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WHAT IS A FRUIT?

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YOUNG REVIEWERS:


LILU
AGE: 10


NIKO
AGE: 6

If you have ever been inside a grocery store, you have probably noticed the produce section. Mountains of lemons, piles of tomatoes, rows of cucumbers, several kinds of apples, and more. Some of these items you might know as fruits, and others as vegetables. But what is the difference between a fruit and a vegetable? When you eat an apple, strawberry, or peach, what part of the plant are you eating? This article explores our knowledge of fruits and how to properly identify them.

FRUIT DEVELOPMENT

Flowering plants are all around us: they line our streets, fill our gardens, and decorate our homes. In fact, flowering plants are currently the most diverse plant group on Earth. Many familiar trees, such as oaks and maples, are flowering plants. Flowers are not only beautiful and attractive to insects and humans, but they are also vital to the plant life cycle. Flowers hold the reproductive organs of the plant, which are

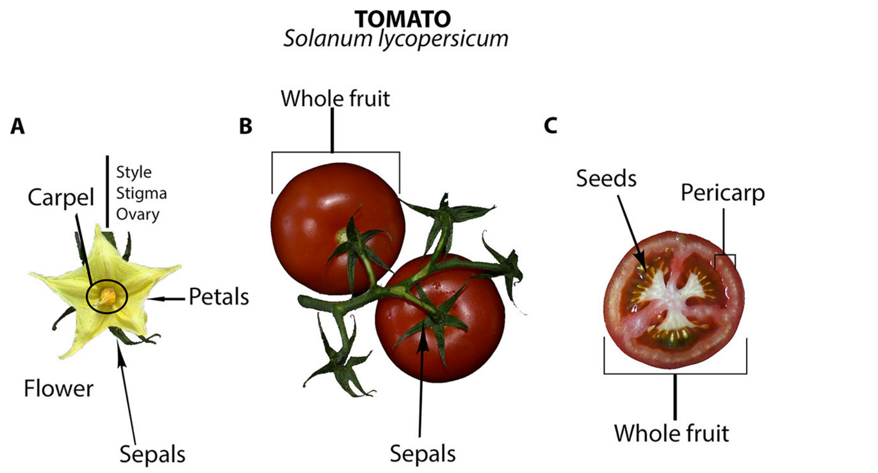

Figure 1

Figure 1

Photographs of *Solanum lycopersicum* (Solanaceae), tomato. **(A)** Tomato plant flower, with green sepals, yellow petals and yellow carpel in the center, encircled in black (Photo: Dr. Mac Alford; http://www.plantsystematics.org/). **(B)** Tomato fruit, with green sepals still attached. **(C)** Cross-section of a tomato fruit. The layers of the fruit (pericarp) and the seeds are shown.

CARPEL

Reproductive organ of a flower, which includes the ovary, stigma, and style. After fertilization, the carpel becomes the fruit.

known together as the stamen and **carpel**. The carpel is in the center of the flower and is composed of three parts, called the ovary, style, and stigma; these parts can all play a role in the development of a fruit (Figure 1A). Inside the ovary are ovules, or immature seeds. The carpel is therefore a protective cover, creating an optimal environment for the ovules to transform into seeds. In order to develop into a fruit, the carpel must first receive pollen grains successfully. After this, the carpel is fertilized, and fruit development can begin. The outer parts of the flower, the sepals and petals, are sterile and are usually bright and colorful to attract pollinators, which helps to assure fertilization.

Fruits are the mature and ripened ovaries of flowers [1]. The first step in fruit growth is fertilization of the carpel. Then, a fruit arises from a series of transformations that occur during the development of the fertilized carpel, resulting in the ovary of the flower maturing and ripening. Throughout this process, the cells in the carpel of the flower change so that the structural layers become the fruit [1] (Figure 1).

