HR (10 or 8 hour day) to limit heating under the cloth. Use a cloth that is reflective on the outside to limit heating inside the cloth to limit 'heat delay'. At no time should temperature under the cloth be >72°F eight hours after the onset of darkness! If plants are short-day plants and have a facultative irradiance response, light during a short day when light levels are low such as in early spring and during cloudy days.

If a plant species is a long-day plant, light plants with night interruption lighting (preferably high pressure sodium) from 2200-0200 HR if they are irradiance indifferent (Figure 5). If plants are long-day plants and have a facultative irradiance response, provide up to approximately 15 moles day of light by lighting during the day on cloudy days and/or extending the day using high pressure sodium lights to induce early flowering and to provide long days.

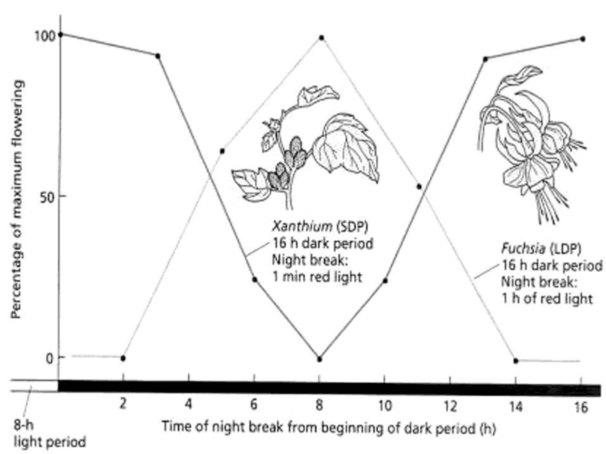

Figure 5. Variation in effect of night break lighting at different times on promoting flowering of the long-day plant Fuchsia x hybrida (Fuchsia) or inhibiting flowering of the short-day plant Xanthium strumarium (Cocklebur).

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It is not always beneficial to induce early flowering. For instance, asters can induce flowers while very young in the plug tray and flower too early and never achieve a desirable size. Undesirable early flowering can also be observed in cosmos, pansies, and celosia. In each of these cases, young seedlings should be grown for a period of time under non-inductive conditions to 'build' the plant before the plants are induced to flower. For example, cosmos and morning glory (short-day plants) should be grown under long-days first (non-inductive) and then placed under short-day conditions (inductive) after they have reach a desirable size.

In contrast to seed-propagated plants, plants from cuttings are, in general, taken from mature plants and are, therefore, mature and capable of flowering. Induced cuttings will continue to flower as long as young leaves perceive inductive conditions. However, if you cut a plant back (cut young leaves off) and place a plant under non-inductive conditions, young leaves on new shoots will not develop under inductive conditions and the new shoots will not flower. This was a common way to produce vegetative stock plants prior to the introduction and/or advent of Florel. However, it is now common practice to place stock plants under long day conditions (whether inductive or non-inductive) to maximize photosynthesis and spray plants with Florel to inhibit flowering on shoots/cuttings. In this case, plants may be induced to flower (as is the case with vegetative petunias) but flower initiation and development are inhibited by Florel (ethylene).

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Garden Center Layouts that Work

Garden Center Layouts that Work

February 18-19, 2004
Midland Hills Country Club, Roseville
Presented by the MNLA Garden Center Committee

February 18 - Full-Day Program

8:00 a.m. Registration

9:00 a.m. Morning Session
Creating a GreenPrint (Layout) for Your Store
Sharpton will use actual store layouts and slides to demonstrate how you can achieve a store layout that maximizes shopper-merchandise contact. Learn how to strategically place displays for maximum impact.

Noon – 1:00 p.m. Lunch

1:00-4:30 p.m. Afternoon Session
Entrance, Customer Flow, and Cash Register Answers
Case studies will be used to pinpoint solutions to the three most difficult store layout issues – entrance, customer flow, and cash wraps.

February 19 – Individual Sessions with the Expert

Sharpton will meet with ten garden centers/staff members for a scheduled 40 minute session. Participants must attend the February 18 program. During each session, members will be asked to bring the following:

- Scale drawing of retail sales area
- Photos of areas to be renovated
- Product list for all selling seasons
- Collection of all customer communication, including a photo of your staff
- Statement of your vision for the store, emphasizing site renovation, branding, and product development

Sharpton will then have a follow-up conversation six months later to determine their progress.

About the Speaker

Judy Sharpton

Judy Sharpton is a marketing consultant who has accumulated over twenty years of experience in advertising and promotion. Sharpton shared her wealth of knowledge at last year's Minnesota Green Expo and at a "Creating Sensational Displays That Sell" seminar in August. Her seminars overflow with new ideas, enthusiasm, and inspiration to enhance your garden center.

Her business, Growing Places Marketing, specializes in store design, renovation, and branding programs exclusively for independent retail garden centers. She is a contributing editor for Lawn and Garden Retailer and Birding Business, and has been published in American Nurseryman, GCM&M Magazine, and the OFA Bulletin.

Call MNLA at 651-633-4987 or register online at www.mnla.biz.

Professional Improvement

Plan to attend Minnesota Grown Marketing Conference

The MNLA is partnering with the MDA's Minnesota Grown Program to offer a one day marketing workshop for garden centers and nurseries. You'll want to reserve Tuesday, March 16, on your calendar for this outstanding event at the Earle Brown Center on the University of Minnesota's St. Paul Campus. The conference will include topics specifically geared to MNLA members as well as topics of interest to all specialty crop marketers. Last year was the first year that the MNLA participated in the annual conference and MNLA members who attended gave the program extremely high marks. The agenda and registration details are being finalized as this newsletter goes to press. Check www.minnesotagrown.com for updated conference information or contact Paul Hugunin at 651-297-5510.

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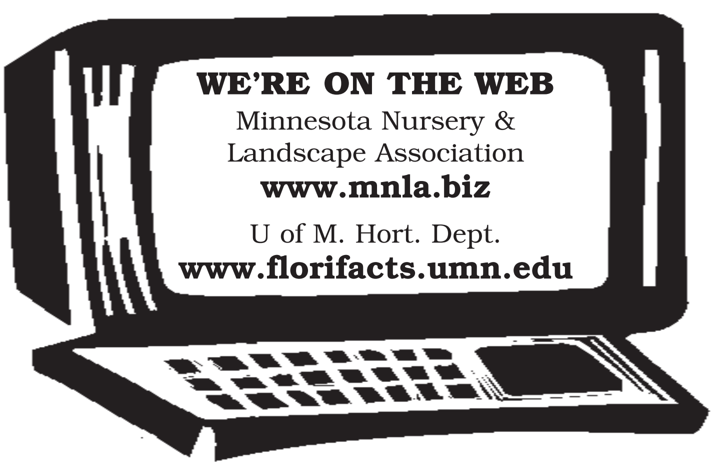

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