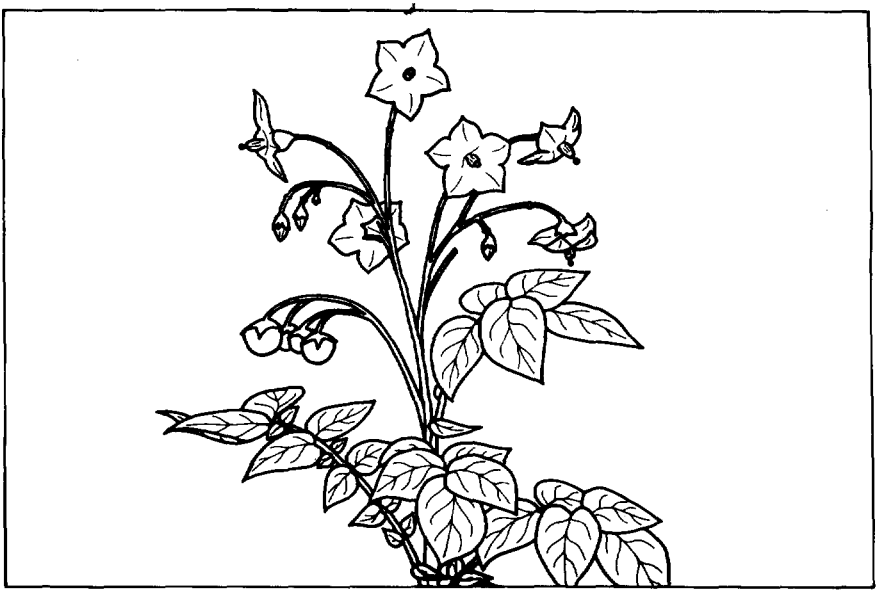
Technical Information Bulletin 6

Systematic Botany and Morphology of the Potato

Zósimo Huamán



Morphology of the potato plant

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Systematic Botany and Morphology of the Potato

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Systematic Botany and Morphology of the Potato

Objectives. Study of this bulletin, enables you to:

- explain the taxonomic classification and distribution of the potato;
- describe the morphology of each organ of a potato plant.

Study materials

- Flowering potato plants (including roots and tubers) of different varieties.
- Mature tubers of different varieties.
- Poster of potato plant.

Practicals

- Describe morphological characteristics of different varieties in the field at flowering stage.
- Describe tuber characteristics of different varieties.

Questionnaire

1 Define the terms *systematic botany* and *morphology*.
2 In which family, genus and section is the potato classified?
3 What is the number of chromosomes in a chromosome set of the potato?
4 What is the range of ploidy levels in cultivated potato species?
5 How many cultivated potato species are generally recognized?
6 Which potato subspecies is grown worldwide?
7 In which part of the world grow wild potatoes in nature?
8 Are all wild potato species tuber-bearing?
9 Name different growth habits of the potato plant.
10 Which plant parts can form roots?
11 Which plant parts form the potato stem system?
12 What are lateral stems ?
13 What are stolons morphologically?
14 What are tubers morphologically?
15 Identify the two ends of a potato tuber.
16 What are tuber eyes morphologically?
17 List the tuber elements in a longitudinal tuber section.
18 Which is the principal storage tissue of a potato tuber?
19 From which plant parts grow the sprouts?
20 Identify all parts of a potato leaf.
21 What is a cymose inflorescence?
22 What are the essential parts of potato flowers?
23 Define the term *true seed* as opposed to *seed tubers.*

Systematic Botany and Morphology of the Potato

Knowledge about systematic botany and morphology of the potato is important to understand botanical aspects of the plant that are related to potato production and research.

Systematic botany is the orderly identification, classification and naming of plants according to a system of rules. All plants included in a group share a number of similarities in attributes (characters), such as form and structures.

Morphology is the study of form and structure of plants.

1 SYSTEMATIC BOTANY AND DISTRIBUTION

On the basis of floral characters, the potato has been classified according to the following system:

Family	*Solanaceae*
Genus	*Solanum*
Section	*Petota*

This Section is further subdivided into Series, Species, and Sub-species. All cultivated and wild potato species are classified within Section *Petota.*

Several systems of classification of potato species exist based mainly on the number of series and species recognized. Thus, there are three systems of classification for the cultivated potato species. They recognize 3, 8, or 18 species depending on the degree of variation within each plant characteristic used to separate one species from another. The system which considers eight cultivated species is the most widely used.

Potatoes may be classified into ploidy levels. Ploidy is defined by the number of chromosome sets (x) present in a vegetative (somatic) cell. Vegetative cells contain normally at least two sets of chromosomes. The chromosome set of the potato consists of 12 chromosomes, thus $x = 12$. Cells of cultivated potato species may carry between two and five sets of chromosomes; thus cultivated potato species range from the diploid to the pentaploid level (see table). The expression 2n symbolizes the total of chromosome sets and, therefore, the total chromosome number in vegetative cells at any ploidy level.

