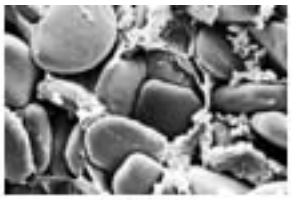
Achira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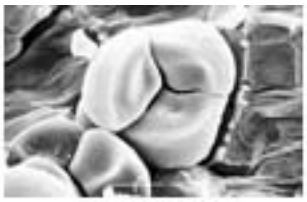
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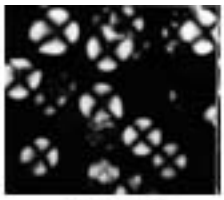
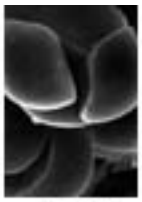

Manioc

Manioc


Jicama

Ethnobotanical Leaflets Starch Research Page

Co-Edited by Don Ugent and Linda S. Cummings

Why study starch? The long and short of it is that size, shape, and optical and chemical properties of starch are useful in the determination of taxonomic species. Starch characteristics can be used in place of, or in combination with other features of the plant to facilitate the identification of macro archaeological plant remains, or even small pieces of modern plant materials which for one reason or the other are lacking the traditional "key" taxonomic characters. As in the case of pollen and phytolith analyses, the study of fossil starch grains can help the ethnobotanist to better understand the diet of ancient human cultures.

The taxonomic usefulness of starch was long ago noted by Edward Tyson Reichert (1913), whose monumental work on "The Differentiation and Specificity of Starches in Relation to Genera, Species, Etc." has today become a classic in its field. He writes:

> **"It must have been recognized by Leeuwenhoek, and by many of the investigators of the earliest part of the last century, that starches from different sources are not morphologically identical, but if so it does not seem to have attracted any particular attention until the investigations of Fritzsche (Ann. d. Physik. u. Chernie, 1834, xxxii, 129). . . Fritzsche described the starches obtained from a variety of plants. . . He noted not only that the starches from different sources were different, but also that often the form was so characteristic as to determine the plant, or, at least, indicate the genus and family from which the specimen was obtained. This statement was confirmed some years later by Schleiden (Principles of Botany, 1849, 14), who examined a number of starches, mostly not described by Fritzsche. From the differences observed he was enabled to tabulate the various forms, and he published a classification that has continued to be quoted in various standard works, even at the present time."**

Starch List Server: Please direct questions on starch to starch@acl.archaeology.usyd.

edu.au

Identification Keys by Early Workers

- Kraemer
- Meyer
- Muter
- Nägeli
- Schleiden
- Winton

Illustrations of Starch Grains

- *Canna* Plate from Reichert (1913)
- SEM of Ancient *Solanum maglia* Starch
- SEM of Ancient Maize
- Drawings of Ancient Starch from Towle, 1961

Light and Chemical Reactions of Starch

The starches of various plant species can be distinguished from one another by using a combination of light and chemical tests. These tests are described in detail in an article entitled "The Differential Analysis of Starches" by James B. McNair (Botanical Series, Vol. IX, Field Museum of Natural History, Chicago, pp. 1-44, June 19, 1930).

Polarization:

An interference figure (or "Maltese cross") is seen when starch grains are examined under the polarization microscope. Intensity, distinctness, shape, regularity and position of the interference figure varies from species to species. With respect to intensity, potato starch has a value of 90 ("very high"), daffodil (*Narcissus poeticus*) a value of 50 (or "moderate"), and *Richardia albo-maculata* a value of 30 (or "low"). Intermediate gradations are readily expressed by both words and numbers (see Polarization Chart).

Coloration:

Iodine. Use 0.25 per cent Lugol's solution (the latter made by dissolving 5.0 grams of iodine plus 10.0 grams of potassium iodide in 100 ml of distilled or deionized water). Several drops are placed on a specimen and examined microscopically under low power. Potato starch, used as a color standard, is

taken as having a value of 60 (or "moderately deep"). *Crinum moorei* has a value of 30 (or "light"). Intermediate values are given in the Iodine Reaction Chart.

