Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.

a. Environmental factors influence many traits both directly and indirectly. [See also 3.B.2, 3.C.1]

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Density of plant hairs as a function of herbivory

-Effect of adding lactose to a Lac+ bacterial culture

-Effect of increased UV on melanin production in animals

-Presence of the opposite mating type on pheromones production in yeast and other fungi

-Seasonal fur color in arctic animals

-Height and weight in humans

-Sex determination in reptiles

-Flower color based on soil pH

Environmental Influences on Gene Expression

The expression of genes in an organism can be influenced by the environment, including the external world in which the organism is located or develops, as well as the organism's internal world, which includes such factors as its hormones and metabolism.

One major internal environmental influence that affects gene expression is gender, as is the case with sex-influenced and sex-limited traits.

Similarly, drugs, chemicals, temperature, and light are among the external environmental factors that can determine which genes are turned on and off, thereby influencing the way an organism develops and functions.

Temperature is an external environmental factor that may influence gene expression in certain organisms.

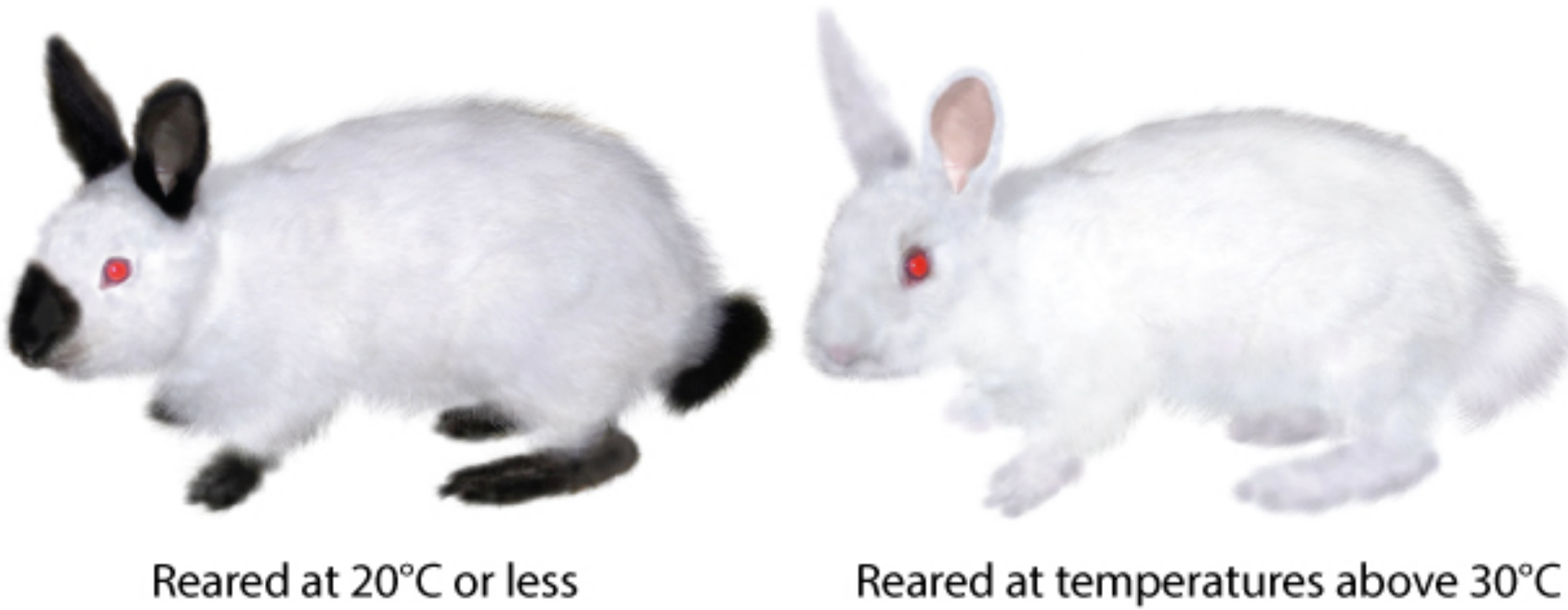


Figure 1 : A pigment gene is influenced by temperature.

