About The Apple – *Malus domestica*
Compiled by Loyd Collett
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**TAXONOMY**

The cultivated apple, *Malus domestica*, belongs to the Rosaceae (Rose) Family, and the subfamily of Pomoideae; along with pear, quince, loquat and medlar.

Throughout its history of cultivation, at least 10,000 apple cultivars were developed, many of which are now lost. This was due in part to the older practice of seed propagation. Commercially there are about 100 cultivars currently being grown commercially, but only 10 of the most popular make up over 90% of US production.

**HISTORY**

It is generally believed that the edible apple originated somewhere in Central Asia. There are many other wild species of Malus, and it is generally assumed that *M. domestica* evolved from chance hybridization among these wild species. The seeds of these early fruits would likely have been spread by animal and birds. The many native herbivores may have gorged themselves on the apple fruits, selecting those trees producing larger, sweeter, and juicer fruit. They therefore selectively spread seeds from better tasting fruit, aiding the evolution of these features. Selected in this way, the apple gradually changed from a bird’s food with edible seeds to a larger Mammal’s food with poisonous (cyanide-containing) seeds.

Apples were probably improved through selection over a period of thousands of years by early farmers. Historians have documented the presence of editable apples as early as 6,500 B.C. when the remains of apples were found among excavations at Jericho in the Jordan Valley and dated to this time period. Many other accounts have been recorded, but in 323 B.C. Theophrastus described six varieties of apples and discussed why budding, grafting, and general tree care are required for optimum production, and stated that seeds almost always produces trees of inferior quality fruit. The excellent keeping qualities of apples were discovered by at least 100 B.C., as the Roman Varro provided written accounts of “fruit houses” for storing apples for winter. Apples were brought to North America with the colonists in the 1600’s, and the first apple orchard on this continent was said to be near Boston in 1625. From these New England origins, apples moved west with the pioneers. In 1790, Thomas Andrew Knight of England begins first controlled apple hybridization program for apple improvement. It was 1904 when J.T. Stinson in an address to the St. Louis Exposition, proclaimed, „An apple a day keeps the doctor away”.

Perdue and the University of Illinois jointly initiated an apple breeding program in 1945 to produce high quality disease resistant apples. One of the best ways to cope with diseases and pests is to select or breed for genetic resistance.

Early Americans prized the apple for cider. The standard recipe for cider: One apple type for TARTNESS, one for FLAVOR, and one for AROMA. You have all heard of John Chapman (Johnny Appleseed) who developed small apple orchards from his birthplace in Massachusetts to Indiana, where he died in 1845. He was a preacher with a love of God and Apples (presumably in that order).

Then there was Sir Iisac Newton who contemplated his thoughts about gravity as he set out in his orchard and watched an apple fall. Recently, I read that live tissue from that same orchard has been rescued and grafted onto healthy rootstock in Tennessee.
The first apple seeds in the Oregon Territory were planted at Vancouver in 1825. And today you can purchase a grafted tree from this ‘Vancouver Apple,’ the oldest in Oregon. Lewelling and Meek brought apple seedlings over the Oregon Trail and established the first Oregon Fruit Nursery at Milwaukee in 1848.

FOLKLORE

There are many myths and legends associated with the apple. Apples were frequently used in Greek, Russian, Norse, and other mythologies as symbols of immortality or reincarnation. One of the most popular stories pertaining to apples is that of Adam and Eve, who ate the ‘forbidden fruit’ of the tree of good and evil in the center of the garden of Eden. Actually the account given in Genesis 2 and 3 never mentions what kind of fruit this tree produced, but numerous works of art commonly depict it as an apple. The Latin noun Malus has the dual meaning of either apple or evil, which probably stems from this bible story. Apples are also symbolic of temptation.

In Greek mythology, Gaia, or Mother Earth, presented a tree with golden apples to Zeus and his bride Hera on their wedding day. These golden apples became involved with many tales of love, bribery and temptation, ranging from the abduction of Helen of Troy to the defeat and marriage of Atlanta. The sexual and romantic connotations of the apple were powerful reasons why apples came as a desert at the end of the meal. They not only tasted heavenly and were good for digestion, but were regarded as a cunning transitional aphrodisiac for the pleasures that followed. Is it any wonder that apples became the most sought after fruit on earth?