THE ROLE OF FRUITS

One of the main functions of a fruit is to spread the seeds and allow the plant to reproduce. Therefore, all flowering plants produce fruit, regardless of whether the fruit is edible, sweet, or soft. This means that, although we call peppers and cucumbers vegetables, they are technically fruits (Figure 2). Acorns, maple keys, and the outside of sunflower seeds are also considered fruits. They too develop from a series of transformations of the carpel, and protect, store, and help to scatter the seeds of a flowering plant.

TYPES OF FRUITS

Every single fruit, regardless of whether it looks like the kind of fruit we are used to seeing in the produce section, has three distinct

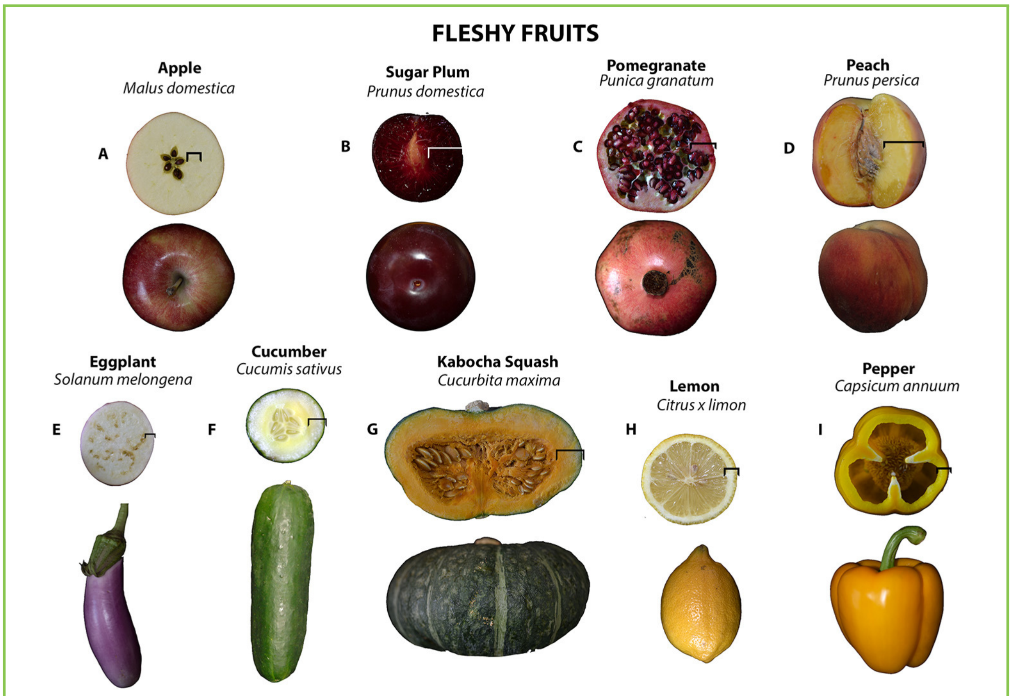

Figure 2

Figure 2

Selected fleshy fruits, along with their Latin names: **(A)** apple; **(B)** sugar plum; **(C)** pomegranate; **(D)** peach; **(E)** eggplant; **(F)** cucumber; **(G)** kabocha squash; **(H)** lemon; and **(I)** pepper. The pericarp of fleshy fruits is shown on each fruit with a bracket.

EXOCARP

Outermost layer of the fruit. Usually in direct contact with the environment, provides the texture of the fruit.

MESOCARP

Middle layer of the fruit, in between the exocarp and the endocarp. It becomes fleshy in fleshy fruits and is thicker in fleshy fruits compared with dry fruits.

ENDOCARP

Innermost layer of the pericarp, in direct contact with the placenta (from where the seeds form). It can be either hard (like in a stone fruit like a peach), membranous, or fleshy in some fleshy fruits (like the tomato).

PERICARP

The part of the fruit that surrounds the seed(s). The pericarp is formed by three distinct layers: exocarp, mesocarp, and endocarp.

