Building with Biology

Genes and DNA

The building blocks of life

Genes are a set of instructions that give all living organisms the information they need to form and grow. They influence what we look like on the outside and how we work on the inside. Genes are made of a chemical called **DNA** *(deoxyribonucleic acid)*.

DNA molecules are located inside a cell nucleus, tightly wrapped around spool-like proteins known as *chromosomes*. DNA carries information and can make copies of itself. It is made of four *nucleotides*, or chemical bases, called adenine (A), thymine (T), guanine (G) and cytosine (C).

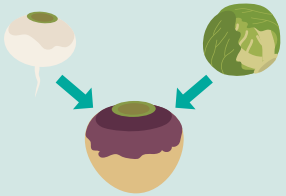
Traditional Agricultural Breeding

Humans have been using **selective breeding** for 10,000 years to improve plants and animals. Farmers choose seeds from plants with the best traits, selecting for traits such as taste, color, disease resistance, and productivity.

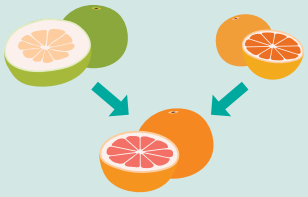
Farmers and scientists have been **cross-breeding** closely related species for hundreds of years to create new hybrids. Cross-breeding can occur only between closely related living organisms. Hybrids inherit a mix of genes from both parent plants, including both positive and negative traits.

EXAMPLES:

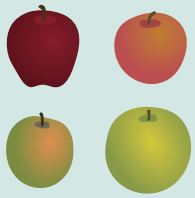
Most modern fruits and vegetables are hybrids of ancient wild plants. Cross-breeding has created many new varieties.



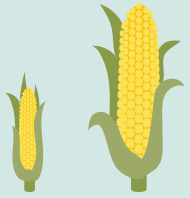
Rutabaga
Cross between
turnips and cabbages



Grapefruit
Cross between
pomelos and oranges



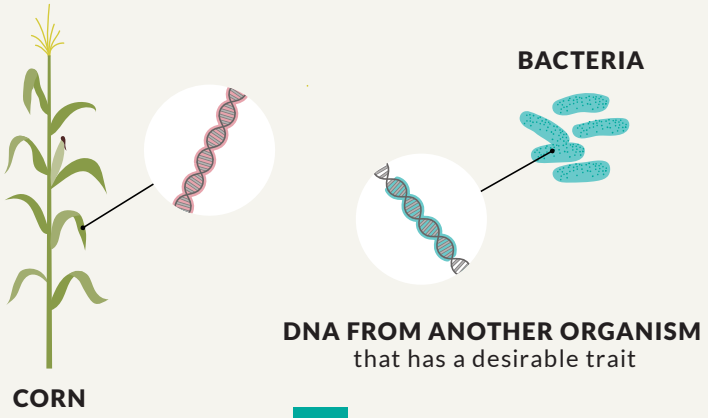
Apples
Many different flavors, colors,
and textures



Corn
Increased size and
productivity

Building with Biology

Genetic Engineering



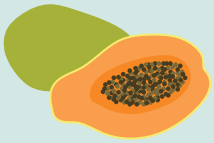
Genetic engineering is a way to speed up and control the plant breeding process by altering or inserting specific genes into a living organism. The DNA does not need to come from a closely related species. Scientists have used genetic engineering to create plants with positive traits such as increased productivity, increased nutritional value, resistance to disease, and resistance to herbicides.

EXAMPLES:

Almost all corn, soybeans, cotton, sugar beets, and canola plants grown in the United States are *genetically modified organisms* (GMOs).

Insect-resistant corn
Includes a gene from soil bacteria that is toxic to some insects

Herbicide-tolerant sugar beets
Genetically modified to tolerate a universal herbicide spray used to kill weeds

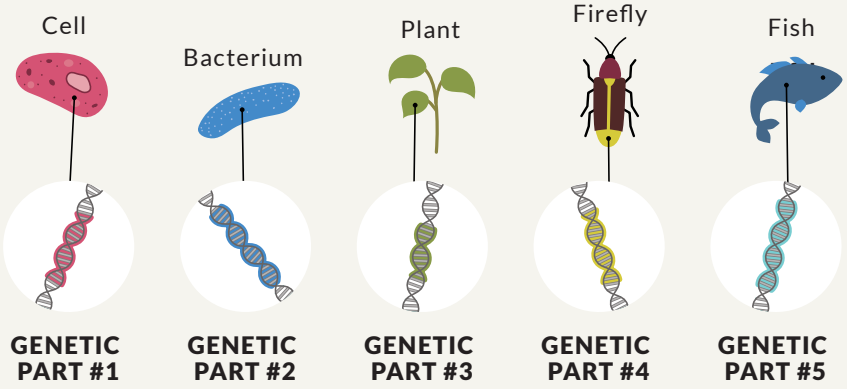


Virus-resistant papaya
Includes a gene fragment from the ringspot virus, making it resistant to that disease

More nutritious rice
Golden rice is genetically modified to include beta-carotene, which your body converts to Vitamin A

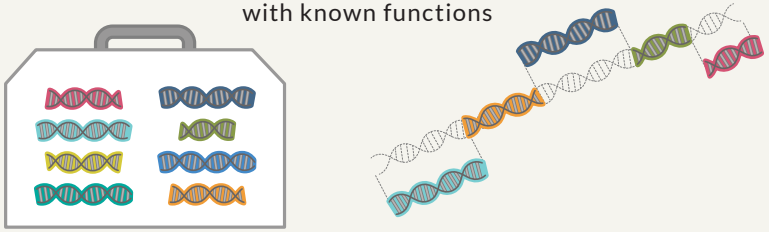
Building with Biology

Synthetic Biology



TOOLKIT OF GENETIC PARTS

Standardized parts with known functions



NEW OR MODIFIED LIVING ORGANISMS AND MATERIALS

Include genetic parts from different organisms

Synthetic biology combines tools and knowledge from biology and engineering to build new living organisms and materials. Scientists are developing a library of standardized biological parts with known functions, which can be mixed and matched to create new or modified living organisms. With synthetic biology, modified bacteria, algae, and yeast cells can be programmed to become tiny factories that produce new materials.

EXAMPLES:

Synthetic biology may provide solutions to problems in areas such as food security, healthcare, energy, and the environment.

Antimalarial drug

A key ingredient can be grown from modified yeast

Glowing plant

Glow-in-the-dark plants can be made using an enzyme from fireflies

More sustainable detergents

Ingredients can be grown from modified algae

Food flavoring

Synthetic vanilla can be grown from modified yeast

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