The Roman Horace, in 100 B.C., noted that Italy had become one big fruit orchard and the perfect meal began with eggs and ended with apples. The Romans even created a deity of the fruit trees: the goddess Pomona. Many cultures since, have responded to the basic human longing for a time and place where men and women could be free from the battle with nature for food and shelter. This place was symbolized by a garden of paradise and pleasure, complete with fruit-laden apple trees.

MEDICINAL PROPERTIES

As recently discovered in many fruit crops, flavonoids may play an important role in preventing many kinds of cancer, and may also reduce the risk of heart disease and stroke. Eating 2 apples or drinking 12 ounces of apple juice daily was shown to reduce build-up of arterial plaque.

The old adage, “An apple a day keeps the doctor away” now has some science backing. Primary nutritional benefit is in the pectin and fiber. The average apple contains about 5 grams of fiber -- as much as a bowl of oatmeal or other cereal. High potassium, low sodium, and zero fat also promote health.

Studies show that regular eating of apples helps control headaches and nervous tension; with fewer colds and upper respiratory ailments. The mild nature and low acid content of apples are more readily accepted and digested by infants, and causes less colic and rashes. Some advocates will even claim that a fresh apple is nature’s own tooth brush. The fibrous texture won’t stick to the teeth, and their mouth-watering appeal accelerates salivary action – nature’s aid for cleaning teeth.

On the darker side, the seeds of apple and pear contain a mild hydrocyanic acid that will inhibit respiration in humans, resulting in spasms, coma, difficult breathing, and ultimate death. It is said that a man who ate a cup of apple seeds died.
BOTANICAL DESCRIPTION

Plant – The small to medium sized tree develops a spreading canopy, to 30 feet in the wild, generally 6-15 feet in cultivation. Tree size and shape is heavily dependent on rootstock and training system used and consistent pruning. Leaves are elliptical with serrate margins, dark green with light pubescence on underside.

Flowers – Petals are white when open, but have red-pink undersides when opening, hence the “pink” bloom stage. The ovary is inferior, embedded in the floral cup. It contains 5 cavities, usually with 2 seeds. The inflorescence is a cyme (cluster) of 4-8 flowers, with the center flower opening first. The central flower is often called the “King blossom”, and has the potential to produce a larger fruit than the other flowers. Flowers are produced terminally from mixed buds (containing both leaves and flowers) and on spurs. Spurs form on 2-year-old and older wood on some cultivars, and generally grow only a fraction of an inch each year. Initiation of floral buds (fruit producing) occurs during the summer before blossom period.

Pollination – Most cultivars are self-unfruitful. Cross-incompatibility is rare, so most cultivars that bloom at the same time will serve as pollinizers, including crab apples. A few cultivars are pollen-sterile. Honey bees and Mason bees are the most effective pollinators.

Fruit-- A special fruit type is given to the apple and related fruits – the *pome*. The bulk of the fleshy edible portion derives from the floral cup, not the ovary as in most other fruit. The apple contains 5 seed cavities with generally 2 seeds each with complete pollination. Seeds are relatively small and black, and mildly poisonous. Fruiting usually starts 3-5 years after grafting.

Most apples reach maturity about 120-150 days after bloom, with a few cultivars maturing in as short as 70 days, and others as long as 180.

GENERAL CULTURAL

Soils and Climate – Deep, well-drained, loamy soils with pH 6-7 are best, but apples are grown on a wide variety of soils worldwide.

Apples are adaptable to various climates, but can be considered best adapted to the cool temperate zone from about 35-50 degrees latitude. They have a more northern range than many other tree fruits due to relative late blooming and extreme cold hardiness. Generally, fruit quality is best in temperate climates with high light intensity, with warm (not hot) days and cool nights. This accounts for the success of apple culture in eastern Washington State and Oregon’s Hood River Valley, which have a cool, desert-like climate.

Apples require about 1000-1600 hours of chill time, between 32 and 45 degrees F, to break dormancy. In growing areas where winters fluctuate between cold and mild temperatures, fruit species have developed with long chilling requirements so they will not begin to grow in midwinter even tough it may warm up to growing temperatures for several days.