The eight cultivated species are

Species	Chromosome number	Ploidy level
S. x *ajanhuiri* *S. goniocalyx* *S. phureja* *S. stenotomum*	2n = 2x = 24	dipllid
S. x *chaucha* *S.* x *juzepczukii*	2n = 3x = 36	triploid
S. tuberosum ssp. *tuberosum* ssp. *andigena*	2n = 4x = 48	tetraploid
S. x *curtilobum*	2n = 5x = 60	pentaploid

The x within a botanical name indicates that the species is a hybrid.
ssp. = subspecies.

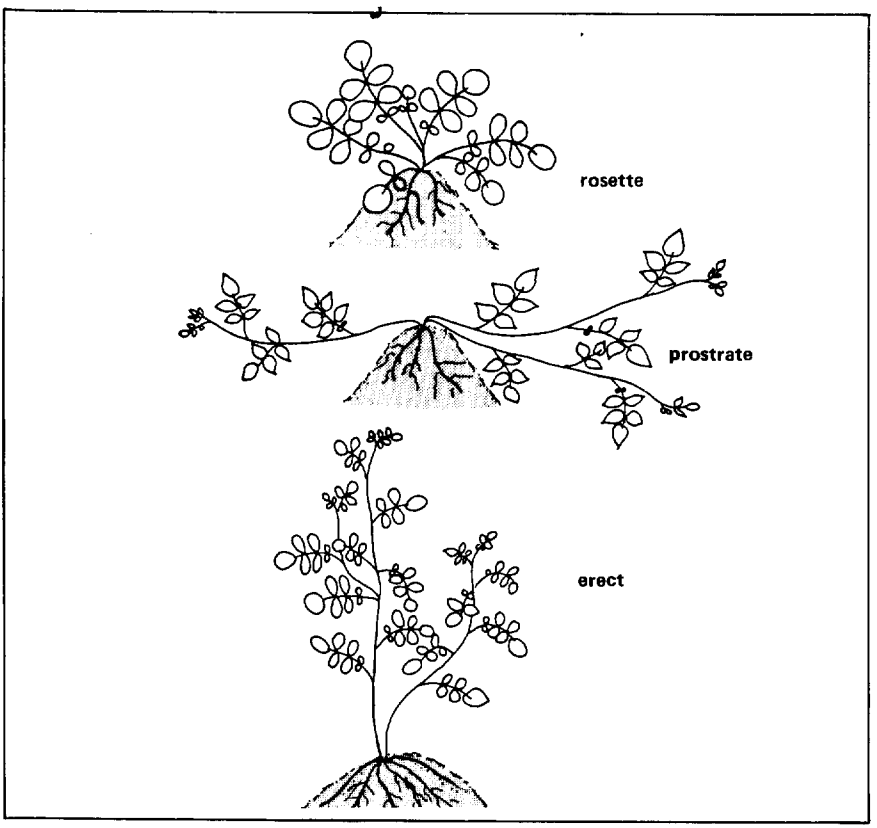
Among the eight cultivated species of Section *Petota*, only *Solanum tuberosum* subspecies *tuberosum* is grown worldwide. Others are restricted to the Andean countries where thousands of primitive cultivars are found. About 13 000 samples of them have been recently collected through several collecting expeditions sponsored by CIP, and form part of the World Potato Collection.

There are about 200 wild species considered taxonomically distinct. They range from the diploid ($2n = 2x = 24$ chromosomes) to the hexaploid ($2n = 6x = 72$) level. All these species are confined to the American continent. They grow from the Southern United States in the North, through Mexico, Central America, the Andean countries to Chile in the South. They are found from sea level up to more than 4 000 m altitude. Although most wild species are tuber-bearing, some do not form tubers.

Marked morphological differences are found among wild and cultivated potato species. Morphologic variation is also considerable between and within cultivated species. Additionally, potato morphology is influenced by environmental factors, such as temperature, daylength, moisture, and soil fertility.

The descriptions in the following pages are limited to cultivated potatoes.

The potato is an herbaceous plant. Its growth habit varies between and within species. When all or most leaves are arranged at or near the base of short stems and are near the soil surface, the plant has a rosette or semi-rosette habit. The frost resistant species *S.* x *juzepczukii, S.* x *curtilobum* and *S.* x *ajanhuiri* are characterized by these growth habits. Within the other species the following habits can be found: prostrate (stems trail on the ground), decumbent (stems trail on the ground, but are bent up at the apex), semi-erect, and erect.