Swelling Agents:

Chloral hydrate-iodine solution. Prepared by saturating a saturated solution of chloral hydrate with iodine. Several drops are placed on the specimen and examined under the polarizing microscope. The time for the disappearance of the Maltese cross (or gelatinization) is noted (see Chloral Hydrate-Iodine Chart).

Other Reagents: Purdy's solution (an aqueous solution of KOH), Pyrogallic acid, chromic acid, and ferric chloride. Use of these reagents is similar to that described for the above Chloral hydrate-iodine solution (see Purdy's Solution Chart; Pyrogallic Acid Chart; Chromic Acid Chart and Ferric Chloride Chart).

Temperature of Gelatinization:

A small quantity of starch is placed in a test tube holding 10 cc of water and slowly warmed in a water bath. The specimen is periodically removed from the water bath and observed under the polarization microscope for the occurrence of any optical changes. The time for gelatinization is noted (see Temperature of Gelatinization Chart).

Did You Know That. . .

Starch paste was used by the ancient Egyptians to cement strips of papyrus stems together for use as writing paper as early as 4000 B.C.

A procedure for starch production was given in a Roman treatise by Cato in the year 184 B.C.

Pliny the Elder (23-74 A.D.) states that the Romans used wheat starch to make papyrus documents, as well as to stiffen and whiten cloth and powder the hair.

Dioscorides (1st century A.D.), in his *Greek Herbal*, recommended the use of wheat starch for the treatment of ulcers, sores and eye inflamtions.

Chinese paper documents of about 312 A.D. were coated with a starch sizing to provide resistance to ink penetration. Starches from rice, wheat and barley were commonly used at that time.

Abu Mansur, an Arabian teacher and pharmacologist, described a method in which wounds could be treated with the use of an artificial "honey" made by mixing starch with saliva in the year 975 A.D.

Starch was used in northern Europe to stiffen linen, possibly as early as the 14th century. Colored and uncolored starches were used as cosmetics, and uncolored starch primarily as hair powder. Blue starch was used by the Puritans until its use was banned by Queen Elizabeth in 1596.

Yellow starch was fashionable during the middle ages until a notorious women prisoner wearing a bright yellow-starched ruffle was publicly executed. Red starch cosmetics remained in fashion for many years (from Whistler, *et al.*, 1984, *Starch Chemistry and Technology*).

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KRAEMER'S (1907) CLASSIFICATION

A. Simple spherical grains.

(a) Not more than 5 mu in diameter: *Cimicifuga, Cypripedium, Frangula, Hydrastis, Leptandra, Piper, Prunus virginiana, Quassia, Quercus alba, Rhamnus purshiana, Spigelia, Viburnum opulus, and Viburnum prunifoliulli.*

(b) Not more than 10 mu in diameter: *Calamus, Eunonymus, Gelsemium, Granatum, Quillaja, Sanguinaria, Serpentaria, Tonka, Ulnus, Xanthoxylum.*

(c) Not more than 15 mu in diameter: *Apocynum, Cinchona, Colchici semen (in caruncle only), Convallaria, Sumbul, Valeriana.*

(d) Not more than 201 mu in diameter: *Glycyrrhyza, Phytolacca.*

(e) Not more than 300 mu in diameter: *Rumex, Stillingia.*

B. Compound spherical or polygonal grains.

(a) 2 to 3 compound: *Belladona radix (5 to 15 mu), Sassafras (7 to 20 mu), Veratrum viride (7 to 20 mu).*

(b) 2 to 4 compound: *Aconitum (4 to 12 mu), Cinnamonum. (7 to 15 mu), Colchici cormus (7 to 20 mu), Ipecacuanha (4 to 14 mu, those of Carthagena ipecac being uniformly larger), Krameria (20 to 30 mu), Rheum (5 to 201 mu), Sarsaparilla (7 to 201 mu).*

(c) 2 to 6 compound: *Podophyllurn (5 to 121 mu).*

(d) More than 6 compound: *Capsicum (3 to 7 mu), Cardamonum (1 to 41 mu), Cubeba (I to 41 mu), Gossypii cortex (5 to 20 mu), Mezereum (10 to 151 mu), Myristica (5 to 7 mu), Pimenta (7 to 10 mu), Rubus (3 to 7 mu).*