Gene C controls fur pigmentation in Himalayan rabbits. Because the gene is active when environmental temperatures are between 15 and 25°C, the rabbit reared at 20°C (left) has pigmentation on its ears, nose, and feet, where its body loses the most heat. The rabbit reared at temperatures above 30°C (right) has no fur pigmentation, because gene C is inactive at these higher temperatures.

Temperature is an external environmental factor that may influence gene expression in certain organisms.

Interestingly, for sea turtles the temperatures at which the eggs are incubated determine whether or not the turtles will be male or female.

Unlike other vertebrates, sea turtles do not have the XX and XY sex determining chromosomes.

Females require a warmer incubation temperature in order to develop compared to male turtles. In one study the temperature needed for male incubation was between 82-88 degrees, however for females the temperature has to be higher than 88 degrees.

pH is an external environmental factor that may influence gene expression in certain organisms.

BLUE HYDRANGEA

To obtain a blue hydrangea, aluminum must be present in the soil. To ensure that aluminum is present, aluminum sulfate may be added to the soil around the hydrangeas.

To make the aluminum **available** to the plant, the pH of the soil should be low (5.2-5.5). Adding aluminum sulfate will tend to lower the pH of the soil. Another method for lowering the pH is to add organic matter to the soil such as coffee grounds, fruit and vegetable peels, grass clippings etc.

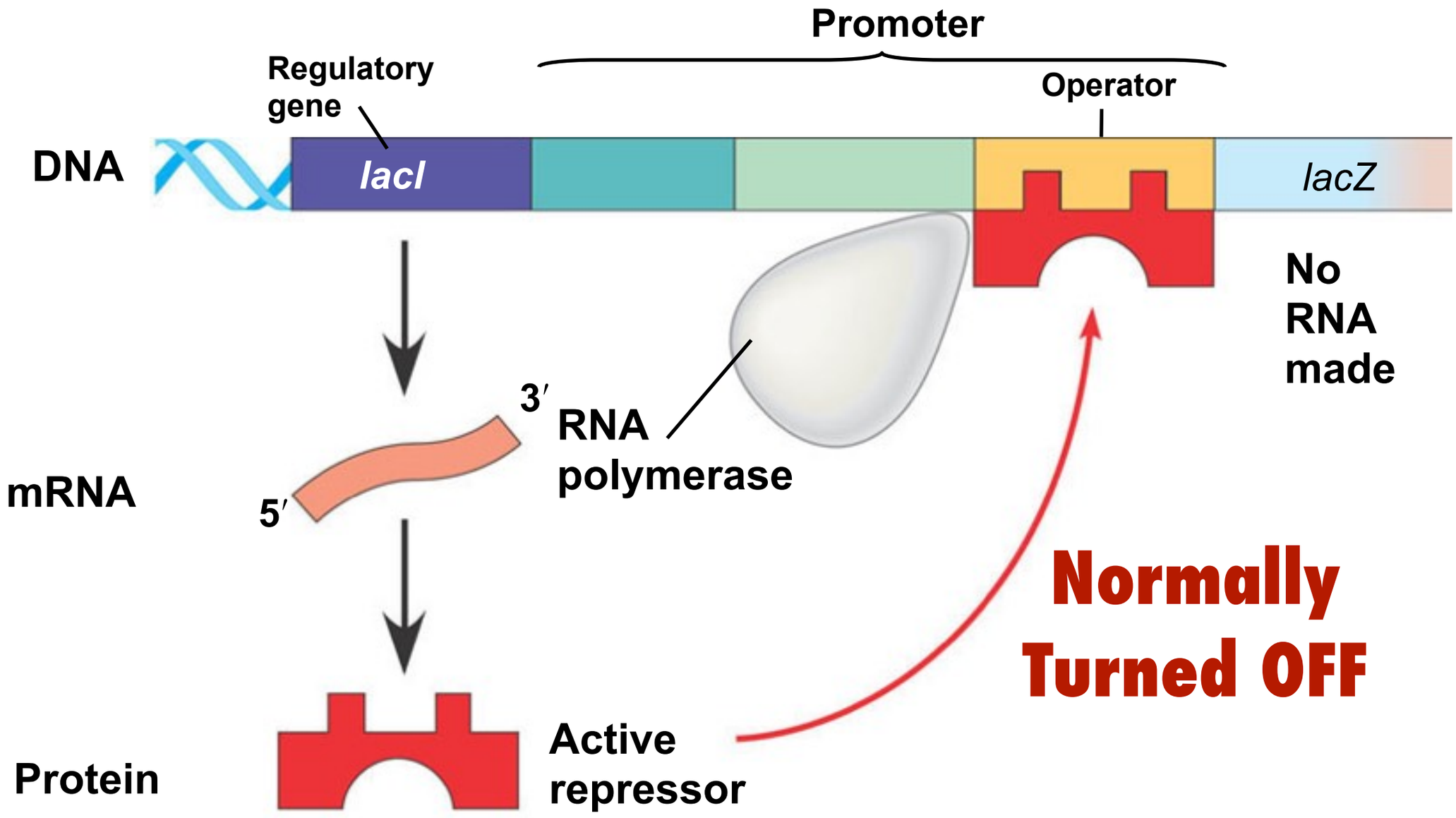
If the soil naturally contains aluminum and is acid (low pH) the color of the hydrangea will automatically tend toward shades of blue and/or purple.