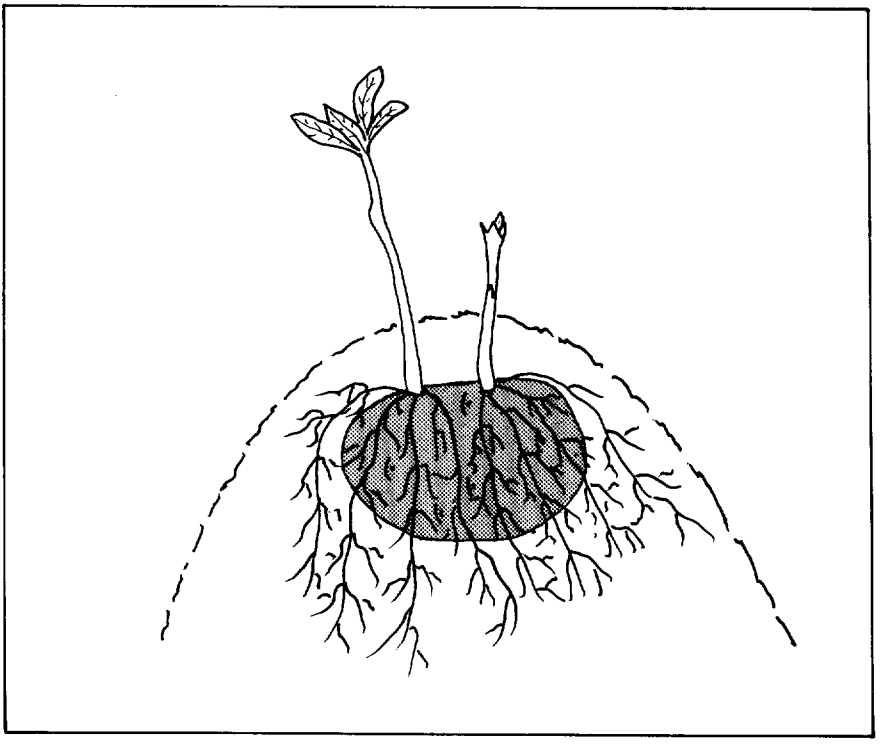


The growth habit of the potato varies between and within species.

3 ROOTS

Potato plants may develop from seed or from tubers. Plants grown from seed form a slender tap root with lateral branches. Plants grown from tubers form adventitious roots at the base of each sprout and, later, above the nodes of the underground part of each stem. Occasionally, roots may also grow on stolons. In comparison with other crops, the potato root system is weak. Therefore, good soil condition is necessary for potato growing. The type of root system varies from light and superficial to fibrous and deep.

Isolated leaves, stems, and other plant parts may form roots, especially when treated with hormones. This root forming ability of potato plant parts is utilized in rapid multiplication techniques.



Plants grown from tubers form adventitious roots at the base of each sprout.

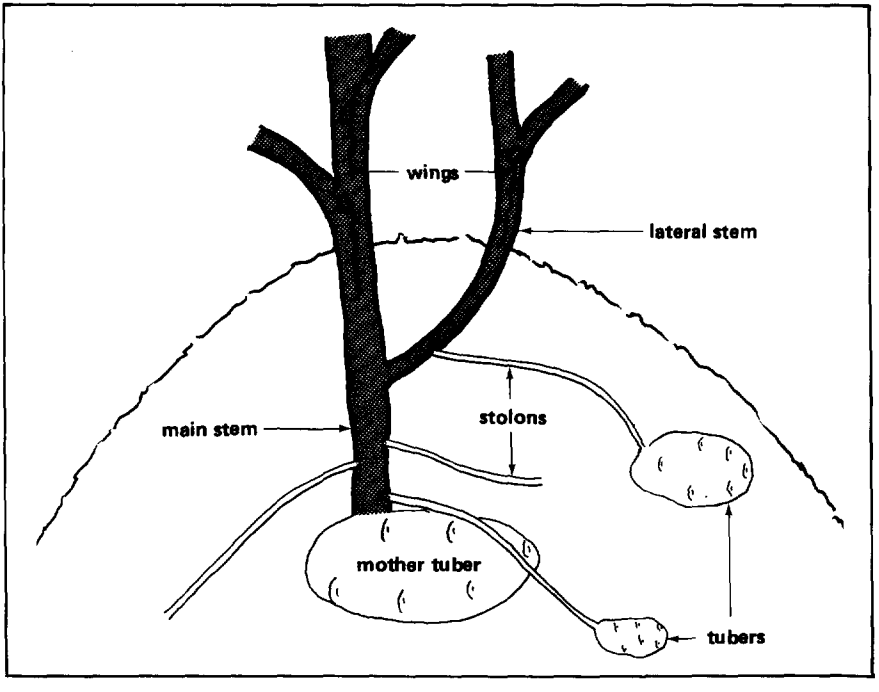
4 STEMS

The potato stem system consists of stems, stolons and tubers. Plants grown from true seed have one main stem; while from a tuber a number of main stems may be produced. Lateral stems are branches of main stems.

Stems are round to angular in cross section. At the angulke margins wings or ribs are often formed. Wings could be straight, undulate, or dentate. Stem color is generally green; sometimes it may be red-brown or purple.

Stems may be solid or partly hollow due to disintegration of the pith cells.

Buds in the axils of leaves may grow out to form lateral stems, stolons, inflorescences, or sometimes even aerial tubers.

