The following information relates to;

Achievement Objectives

Life Processes, Ecology & Evolution LW 8-1: Understand the relationship between organisms and their environment.

and

Achievement Standard

3.3: Demonstrate understanding of the responses of plants and animals to their external environment.

Honey Bee- Biological Clock

Honey bees and other pollinators have the ability of timing their reproduction to coincide with plant reproduction therefore maximising their ability to collect optimal pollen and nectar for hive storage and feeding honey bee larvae. They are able to do this because of an innate biological clock.

The biological clock is an internal system in the bodies of living creatures that creates circadian rhythms. The critical role of the circadian clock stems from its influence on many processes, such as time of alertness and fatigue, activity rhythms, cyclic changes in body temperature and the secretion of hormones.

Biological clocks have been shown to be a very ancient adaptation. Photosensitive proteins and circadian rhythms are believed to have originated in the earliest cells, with the purpose of protecting the replicating of DNA from high ultraviolet radiation during the daytime. As a result, replication was relegated to the dark. The fungus *Neurospora*, which exists today, retains this clock-regulated mechanism.

Biological clocks allow organisms to anticipate and prepare for precise and regular environmental changes; they have great value in relation to the outside world. The rhythmicity appears to be as important in regulating and coordinating internal metabolic processes, as in coordinating with the environment. This is suggested by the maintenance (heritability) of circadian rhythms in fruit flies after several hundred generations in constant laboratory conditions, as well as in creatures in constant darkness in the wild.

Bees rely on the biological clock for annual timing visits to flowers when nectar and pollen flow is at its highest. They can learn to reach flowers at nine different points of time during the day within an accuracy of about 20 minutes. The clock is also essential for navigation. Bees uses the sun as a compass but the sun appears to move during the day from east to west. Bees account for this apparent movement during navigation.

The central biological clock is located in the tiny brain of the honey bee and is made up of groups of "clock cells," each of which is capable of creating a circadian rhythm independently. These circadian rhythms are generated by complex interactions between "clock genes" that accumulate in the cells and eventually close a cycle of about 24 hours when they shut down their own production.

http://www.nature.com/nature/journal/v443/n7114/full/nature05260.html

http://www.sciencedaily.com/releases/2006/10/061025185102.htm

Sheeba, V.; Sharma, V.K.; Chandrashekaran, M.K.; Joshi, A. (September 1999). "Persistence of eclosion rhythm in Drosophila melanogaster after 600 generations in an aperiodic environment". *Die Naturwissenschaften* **86** (9): 448–9.

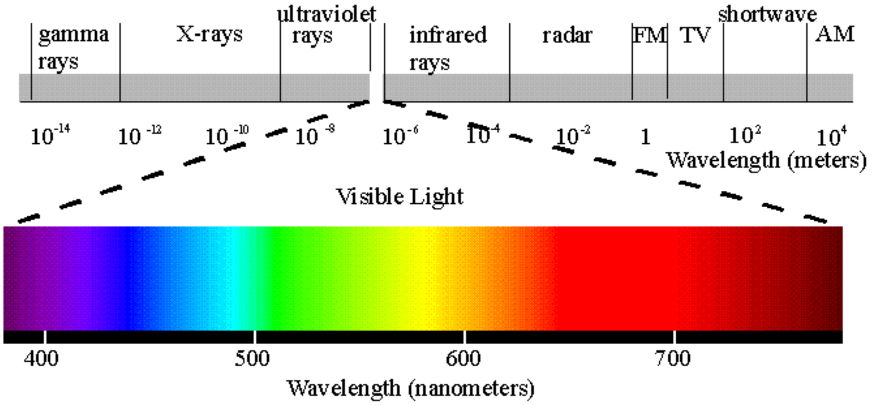
Guyomarc'h, C.; Lumineau, S.; Richard, J.P. (May 1998). "Circadian rhythm of activity in Japanese quail in constant darkness: variability of clarity and possibility of selection". *Chronobiology International* **15** (3): 219–30.

Sharma, V.K. (November 2003). "Adaptive significance of circadian clocks". *Chronobiology International* **20** (6): 901–19

http://en.wikipedia.org/wiki/Circadian_rhythm

Honey Bee Navigation - Polarised Light

Plants produce flowers for reproduction. Unlike humans, who produce phenotypes to attract other humans, plants produce flowers to attract pollinators. However, a flower to a human looks very different to the eyes of a bee. Like us, bees are trichromatic (possess three different types of colour receptors, cone cells in vertebrates). However, humans base colour on red, blue, and green whereas bees base all their colours on ultra-violet (UV), blue and green. Just as colour blind people do not see red or green, and therefore experience the world of colour differently, bees also perceive the world in colours entirely different from humans. Bees do not see red and have a hard time distinguishing it from surrounding green leaf backgrounds. Bees that frequent red flowers either perceive them in colour they can see, or the red flower is not being lost against a green background. Even though bees don't see red, they can see other reddish wavelengths such as orange and yellow.