PINK HYDRANGEA

For hydrangea blooms to be pink, the plants must **not** take up aluminum from the soil. If the soil naturally contains aluminum, one must try to keep it away from the hydrangea's system.

This will help to raise the pH. Shoot for a pH of about 6.0 to 6.2 (If it goes above 6.4 hydrangeas may experience an iron deficiency). Since hydrangeas take up aluminum best at lower pH levels, raising the pH will help to keep the bluing effect of aluminum out of the hydrangea's system.

Metabolites are external environmental factors that may influence gene expression in certain organisms.

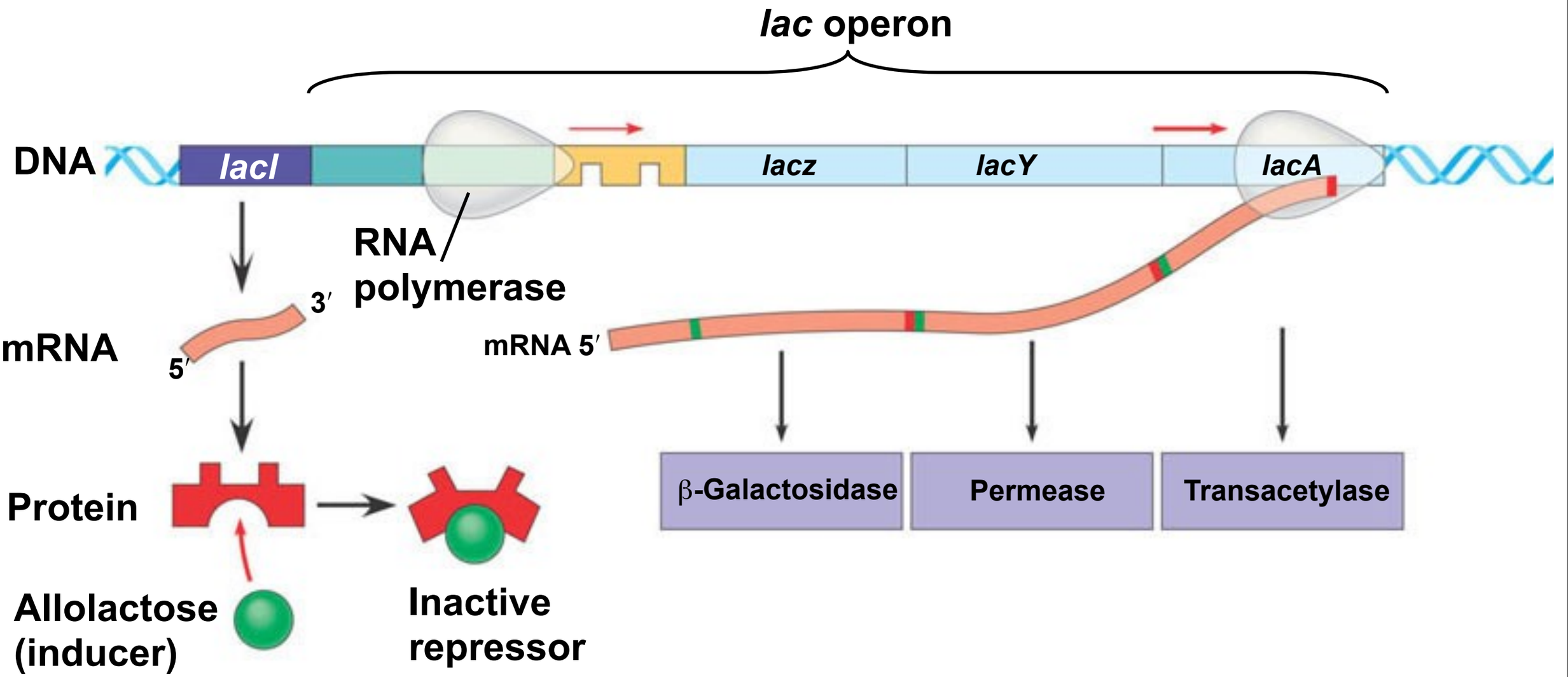


Lactose absent, repressor active, operon off. The *lac* repressor is innately active, and in the absence of lactose it switches off the operon by binding to the operator.

Inducible Operons "turn-on-able"