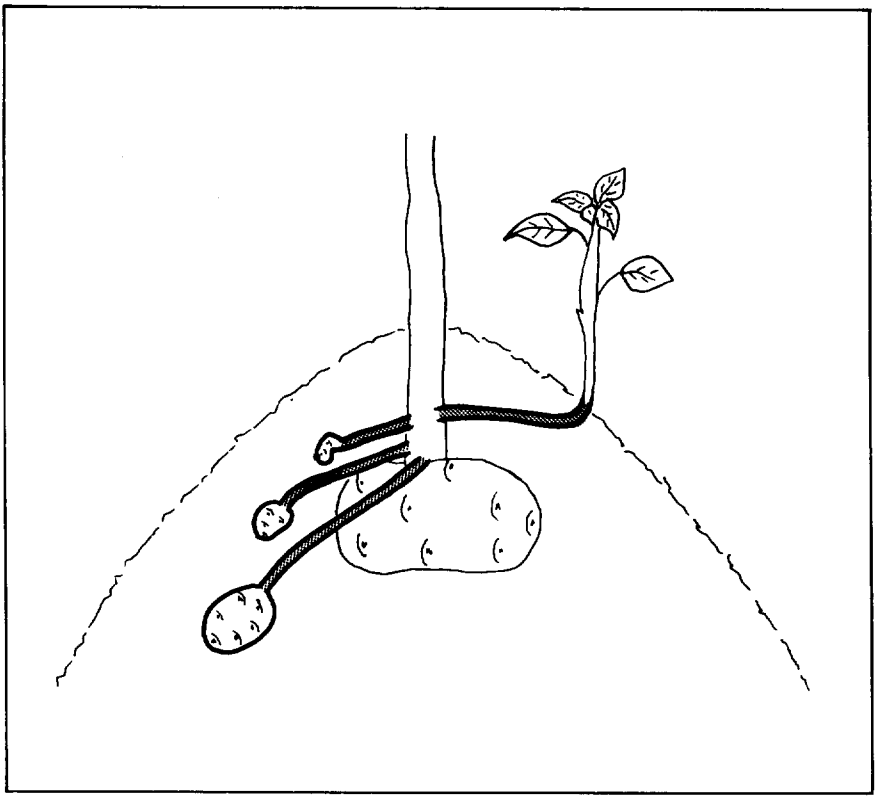


The potato stem system consists of stems, stolons and tubers.

5 STOLONS

Morphologically, potato stolons are lateral stems which grow horizontally below ground from buds of the underground part of stems. The length of stolons is an important varietal character. Long stolons are common in wild potatoes; potato breeding aims at short stolons.

Stolons may eventually form tubers by enlargement of their terminal end. However, not all stolons may form tubers. A stolon not covered by soil may develop into a vertical stem with normal foliage.

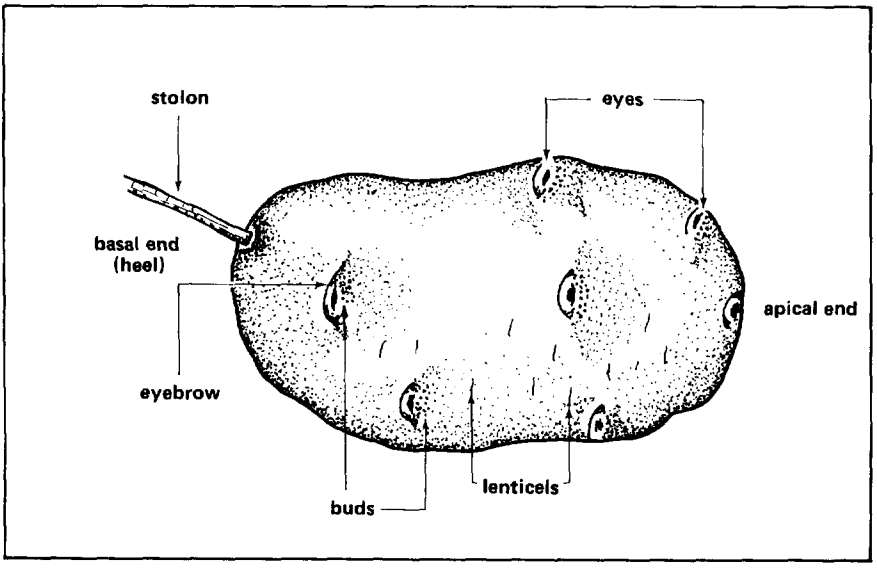


Stolons are lateral stems which grow horizontally underground and may eventually form tubers by enlargement of their terminal end.

Morphologically, tubers are modified stems and constitute the main storage organs of the potato plant. A tuber has two ends: The *heel* end is attached to the stolon; the opposite end is called either the *apical, rose* or *distal* end.

The eyes are spirally arranged on the tuber surface and concentrated towards the apical end. They are located in the axils of scale-like leaves, or the eyebrows. Depending on the variety, eyebrows may be elevated, superficial or deep. Each eye contains several buds.

The eyes of a potato tuber morphologically correspond to the nodes of stems. Eyebrows represent scale leaves, and eyebuds represent axillary buds. The eyebuds eventually grow out to form sprouts and a new system of main stems, lateral stems, and stolons. Generally, at tuber maturity, eyebuds are dormant in that they are unable to develop. After a period of time, depending on the variety, the apical eyebuds break dormancy first. This characteristic is called *apical dominance*. Later, the other eyebuds develop into sprouts.

