Biotech In focus

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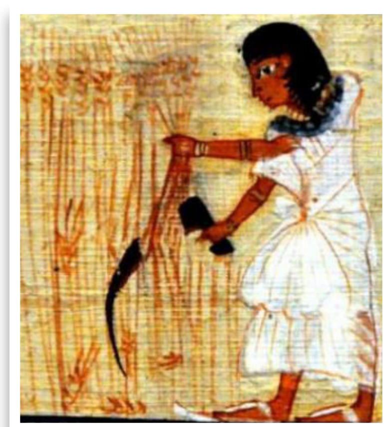
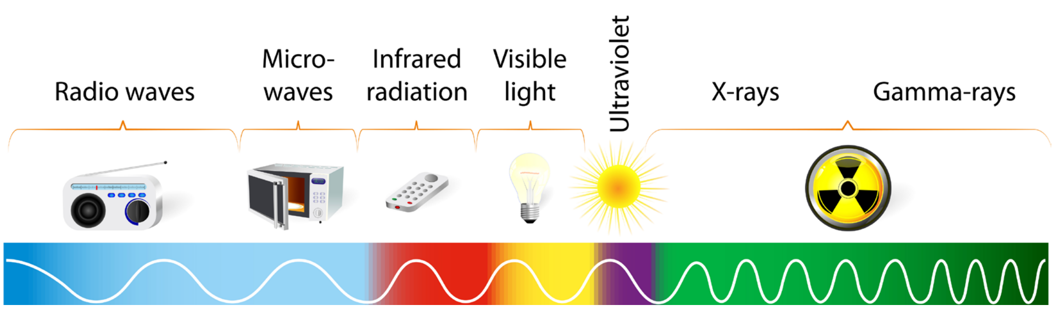
Radiation Mutagenesis: Genetic Engineering Through Energy

This week's Biotech in Focus came from a paper written by Christian Mathias, a University of Hawaii at Manoa student who recently enrolled in TPSS 416 (Introduction to Social, Ethical, and Political Issues Associated with Biotechnology). Designed for non-majors, this class is offered by the Department of Tropical Plant and Soil Sciences in UH Manoa's College of Tropical Agriculture and Human Resources.



Genetic mutations are a driving force in evolution and crop improvement. Since the beginning of agriculture, farmers have selected plants with desirable traits like good flavor, high yield, and hardiness to drought or other environmental factors. Plants with these traits were different because of mutations, which can be defined as sudden changes in genetic material through random changes in DNA. The mutations that shape evolution and plant breeding are passed down from parents to progeny - they are inherited.

Mutations in nature can result from mistakes in cell division or from environmental factors, including high-energy ultraviolet light, which is a form of electromagnetic radiation. Other forms include the infrared light that we perceive as heat, the visible light we can see, x-rays, and gamma rays. The most common methods of mutagenesis that scientists use to cause DNA mutations include exposure to chemical or physical mutagens (mutation-causing agents). Radiation is a prominent physical mutagen.



At the turn of the 20th century, sources of energy that cause mutations were discovered. First, x-rays were identified. Not long after, chemical elements were found that are radioactive, meaning they decay and release energy. Even before DNA was identified as the basic genetic material, researchers used radiation to alter the traits of living organisms, including plants. Since the 1930s, mutagenesis by radiation has been done primarily with gamma rays, which are emitted by some radioactive elements. In the last twenty years, a successful alternative has been used is ion beam radiation, which uses groups of charged particles.