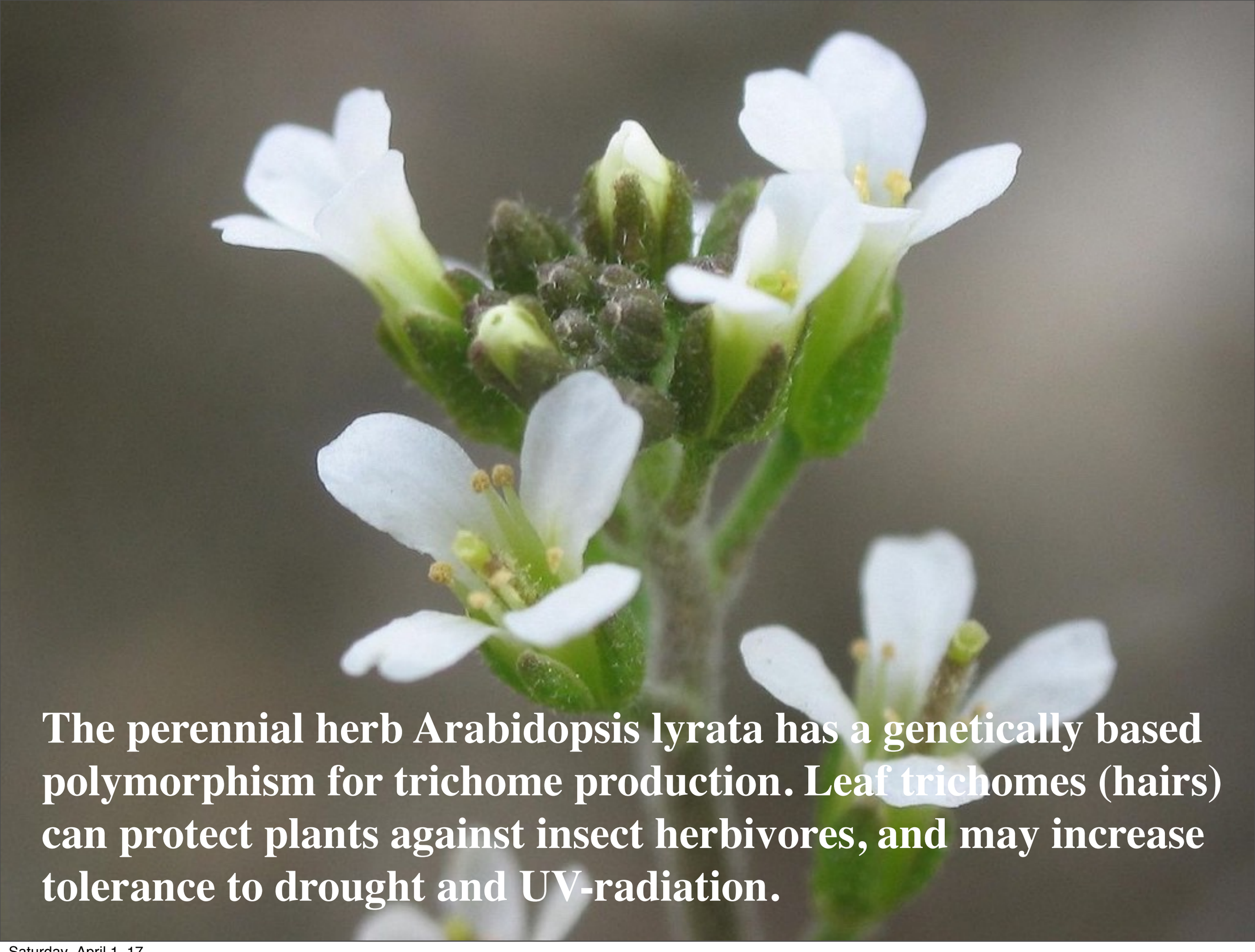
Negative Gene Regulation

Normally Turned OFF



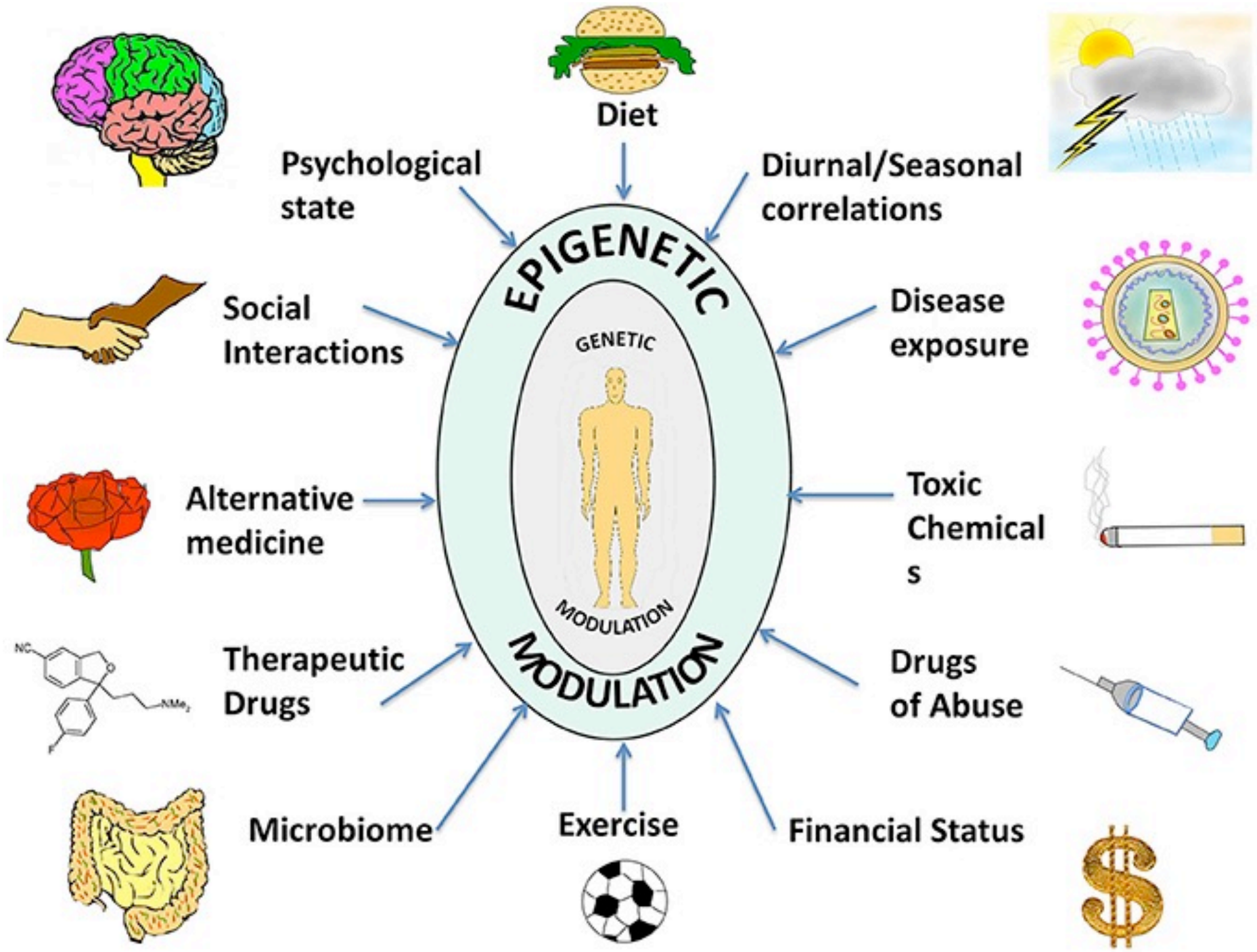
Lactose present, repressor inactive, operon on. Allolactose, an isomer of lactose, derepresses the operon by inactivating the repressor. In this way, the enzymes for lactose utilization are induced.