In the Pacific Northwest, late winter weather in January-February is often interrupted by what we sometimes call “Chinook Winds.” Suddenly, as if by the breath of inspiration, the fog parts, the peaks of the mountains may be seen half stripped of snow, and then, roaring and whistling, the warm south wind comes like an army. The snow begins to drip like a pressed sponge, the thermometer goes with a jump to sixty, and within two hours we find ourselves in the climate of Southern California. What can happen next is bad news and likely a crop failure of some of our introduced low chill tree fruit varieties (plums, peaches, even early flowering apples and pears). If their winter chill requirement has been met before the warm winds arrive, they respond quickly and enter full bloom. With several weeks of possible cold wet weather to follow, pollination and fruit set is unsuccessful. Sometimes the early tender leaves and shoots may even die and abort. This crop failure is especially troublesome in the coastal zones of Oregon and
Washington where the climate is already moderated by the Japanese Current and nearby warm ocean waters.

The wood and buds of dormant trees are hardy to -40°F, but open flowers and young fruitlets are killed by brief exposure at 28°F or less. Apples are among the latest blooming tree fruits, and are therefore less frost prone than other species at any given location.

Many of our cultivated plants have been moved from the climate in which they evolved. Thus, many domestic forms are not completely adapted to the environment in which they are cultivated. Cultural practices then become important in augmenting the natural ability of species to survive in cold winters. These factors include manipulation of water and fertilizers to prevent late-season growth and the choice of variety and rootstock can also be important.

In good soil, apple roots will normally spread 2 to 3 times as far as the top. Downward growth of roots will stop at a permanent water table or at an impervious layer of subsoil or rock. Roots may grow in the winter. Unlike tops, roots have no distinct period of dormancy and are able to grow whenever temperature, soil moisture and other conditions are favorable. Because of this, fall planting of young fruit trees in Western Oregon can be an advantage by gaining a year’s growth.

**Early Development and Variety Selection** -- Most of the genetic diversity of temperate fruit and nut crops is found in related wild species, growing mostly between 30° and 50° latitude. Exceptions are found in lower latitudes at higher elevations and higher latitudes near large bodies of water. Of the more than 2400 species of fruit and nuts, about 80 have been domesticated. Many of the wild forms were used by people for thousands of years before the first species was cultivated.

First immigrants to the new world brought seeds – hence our first fruits were from seedlings. From these seedlings a large explosion of named varieties were established. Variety selection was perhaps the first step in domesticating fruit species. Selection of clones has always been based on specific genetic traits (flavor, size, time of ripening, storage life, adaptation to climate and soil, or resistance to pests and diseases). Selection criteria have differed for each area of the world, based on local tastes and critical limiting factors. Thus, early farmers used sound selection practices centuries before genetic or plant breeding principles were known. Wild edible species were gathered, and the best ones ultimately brought to cultivation.

Fruit breeding by controlled cross-pollination of selected parents was not done to any degree until the 19th century. Even though a great many breeding programs were carried out during the 20th century, the new varieties of some fruits, such as apple and pear, have not replaced many of the grand oldies like – Golden Delicious, Delicious, Cox, Granny Smith, Rome Beauty, Jonathan, Yellow Transparent, Gravenstein, McIntosh, and others – all chance seedlings, selected more that 100 years ago.

Scientific fruit culture in general has largely developed since the mid-19th century, and at an accelerated pace in the past 70 years. Not only does it involve new knowledge in the physiology of plant growth and development, but also the use of disease and insect control, soil moisture dynamics, and soil chemistry and its relation to essential mineral uptake. Further, it involves rootstocks suited to specific soil conditions and to the desired tree size. The great diversity of climatic adaptation has made apples the most widely planted tree fruit of the temperate climatic zone.

Fruit breeding will play an increasing role in the 21st century. Introduction of superior varieties for specific sites and purposes will be aided by an increased knowledge of genetics, by better techniques for including mutations and for combining genes in tissue culture, and by direct gene transfer through genetic engineering. Special rootstock clones also will be developed using
these same advanced technologies. When we study apple pedigrees today we discover many hybrid crosses utilizing: Delicious, Golden Delicious, Jonathan, and Cox’s Orange Pippin.

**Propagation** – Today all apple trees are propagated by grafting because they do not grow true to seed and it is difficult or impossible to either layer or root from cuttings. In order to maintain a high-quality line of fruit trees, cuttings (scions) must be made from a successful tree and grafted on established and healthy roots.

Success in making a permanent graft union between plants or plant parts depends upon compatibility and cambial contact. It is critical that the cambium (the thin layer of cells between the outer sapwood and the inner bark) layers of both the scion and rootstock make contact and that they are held there with an air-tight seal until healing is complete. The rate of healing (callusing) varies with air temperature and plant species.