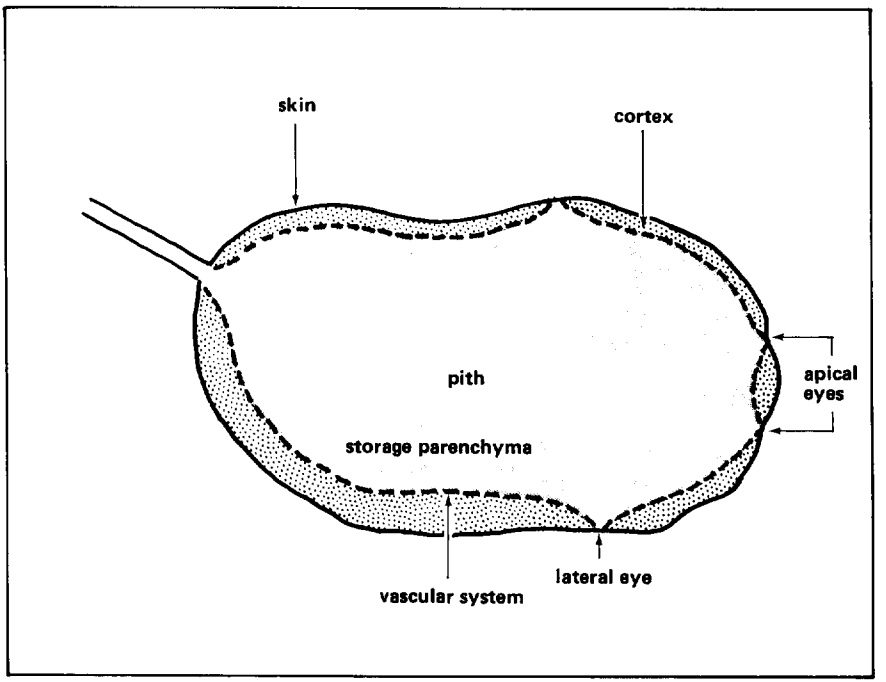


Tubers are modified stems...

In most commercial varieties, the shape of the tuber ranges from round to oval and oblong. Besides these shapes, some primitive cultivars form tubers of many irregular forms.

In a longitudinal section the tuber shows the following elements (from the outside to the inside): skin, cortex, vascular system, storage parenchyma, and pith.

The skin (*periderm*) is a thin protective layer on the outside of the tuber. Its color may vary between white-cream, yellow, orange, red, or purple. Some have two colors. When exposed to the light for some days, tubers normally turn greenish. The skin is usually smooth, and in some varieties russet or rough. It can be easily peeled off by rubbing when the tuber is immature. Thus skin damage is frequent when tubers are harvested immaturely.



... and constitute the main storage organs of the potato plant.

Gaseous exchange in the tuber takes place through the *lenticels* (breathing pores) distributed on the surface of the skin. Under wet conditions lenticels increase in size and appear as prominent white spots.

The cortex is immediately below the skin. It is a narrow band of storage tissue that contains mainly protein and starch.

The vascular system connects the tuber and the tuber eyes with other parts of the plant.

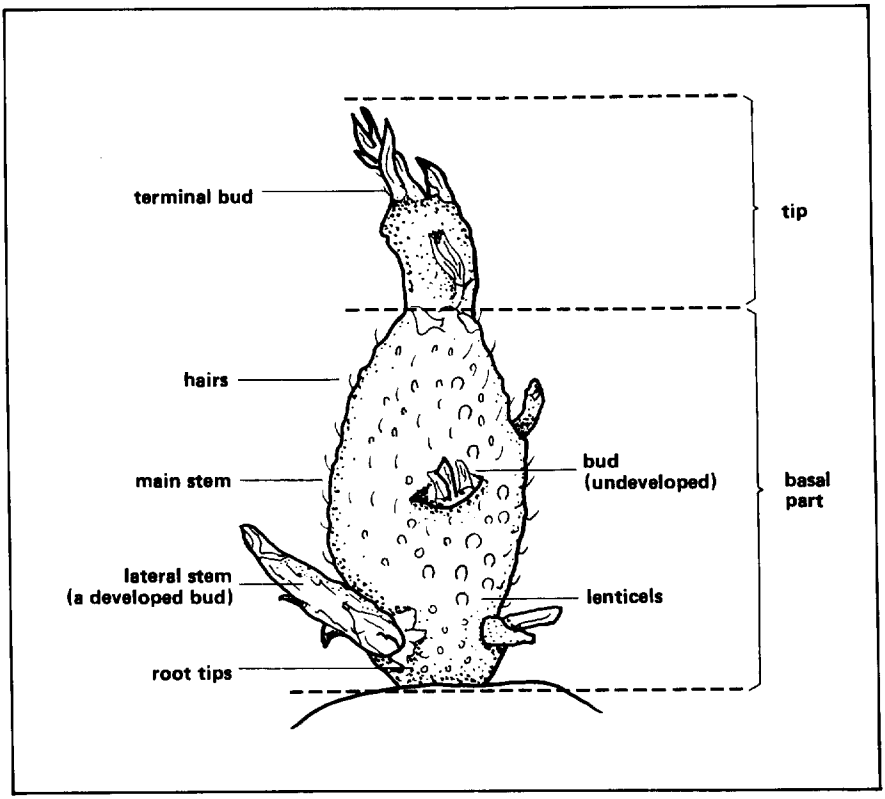
The storage parenchyma follows inside the vascular ring. It is the principal storage tissue and covers the greatest part of the tuber. The pith forms the central part of the tuber.