C. Ellipsoidal or ovoid grains. *Althea (10 to 201 mu), Geranium (10 to 15 mu), Glycyrrhiza (5 to 10 mu), Pareira (7 to 15 mu), Physostigma (25 to 40 mu), Rumex (10 to 20 mu), Stillingia (15 to 30 mu), Strophanthus (2 to 4 mu), Zingiber (15 to 301 mu).*

D. Grains of characteristic shape. *Calumba (25 to 35 mu), Iris florentina (15 to 30 mu), and potato and other starches, such as arrowroot, wheat, corn, yam, canna, bean, pea, cassava.*

E. Altered grains. *Guarana (10 mu), Jalapa (15 to 35 mu; also 2 to 3 compound grains), Tragacantha (2 to 101 mu), turmeric in masses (70 to 140 mu).*

F. Amylodextrin grains. Mace contains starch-grains which give a reddish color with iodine. Kraemer notes that leaves, herbs, and flowers do not as, a rule, contain starch.

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MEYER'S (1895) CLASSIFICATION OF STARCH-GRAINS

DEFINITIONS:

(a) Simple or monarch starch-grains. Grains which have but one hilum.

(b) Complex starch-grains. Grains that axe formed from several starch-grains which are so crowded in one chromatophore that they become enveloped within common starchy layers, and thus bound into a single individual. Complex starch-grains may be diarch to poIyarch.

(c) Solitary starch-grains. Grains which grow singly in one chromatophore.

(d) Adelphous starch-grains. Those which grow along with other grains in one chromatophore. They may be di- to poly-adelphous; up to 6-adelphous would be designated as oligo-adelphous.

(e) Monotone starch-grains. Grains which during their entire life have undergone periods of solution, leaving coherent traces of each of the lamellae formed during the period of storage. Perfect monotone starch-grains in which there still exists a trace of every lamella which has been formed and in which, even if eccentric, the lamellae are closed are exceedingly rare. This term is also to be used in all cases in which no distinct characters of a polytone type are present.

(f) Polytone starch-grains. Grains that have during their development undergone two or more periods of solution in which numerous lamellae completely disappear or decrease in width, interspersed with other periods during which they developed as the relative monotone type. Polytone grains if they have an eccentric structure show a series of lamella) which are open laterally.

Meyer's 1895 Classification

A. Monarch Starch-Grains.

(a) Solitary Starch-grains.

I. Centric starch-grains. Hilum. in the mathematical center; lamellae always equal at two diametrically opposite points (Nägeli, Type 1).

(1) Monarch solitary, spherical. (Nägeli, Type 1.) Hilum spherical in the center of the spherical grain; lamellae of uniform thickness, forming complete circles.

(2) Monarch solitary, centric, lens-shaped. Hilum and grains rounded and compressed (also rounded-reniform. or rounded-oval, compressed).

(3) Monarch solitary, centric, oval grains. Hilum and grains oval and lanceolate-oval; circular in cross-section; lamella) equal at two diametrically opposite points, being coarsest at two poles.

(4) Monarch solitary, centric, rod-shaped, and cone-shaped grains are bone-shaped and somewhat flattened.

II. Eccentric starch-grains.

(5) Monarch solitary, eccentric, rod-shaped. Lamellae on one side the heaviest, and at the diametrically opposite side the finest. Grains are circular in transverse section; both ends of almost equal width and thickness.

(6) Monarch solitary, eccentric, conical. Lamellae are the densest at one side and the most delicate at the diametrically opposite side. Grains are conical; circular in transverse sections. Hilum located at the narrower, less dense end.

(7) Monarch solitary, eccentric, inverted-conical. Grains similar to those in Type 6, but with the hilum. at the more dense end. Grains of Type 7 are usually found in company with those of Types 5 and 6.

(8) Monarch solitary, eccentric, flattened.

(b) Adelphous starch-grains.