Herbivory is an external environmental factor that may influence gene expression in certain organisms.



The perennial herb Arabidopsis lyrata has a genetically based polymorphism for trichome production. Leaf trichomes (hairs) can protect plants against insect herbivores, and may increase tolerance to drought and UV-radiation.

In fact there are many external environmental factors that may influence gene expression in certain organisms.



Essential knowledge 4.C.2: Environmental factors influence the expression of the genotype in an organism.

b. An organism's adaptation to the local environment reflects a flexible response of its genome.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Darker fur in cooler regions of the body in certain mammal species

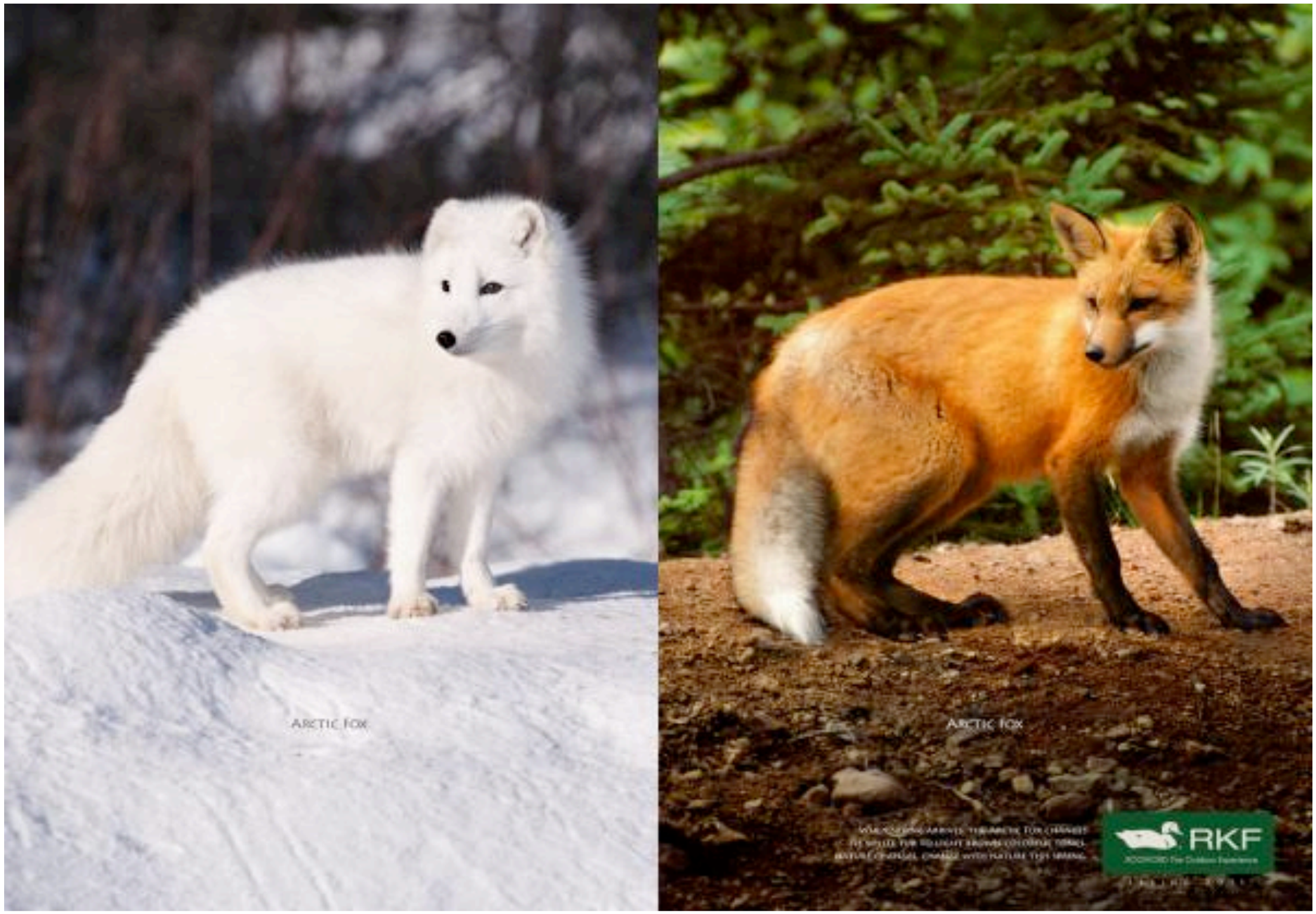
-Alterations in timing of flowering due to climate changes