All elements from cortex to the pith constitute the tuber flesh which in commercial varieties is usually white, cream or pale yellow. However, some primitive cultivars also produce tubers with deep yellow, red, purple, or two-colored flesh.

7 SPROUTS

Sprouts grow from the buds in the eyes of a tuber. The color of the sprout is an important varietal characteristic. Sprouts can be white, partially colored at the base or the apex, or almost totally colored. White sprouts when exposed to indirect light turn green.

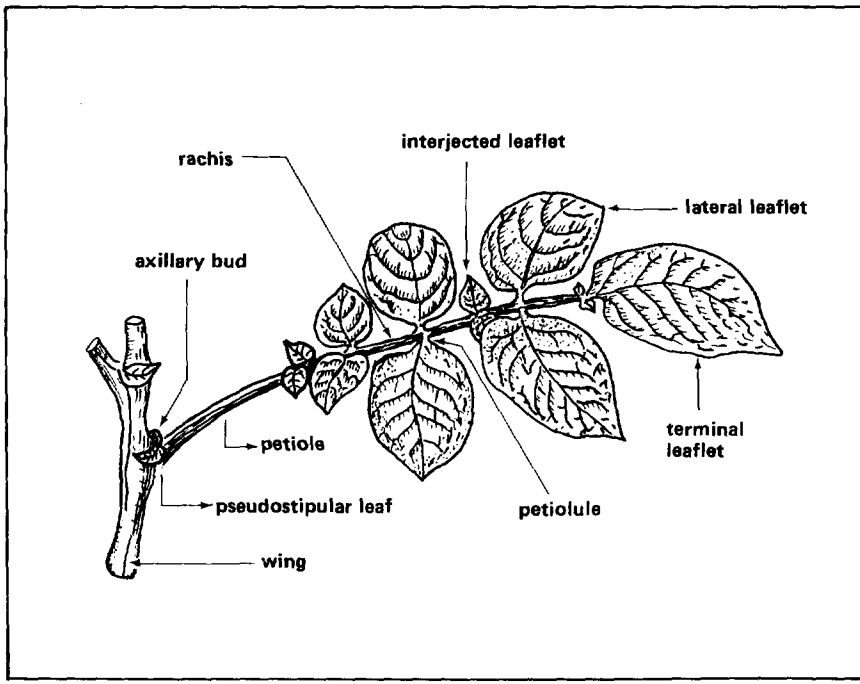
The basal part of the sprout normally forms the underground portion of the stem and is characterized by the presence of lenticels. After planting, this part rapidly produces roots and later stolons, or lateral stems. The tip of the sprout is leafy and represents the growing part of the stem.



Sprouts grow from the buds in the eyes of a tuber.

Leaves are arranged spirally on the stem. Normally, leaves are "compound," that is they consist of a midrib (*rachis*) and several leaflets. Each rachis may carry several pairs of lateral primary leaflets, plus a terminal leaflet. The part of the rachis below the lowest pair of primary leaflets is called a *petiole*. Leaflets may be attached directly (*sessile*) on the rachis, or by means of small stalks (*petiolules*). The regular sequence of these primary leaflets may be interrupted by small interjected secondary leaflets.

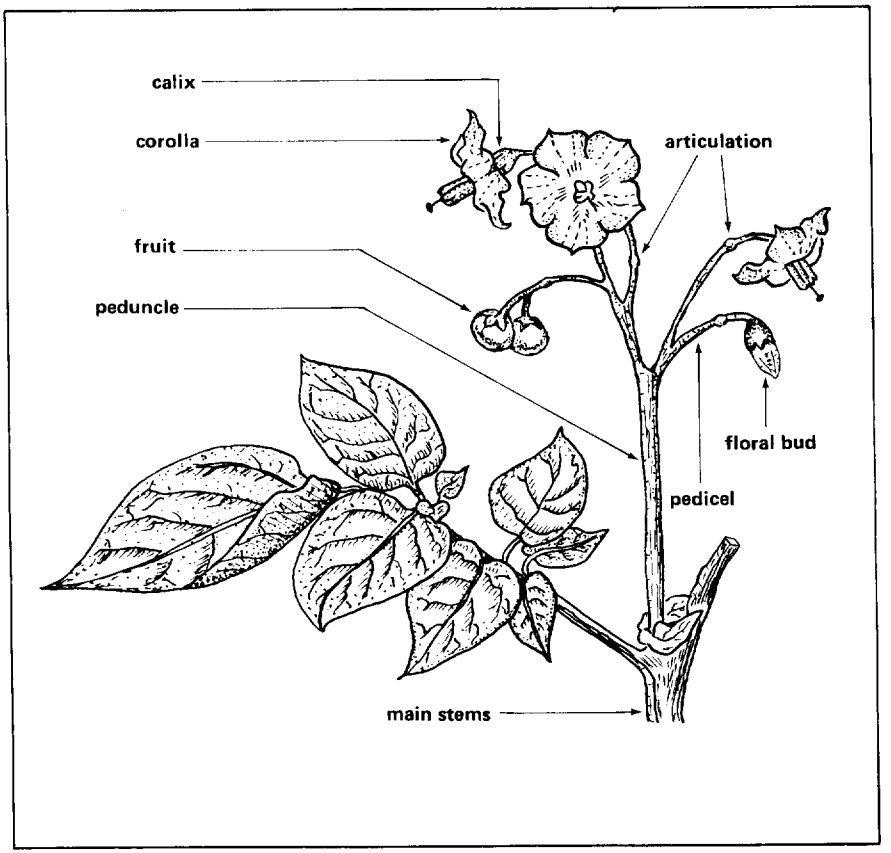
At the base of the petiole, the size and form of the two small lateral (*pseudostipular*) leaves, as well as the angle of insertion of the petiole on the stem, are useful in distinguishing varietal characteristics. From the point of insertion, wings or ribs may extend downward on the stem.