The practice of grafting is an ancient one. Theophrastus, the Greek plantsman credited as the founder of botany who died ca. 288 BC, described the joining of a root and branch, and catalogued the feasible combinations of fruit trees.

Grafting, a form of surgery, and is that part of horticulture that brings us closest to the realization that plants and animals are much alike. The grafter works with living tissue, and works quickly, because plant parts perish in the same manner, and with nearly the same speed, as their animal counterparts. And a reasonable degree of precision is required. Although it is not necessary to match nerve with nerve, the grafter must match cambium with cambium. Foreign body rejection is likewise found among plants, and the rootstock’s first response can be to expel the alien tissue and then close the wound. Infection with fungi, bacteria and viruses are also possible hazards. Therefore, clean tools, hygienic surroundings and healthy plant parts are all necessary for success.

There are several methods used in grafting woody plants. The four most frequently used grafting methods for apples, pears and stone fruits are (1) Whip-and-Tongue Grafting, (2) Cleft Grafting, (3) Bark Grafting and (4) Budding.

Commercially, apples are T-budded or chip-budded in the nursery, and sold as 1-year-old whips on 1.5 to 2-year-old rootstocks. Rootstocks are also produced vegetatively, generally by mound layerage. Young apple trees are more expensive than other species due to the use of clonal rootstock and the extra time required producing trees. Seedling rootstocks are still used in some of the extreme cold regions, and in countries where non-intensive orchards exist.

**Rootstocks** – One of the best ways to cope with diseases and pests is to select or breed for genetic resistance. Hundreds of years of selection and decades of research have led to more rootstock choices for apple than practically all other major temperate tree fruits combined. There is a remarkable range of tree size control available among rootstocks. In addition, apple rootstocks vary greatly in cold hardiness and disease tolerance.

Several series of rootstocks are available, the most popular being the Malling and Malling-Merton. The single letter “M” stands for “Malling”, after the East Malling research station in England where these rootstocks were introduced. The “MM” designates “Malling-Merton”, since these stocks were a joint venture between the East Malling station and an institute located in Merton, England. Another important series is Budagovsky (Bud” or “B”). More kinds are added yearly.

In the US the most common are M.26 (Dwarf), M.7 (semi-dwarf), and M.9 (dwarf). Intensive plantings are almost exclusively on M.9. The M.27 rootstock is the most dwarfing, and trees are actually too small to be used commercially. M.9 is the most dwarfing of the commercially viable rootstock. They can easily be managed at 6 feet high.
Almost all dwarf and semi-dwarf trees require staking because of poor anchorage and leaning due to heavy fruit loads borne in early years. The use of these stocks is often combined with a trellis or stake. To circumvent some of the problems of dwarfing rootstocks, 3-part trees (interstocks) are used in some applications. Poor anchorage can be avoided by using the strong rooted MM series rootstock with a short length of the more dwarfing M.9 or B.9 grafted between rootstock and scion. By default, trees that are top-worked to new cultivars have an interstem. The poor anchorage is sometimes due to the brittle nature of the roots rather than to their being shallow-rooted. Tests have shown that in deep soils, many dwarf roots go just as deep as those of vigorous stocks.

**Popular apple rootstocks and characteristics**

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<th>Precocity</th>
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**Planting Design** – The range of rootstocks available for apples permit a wide variety of orchard designs and tree training systems. In most cases, trees are grown in rectangular arrangements or in hedgerows. Conventional apple orchards on seedling rootstocks require spacing of 20X20 ft. or wider. Semi-dwarf trees require a spacing of about 15X15 ft., and dwarf trees spacing can be reduced to 10X10 ft. or slightly closer. In an orchard setting with several rows of trees and where tractors and other powered equipment will be used, it is advisable to increase the distance between rows by several feet to allow passage.

**Training System** – Worldwide, the most common training system for apple is the central leader. This is where one branch is allowed to grow vertically and form the main bole upon which scaffold limbs are spaced at selected intervals in Christmas tree fashion. This system works well in areas of high light intensity and long sunny days.

