- environmental factors, such as day length and water availability
- receptors, which allow the plant to detect certain environmental factors
- the genetic makeup of the plant
- hormones, which are chemical messengers.

Specific cells have proteins (receptors) in their plasma membrane, cytoplasm, or nucleus that allow them to receive different environmental stimuli. Upon reception of a certain stimulus, the protein receptor becomes activated, initiating a metabolic pathway. This pathway often results in the production of a hormone (a chemical messenger). These hormones are produced in very small amounts and have effects in many parts of the plant. The hormones move in the plant through the phloem or from cell to cell. Cells on which a hormone has an effect are referred to as target cells.

NATURE OF SCIENCE

In 1880, Charles Darwin and his son Francis carried out some of the first experiments involving plant hormones. They described the effects of light on the movement of canary grass (*Phalaris canariensis*). The Darwins worked with the coleoptiles, the initial section of the stem during germination, of canary grass to find that they could bend the plant towards a unidirectional light source. In 1926, Fritz Went isolated the plant growth substance that the Darwins had been studying all those years before. For his isolation technique, Went used agar blocks. He even indirectly quantified the amount of growth substance in the agar blocks, by measuring actual curvatures of the stems. His results suggested that the curvature of stems was directly proportional to the amount of growth substance in the agar.

However, it is only recently that techniques have been developed to measure the extremely small amounts of the growth substance the Darwins and Went had experimented with. Another recent finding has allowed scientists to determine the effects of plant hormones on gene expression. Because of these developments, scientists are developing methods to provide greater plant growth and food production.

TOK

Research indicates a rather sophisticated communication abillity in plants. They have sophisticated systems for receiving information from their environment. Their responses to the environment increase their chance for survival as an organism and as a species. Do you believe plants possess a 'language' based on the information presented here?

Even though both plant and animal hormones act as chemical messengers in the organism, plant hormones differ from animal hormones in several ways. Plant hormones have varying effects depending on the receptor's location in the plant. In plants, unlike in animals, there is often a great deal of interaction between the different hormones to bring about the most appropriate response. In animals, it is common for one specialized gland or cell to produce a hormone. In plants a hormone may be produced throughout the plant.

The remainder of this section will focus on a group of common plant hormones called auxins.

Auxins and phototropism

Tropisms are generally defined as growth or movement to directional external stimuli. Tropisms may be positive (towards the stimulus) or negative (away from the stimulus). Common stimuli for plant tropisms include chemicals, gravity, touch, and light. Let's consider light as a stimulus. Phototropism means plant growth in response to light. Generally, plant stems exhibit positive phototropism, and plant roots demonstrate negative phototropism (see Figure 9.18). It is easy to demonstrate plant tropisms in the laboratory.

The leaves of plants grown inside will often show movement in the direction of the light they receive. To make sure a house plant maintains a more rounded appearance, it has to be turned regularly. This is an example of positive phototropism.