Normally, leaves are compound, that is, they consist of a midrib and several leaflets.

The main stalk (*peduncle*) of the inflorescence is normally divided into two branches. Each branch is usually further divided into two other branches. In this way, they form a so-called *cymose* inflorescence.

From the branches of the inflorescence arise the flower stalks (*pedicels*), whose tips merge into the calyx. The pedicels bear a joint (*articulation*) where flowers or fruits may drop off. In some cultivars this articulation is pigmented. The position of the articulation is a useful taxonomic character.

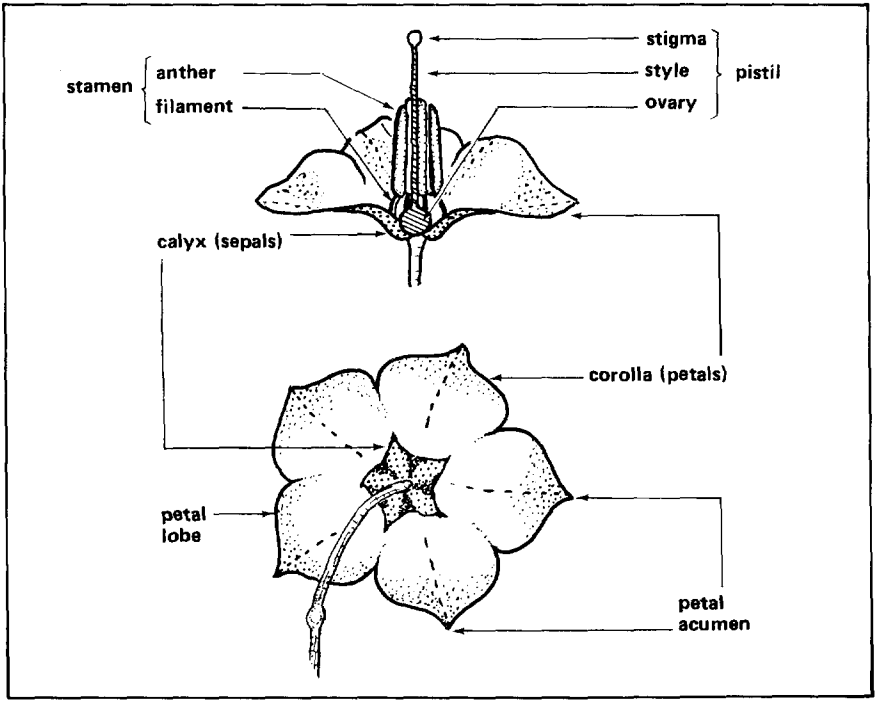


The peduncle forms a cymose inflorescence.

Potato flowers are bisexual. They possess all four essential parts of a flower: calyx, corolla, male elements (*androecium* = stamen) and female elements (*gynoecium* = pistil).

The calyx consists of five sepals that are partly joined at their base, forming a bell-shaped structure below the corolla. The shape and size of the lobes or free ends of the sepals vary according to cultivar. The calyx color may be green, or partially or totally pigmented.

The corolla consists of five petals. These are also joined at their base and form a short tube and a flat five-lobed surface. Each lobe ends in a triangular point (*acumen*). The outline of the corolla is generally round (*rotate*). Some primitive cultivars have pentagonal or star-like corollas. The corolla color may be either white, light blue, blue, red and purple with different tones and intensities.



Potato flowers are bisexual. They possess all four essential parts of a flower: calyx, corolla, stamens, and pistil.

The androecium consists of five stamens that alternate with the petals. The stamen is composed of anther and filament that are joined to the corolla tube. Anthers are generally fused in a conical column enclosing the pistil. In some cultivars they may be spread apart loosely. The color of anthers varies from light yellow to deep orange. Pollen grains are shed through pores at anther tips.

The gynoecium (female elements) of the flower consists of a single pistil which is composed of the ovary, style, and stigma. The ovary is superior, that is, the sepals, petals and stamens are attached to the receptacle just below the ovary. In transverse section, the ovary shows two cavities (or locules and, therefore, is *bilocular*) where, generally, numerous ovules are arranged along the periphery of the placenta (*axile placentation*).