DEHISCENCE

Splitting open at maturity in order to release its contents (example: the fruit splits to release the seeds).

layers—the **exocarp** (outside), **mesocarp** (middle), and **endocarp** (inside). Together, these layers form the **pericarp** [1]. Although these layers are sometimes hard to tell apart, they can be identified within most fruits you eat. Fruits are usually classified based on tissue types, texture, shape, **dehiscence** (when the fruit splits open as a stage of development, like peas), and other morphological characteristics. Fruits can be divided into two main categories: fleshy fruits and dry fruits [1, 2].

FLESHY FRUITS

Fleshy fruits have high water content in the pericarp, and a fleshy mesocarp once they are mature. This means that fleshy fruits are juicier than dry fruits. The group of fleshy fruits includes many of the fruits that you may find in the grocery store, and many sweet fruits, such as peaches and apples. Pomegranates, although we eat the seed and not the fruit, also fall under this category, because their pericarp is soft and fleshy. Avocados, peaches, plums, and other fruits with pits are also fleshy fruits, because they have a thick and fleshy mesocarp (Figure 2). Peppers, cucumbers, and tomatoes are also examples of fleshy fruits, even though they are usually referred to as vegetables (Figure 2). In fact, most edible fruits fall into the category of fleshy fruits. These fruits use animals, such as birds or humans, to disperse the seeds.

DRY FRUITS

Dry fruits are hard and dry when they are fully mature (Figures 3A–C). The pericarp of dry fruits still has three layers—exocarp, mesocarp, and

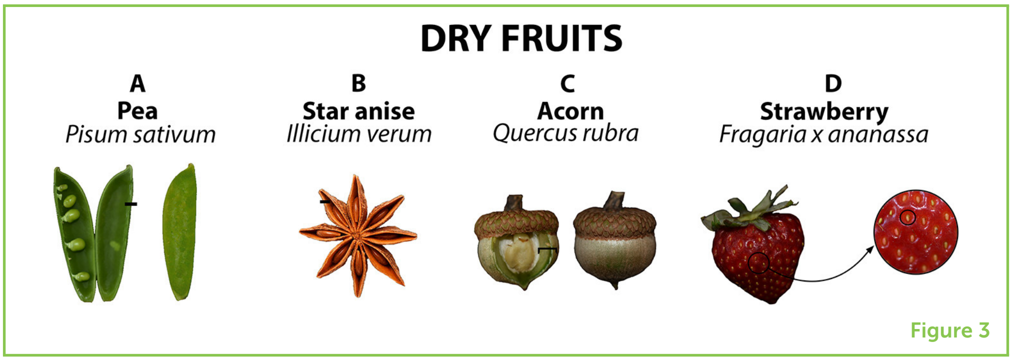

Figure 3

Selected dry fruits, along with their Latin names: **(A)** pea; **(B)** star anise; **(C)** acorn; and **(D)** strawberry. The dry fruit, also known as "achene," of the strawberry is circled in black. The pericarp of each dry fruit is shown with a bracket.

endocarp—but compared with fleshy fruits, they are thinner and do not have as much water. Sometimes the pericarp is in direct contact with the seed, making it hard to tell the fruit apart from the seed. Most dry fruits do not depend on animals to spread their seeds. Instead, they use other mechanisms, such as dehiscence (Figures 3A,B) to free the seeds, or using water or the wind to blow their seeds away (think of dandelions: the slightest wind will send the fruits, equipped with parachute-like hairs, flying away).

A strawberry is an example of a dry fruit. If you look closely at a strawberry, you will notice specks on the outside (Figure 3D). Each of those specks is a dry fruit, called an achene; the sweet, red flesh of the strawberry is not actually part of the fruit. It is part of the flower that becomes fleshy and edible. Some other examples of dry fruits are corn and pistachios.