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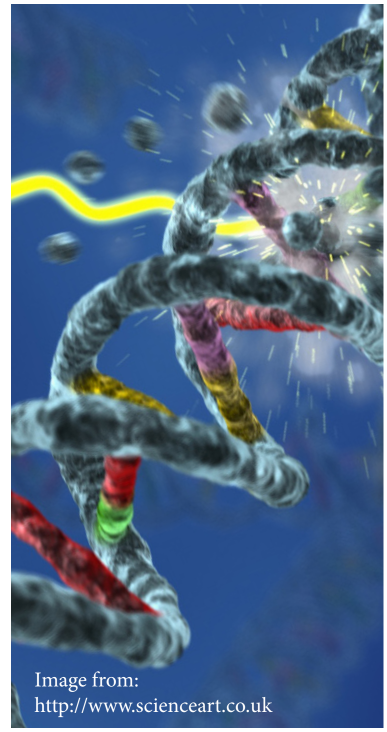
Ionizing Radiation Can Cause Mutation

Atoms, which are the building blocks of all molecules, have three main classes of particles. Protons and neutrons make up the nucleus at the core of the atom, while electrons orbit around the nucleus. Radioactivity results when an unstable nucleus releases energy. When this radiation is absorbed by a molecule, the electrons in the molecule are altered: the energy levels of the electrons may increase (excitation), or the electrons may be knocked off the atoms (ionization). The type of radiation strong enough to eject electrons is called ionizing radiation, because the removal of a negatively charged electron can create an ion, which is an atom or molecule with a non-neutral charge.



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The ions produced by ionizing radiation are highly reactive chemicals that can damage structures within the cell, including DNA. A common cause of mutations from radiation damage is double-strand breaks in the DNA. If you imagine the double helix of DNA untwisted like a ladder, then a double-strand break would be a complete cut through the ladder parallel to the steps. If the cell is able to recover from the damage caused by the reactive ions, it can repair the breaks along the DNA. However, double-strand breaks are difficult to fix and are often improperly repaired. This can result in a different DNA sequence, which by definition is a mutation. Mutagenesis through radiation has produced many crop varieties grown today, including 'Rio Star' grapefruits and 'Golden Promise' barley.

Mutant Grapefruit

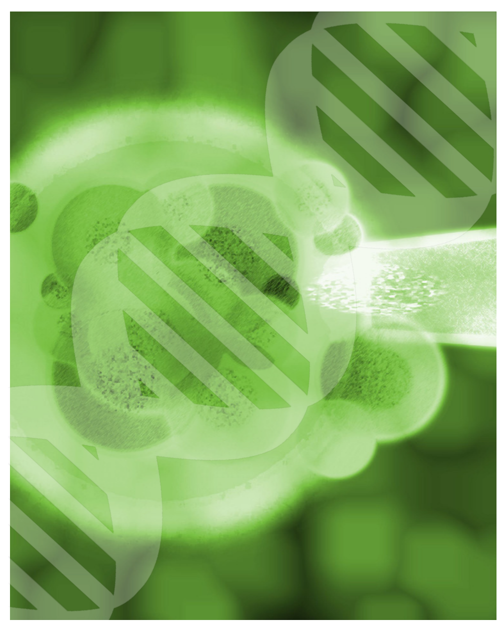
'Rio Star' grapefruits include two seedless, red-fleshed varieties, 'Star Ruby' and 'Rio Red', which were produced using thermal neutron radiation. 'Star Ruby' was generated by irradiating 'Hudson' seeds, and the higher yielding 'Rio Red' resulted from irradiating 'Star Ruby' bud wood. In addition to being seedless, these grapefruits are also altered by mutations that deepen the red pigment and help the flesh retain its color, improving the grapefruit's juice characteristics.

Salt Tolerant Barley

Another crop improved by radiation mutagenesis is 'Golden Promise' barley. Produced from salt-sensitive 'Maythorpe' barley through the use of gamma radiation, the salt-tolerant 'Golden Promise' is valued for its malting characteristics and has been a favorite of brewers since its release in 1967. Salt tolerance allows the crop to grow in unfavorable soils, thus permitting utilization of otherwise marginal agricultural lands.

Future Challenge

Crops like 'Rio Star' and 'Golden Promise' illustrate how useful and varied the results of radiation mutagenesis can be. A future challenge is making radiation mutagenesis more controlled, so that we can target specific genes to generate desirable traits.



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