In the coastal areas of Oregon where every possible ray of light needs to be captured and utilized, the open-center system is preferred. At an early age, 3-5 branches, evenly spaced around the tree, and located at different levels, are selected for the main scaffold branches. With pruning and limb bending, the selected branches are positioned to grow at the angle of about 60 degrees from vertical. This open-center or vase-like training system allows the maximum amount of light penetration for better fruit quality. It is almost always used for stone fruit.
Pruning – Pruning is a dwarfing process. Any desired tree size can be maintained by pruning. However, pruning stimulates vegetative growth; thus excessive pruning reduces fruitfulness. This is especially true with young vigorous tree. Removal of a branch not only eliminates stored carbohydrates, but it reduces potential leaf surface as well. From these reductions also comes a loss of root growth, thus the control of tree size. Pruning increases fruit size and N per growing point, and stimulates growth near the cut. Large cuts results in excessive stimulation of sprouts near the cut, while well-distributed, small cuts spread the stimulus better over the entire tree. Heading-back cuts, to control tree height, strongly stimulate the local area within a few inches of the cut. Thinning-out cuts (removal of limbs and branches back to their point of origin) tend to have less local stimulus.

Pruning is typically done when trees are still dormant in late winter. Unwanted wood however, can be removed any time of the year. The severity and type of pruning cuts depend on bearing habit, desired fruit size, inherent tree vigor, and training system. Most apples bear fruit on spurs, so one objective in pruning is to retain spurs on 2-year-old and older wood, exposing them to light as much as possible. Since long 1-year-old shoots will not bear fruit, they are removed unless needed to fill in an open space in the tree or to replace declining fruiting wood. For the most part, pruning is a hands-on learning experience, but you can start with a good book or learn from an experienced friend.

Under good conditions most tree fruits will set more fruit than needed for a full crop. Fruit thinning is done to reduce limb breakage, increase fruit size, improve color and quality, and stimulate floral initiation for next year’s crop. About 20-40 leaves per fruit are required to give a proper balance between fruit size and yield. The leaves of dwarf trees, however, can be more effective because they are exposed to direct sunlight for more hours of the day than those on larger trees.

HARVEST

Maturity – Several methods are available for determining optimal harvest time. Days from full bloom is relatively consistent from year-to-year for different cultivars, and provides a rough estimate of picking date. As maturity approaches, apples soften, so a fruit firmness meter can be used to measure the force required to puncture the flesh. Target values of firmness vary by cultivar and intended storage method, with firmer fruit reserved for long-term storage. Soluble solids can be measured with a refractometer, giving an indication of fruit sugar content, which increases as apples ripen. Starch is broken down into sugars during ripening, and a quick iodine stain test on a half-cut apple can be used to indicate how far along this process has occurred. This method is also used on stored apples to assess remaining shelf-life. The back-yard grower may start consumption as soon as the seeds turn dark, the background color (if present) turns yellow, and the apple tastes good. If you can not eat an entire apple before your stomach turns sour, it is too green.

Harvest Method – Apples must be picked by hand to avoid bruising, which reduces quality grade and increases storage losses. Fruit also must be picked carefully to avoid damaging the fruiting spur, where next season’s fruit will be borne. Do not reach and pull, but rather hold the fruit gently in the hand and rotate it upwards, as if you are trying to un-hook it from the spur or attachment point. *Apples are to be un-hooked – not snatched.* If the apple does not release when raised slightly above horizontal, it is likely not ripe.
**Storage** – The apple is one of the few fruits that can tolerate long-term storage without significant loss of quality. Commercially, apples are stored in a controlled atmosphere where the oxygen is reduced to 2-3% and CO2 is elevated slightly to retard respiration. Firmer, less ripe fruit are placed in long-term storage, while more mature fruit are sold directly or placed in short-time storage.

At home, apple storage can be extended by packing firm unblemished fruit in tight boxes or plastic bags and refrigerated cold as possible with out freezing. At 40 degrees they will ripen and soften 5-times faster -- at room temperature – 10-times faster. Winter storage on the floor in a cool unheated garage can work well, but will require additional protection when temperatures fall below freezing.

**CONTRIBUTION TO DIET**

Apples have a broad spectrum of food uses: pies and cakes, jams, sauces and juices, apple butter, dried apples, and much more. Apple juice has surpassed orange juice consumption in the USA. A medium sized apple contains about 80 calories, and is unusually high in fiber; generally about 5 grams per fruit (mostly from pectin). In 2001, United States consumers ate an average of 45.2 pounds of apples and processed apple products. About 60% of these are eaten fresh. More apples are consumed world-wide than all the other tree fruits combined.

Loyd Collett