SIMPLE, AGGREGATE, AND MULTIPLE FRUITS

In addition to "dry" and "fleshy," fruits can be further described by their structures: simple, aggregate, or multiple. A simple fruit develops from one single ovary, such as a peach or a tomato (Figure 2D). An aggregate fruit forms from multiple ovaries in a single flower. Strawberries and blackberries are examples of aggregate fruits (Figure 3D). Lastly, a multiple fruit develops from multiple ovaries of multiple flowers. Pineapples are a good example of aggregate fruits.

VEGETABLES

Fruits are not the only parts of the plants that we eat. The term vegetable can be used to refer to other edible parts of the plant—leaves, stems, shoots, and roots. A carrot, for example, is a vegetable, because the part of the plant that we eat is the root. Broccoli is made of multiple floral buds, and is also traditionally known as a vegetable. Spinach is a vegetable, because it is a leaf.

THE SEEDLESS FRUIT PROBLEM

If a fruit's purpose is to house and disperse seeds, then why do we call seedless fruits like grapes, oranges, and watermelons fruits? Although they do not contain seeds, these structures are still considered fruits, because they develop from the carpel of the flower through a series of transformations. Seedless fruit can come about due to a process called parthenocarpy, in which fruits are still produced, even without successful fertilization [3].

Some plants have mechanisms in place so that fertilization by their own pollen, or pollen from an extremely similar plant, results in unsuccessful fertilization. This is called self-incompatibility, meaning the plant cannot properly fertilize its flower to create seeds with its own pollen. This allows for fruit development, but without seeds. This is how navel oranges are grown to be naturally seedless [3].

Another example of a seedless fruit is a banana. Like humans, plants have genes located in structures called chromosomes. Humans have two sets of chromosomes—we get one set from each parent. Many plants follow this pattern, but bananas are different: they have an odd number (3 to be precise) of chromosomes which makes them unable to produce functional seeds, and therefore after many years of evolution bananas do not have seeds. Instead, bananas have to be grown by planting a piece of an already existing plant to make a new one [3]. Next time you eat a banana, look for the brown dots in the center which are the remnants of the seed.

TRY IT YOURSELF!

Fruits are all around us, sometimes requiring close observation in order to be discovered. The next time you are eating a salad, look a little bit closer to see which fruits are in the bowl. The next time you hold a strawberry, feel the outside, and see if you can count how many fruits you are about to eat! The next time you go outside, open a maple key and find the seed. When spring comes, check out a flower in your backyard, on your street, or in a park, to see if you can find the carpel. And lastly, the next time someone tells you to eat your vegetables, politely correct them, and tell them you will be happy to eat all of your fruits!

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YOUNG REVIEWERS

LILU, AGE: 10
I love polar bears and I am fighting against Climate Change to save them! I love guinea pigs too.

NIKO, AGE: 6
I love Pokemon and soccer. I love writing about animals. My favorite books are about dinosaurs and predators.

AUTHORS

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I am an undergraduate student at Brandeis University studying biology and environmental studies. I have always been interested in living organisms and their interactions with the environment, but recently have been focused on plant systems. I am interested in plant evolution, structure, and plant interactions in a changing environment. I love sharing information with others about plant biology, and I hope to continue this area study after my graduation this year.

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I am interested in the genetic processes involved in the evolution and development of carpels and fruits across seed plants. I obtained my bachelor's degree at the Universidad de Antioquia in the Pabón-Mora's lab, looking at genes involved in fruit development across flowering plants. I am currently a Ph.D. candidate at the New York Botanical Garden and the City University of New York in Ambrose's lab, mainly working in seed evolution and development in seed plants, in order to better understand the genetic processes underlying the enormous diversity of seeds.

BARBARA AMBROSE

I am the Director of Laboratory Research and Associate Curator of Plant Genomics at the New York Botanical Garden. My main research interest is in understanding the genetic network that underlies the enormous diversity of plants. My work includes investigations of the development of plant forms using scanning electron microscopy and examining the structure of plant tissues, as well investigations of gene function in development. Although I investigate the evolutionary genetics of flowers and fruits, most of my current research is focused on the evolution and development of plants known as lycophytes, and ferns. *bambrose@nybg.org