The most basic form of camouflage is a coloration that matches an animal's surroundings.

Of course, an animal's surroundings may change from time to time. Many animals have developed special adaptations that let them change their coloration as their surroundings change.

One of the biggest shifts in an animal's surroundings occurs with the **changing of the seasons**. In the spring and summer, a mammal's habitat might be full of greens and browns, while in the fall and winter, everything can be covered with snow. While brown coloration is perfect for a summer wooded environment, it makes an animal an easy target against a white background. Many birds and mammals deal with this by producing different colors of fur or feathers depending on the time of year. In most cases, either changing amounts of daylight or shifts in temperature trigger a hormonal reaction in the animal that causes it to produce different biochromes.

As the seasons change, the Arctic fox changes the color of its coat. In the spring and summer, it has a dark coat, to match the brown dirt in its environment. In the fall and winter, it turns white, to match the surrounding snow.



Earliest Blooms Recorded in U.S. Due to Global Warming

In 2010 and 2012, plants in the eastern U.S. produced flowers earlier than at any point in recorded history, a new study says.

Two recent warm spells triggered many spring-flowering plants to blossom up to 4.1 days earlier for every 1 degree Celsius rise in average spring temperatures, which translates to 2.3 days for every 1 degree Fahrenheit.

Many studies have already shown that flowering times have come earlier as a result of recent global warming

Plants need to flower to reproduce. And in order to flower, they need a trigger—which is usually a long winter chill.

The concern is whether plants are "going to be able to adapt fast enough as climate changes radically, [or] is there some physical limit against which you're going to bump up [so] that you can't adapt any longer?"

And…"Across the Pond?"

Bluebells are a classic species of old woodland and are found throughout Britain which is one of its few remaining strongholds in Europe.


Mark Spencer, curator of the British plant collection at the Natural History Museum, said: "February is the earliest we've ever known bluebells to flower. It really is quite extraordinary.


"Combined with changes in the climate, we don't know what is in store in terms of survival for the British bluebell - they may even become seriously threatened as weather patterns change.

Learning Objectives:

LO 4.23 The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism. [See SP 6.2]

LO 4.24 The student is able to predict the effects of a change in an environmental factor on gene expression and the resulting phenotype of an organism. [See SP 6.4]