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Electromagnetic spectrum. Humans can see visible light, 390 to 750 nm whereas honey bees can see wavelengths 300 to 600 nm.

The colours bees see are blue-green, blue, violet, and ultraviolet, with research showing our purple followed by our violet then our blue as their favourites. Mixing ultraviolet wavelengths with the wavelengths of colours they can and can't see, gives bees a world of colour different from our own. If deprived of UV light, bees lose interest in foraging, and remain in the hive until forced out by severe food shortages. This is an example of a physiological adaptation.

Evening primrose (*Oenothera biennis*): To the human eye the flower looks solid yellow but bees can aim for the bullseye in the centre

Wood anemone (*Anemone nemorosa*): Bees are often drawn to darker colours, so this vibrant hue would be instantly attractive and draw them in.

Resources

Richard Hammond series 'Invisible World' shows how honeybees view flowers very well. Below is a clip from the series that could be shown to a class.

http://www.youtube.com/watch?v=zZEoAMfRICM

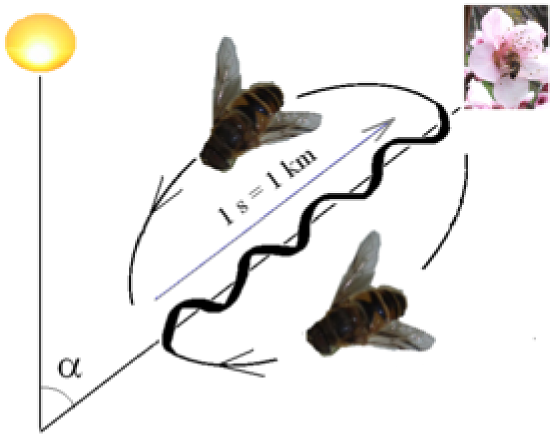
Waggle Dance

Bees are excellent navigators and use the sun as a compass. Its spherical-shaped eyes allow the honeybee to measure angles accurately between the relative positions of the sun, the food source and the hive. These field observations are then interpreted and communicated to other bees inside the hive through a 'dance'. Scout bees can direct their fellow worker bees to the location of a food source, negating the need for each individual to search. Unlike most other insect pollinators, the adaptation of communication has enabled honeybees to utilise floral resources of a large area. As a result, honeybee colonies collect more food than insects that are solitary. Also because bees can see ultra-violet light they are able to detect the sun under cloudy conditions therefore their foraging is not sun dependent.

There are two types of dances, the round dance used for food sources that are close to the hive (within 15m) and the waggle dance used for food sources that are further away. The round dance does not indicate the food source's distance and direction. It does, however, tell the workers that the source is closer than 15 meters from the nest. Having located a food source, the bee first gives nectar to the workers in the nest, and then begins her dance, repeatedly making small circles. The other bees then gather around the dancer. She reverses direction and turns around the other way every one or two revolutions, or even more often. This dance, which can last for a few seconds or up to minutes, consists of up to 20 reversals and is followed by another exchange of nectar between the dancer and the bees in the nest. Eventually the dance comes to an end. The dancing bee flies off to look for another source of food.

The waggle dance consists of one to 100 or more circuits, each of which consists of two phases: the waggle phase and the return phase. A worker bee's waggle dance involves running through a small figure-eight pattern: a waggle run followed by a turn to the right to circle back to the starting point, another waggle run, followed by a turn and circle to the left, and so on in a regular alternation between right and left turns after waggle runs. The direction and duration of waggle runs are closely correlated with the direction and distance of the patch of flowers being advertised by the dancing bee. Flowers located directly in line with the sun are represented by waggle runs in an upward direction on the vertical combs, and any angle to the right or left of the sun is coded by a corresponding angle to the right or left of the upward direction. The distance between hive and recruitment target is encoded in the duration of the waggle runs. The farther the target, the longer the waggle phase, with a rate of increase of about 75 milliseconds per 100 meters.

Waggle dancing bees that have been in the hive for an extended time adjust the angles of their dances to accommodate the changing direction of the sun. Therefore, bees that follow the waggle run of the dance are still correctly led to the food source even though its angle relative to the sun has changed.



The waggle dance - the direction the bee moves in relation to the hive indicates direction; if it moves vertically upwards the direction to the source is directly towards the Sun, the duration of the waggle part of the dance signifies the distance.

Resources

[Bee hive role play activity]

[Role play of waggle dance]

[Where is that flower? Years 10 - 13]

Very good videos clip showing the structure of a hive and waggle dance

http://www.youtube.com/watch?v=46noJXIrdVg

http://www.youtube.com/watch?v=VsCmSWoF8PY&feature=related   shows social aspects

References

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http://nativeplants.msu.edu/about/pollination/

http://westmtnapiary.com/Bees_and_color.html

http://en.wikipedia.org/wiki/Waggle_dance