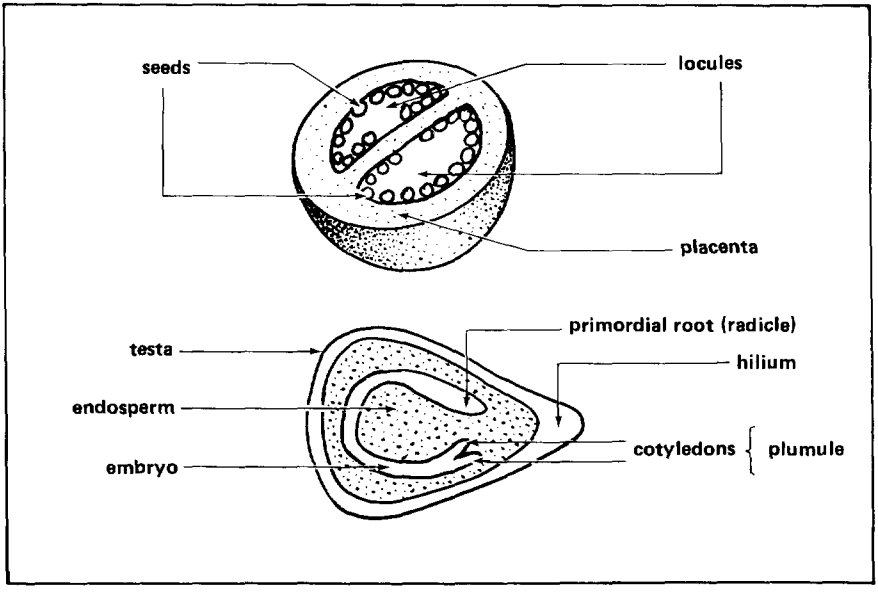
The style is an elongated portion of the pistil connecting the stigma and ovary. The style length may be longer, equal or shorter than that of the stamens. The stigma is the receptive portion of the pistil, where pollen grains germinate to grow down the style. Following fertilization the ovules develop into seed.

Upon fertilization the ovary develops into a fruit (*berry*), containing numerous seeds. The fruit is generally spherical, but some cultivars produce ovoid or conical fruits. The fruit color is generally green. In some cultivars they have white or pigmented spots, or pigmented stripes or areas.

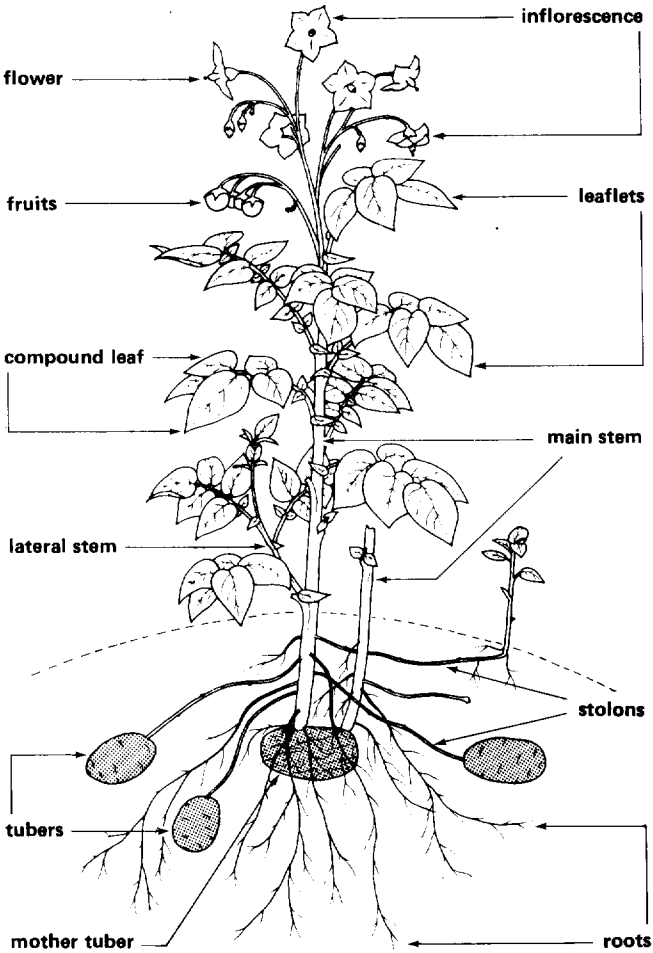
The number of seeds per fruit reaches up to more than 200, depending on the fertility of the particular cultivar. Seeds are flat-oval and small (1000 to 1500 seeds per gram). Each seed is surrounded by a seed coat (*testa*), which protects the embryo and a nutrient storage tissue (*endosperm*).

The shape of the embryo is generally curved like an *U* and oriented towards the point of attachement to the placenta (*hilium*). The embryo has two opposite poles. One pole (*radicle*) is the primordial root, and the other (*plumule*) contains two cotyledons.

Seeds are also known as *true* or *botanical* seed (as opposed to tubers, called *seed tubers*, when used to produce a potato crop).



The ovary shows two locules (top). The shape of the embryo is generally curved like an *U* (bottom).



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11 ADDITIONAL STUDY

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