I. Oligoadelphous Starch-grains. If several starch-grains grow simultaneously in a chromatophore, they behave just as spherocrystals do when growing in an inexhaustible mother liquor. Only in the very earliest stage are the two starch-grains spherical, and, as is apparent, the spherical shape is the more pronounced the larger the chloroplast when the first grains start to form. If the chloroplast is still small when the starch-gains begin to grow, so that the grains develop along with the chloroplast and exceed it in growth, they are very soon prevented from increasing in size on the inner side, and both become flattened. The lamellae are heaviest within and below, and in purely monotone grains they are always closed, since the crystallization substance between the grains is furnished in the greatest quantity. Flattening of the grains results, as is readily seen if one considers that when two spherical grains grow side by side in a chromatophore, the chromatophore

layer being thinnest where the two spheres come in closest contact with their surfaces. The entire process of growth of the diadelphous starch-grains is similar to that of monarch, solitary grains of *Pellionia*.

II. Polyadelphous starch-grains. The polyadelphous starch-grains of a chromatophore, which are not easily distinguished from the diadelphous, forms, are approximately similar in form and size, though the proportion of the diameter of the smallest to that of the largest is usually as 1 to 4. The greatest diameter of a chromatophore filled with starch-grains which was measured by Nägeli is 106 mu. Such a chromatophore may, according to Nägeli, contain between 10 and 30,000 growing starch-grains. The form of the polyadelphous grains is mostly polyangular or rounded with centric structure. Some exceptions are found in the flattened forms of *Arenaria* and *A. graminifolia* and *Drymaria cordata* described by Nägeli. The polyadelphous grains are found relatively seldom in rhizomes and roots, although there axe some exceptions, but occur most abundantly in the reserved food of seeds.

B. Complex (Di- to Poly-arch) Starch-Grains. It can not be readily demonstrated that complex grains, like certain grains, for example, of *Pellionia*, are descended from adelphous grains. It has, however, proven that all plant parts in which complex grains are present also at times develop adelphous starch-grains which correspond entirely with the central lamellie of the complex grains. Furthermore, gradations between the adelphous and the similar complex forms can be found. Additional proof of the connection between adelphous and complex starch-grains is the fact that plant parts which produce few and irregular adelphous grains likewise have relatively few and irregular complex grains in their cells.

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MUTER'S (1905) CLASSIFICATION

Muter's classification, which is based upon histological and polariscopic peculiarities, is characterized by the designation of each group by some important type of starch:

Potato group. Oval or ovoid granules, showing hilum and concentric rings clearly; cross and colors with selenite usually distinct.

Legume group. Round or oval granules, hilum marked, rings faint, but rendered visible in cases by chromic-acid solution; cross and colors feeble.

Wheat group. Round and oval granules, hilum and rings generally invisible; feebly marked cross and colors.

Sago group. Truncated granules, hilum distinct, rings faint; cross and colors usually faint.

Rice group. Polygonal granules, hilum distinct, rings faint; cross and colors usually faint.

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Nägeli's (1874) Classification of Starches From Different Sources

A. Grains Simple.

I. Centric. Hilum in the mathematical center; lamellae always equal at two corresponding diametrically opposite points.

Type 1. Spherical. When the grain is free both hilum and grain are spherical (Plate 1, *Zea mays*).

Type 2. Lenticular. When the grain is free both hilum and grain are rounded; grains compressed; sometimes circular or ovoid; sometimes triangular or quadrangular (Plate 2, *Secale*).

Type 3. Oval. When the grain is free both hilum and grain are oval to lanceolate-oval; occasionally kidney-shaped or somewhat curved; when on end they appear circular or somewhat compressed (Plate 6, *Phaseolus* and *Doliches*).

Type 4. Spindle-shaped. Grain linear or lanceolate, tapering towards the pointed ends, or of equal width with blunt ends; when on end they appear almost circular (*Euphorbia*, none illustrated).

Type 5. Bone-shaped. Grain elongated and compressed from the narrow aspect, but linear spindle-shaped from the broad aspect, with enlarged laminated ends (*Euphorbia*, none illustrated).

II. Eccentric. Hilum usually more or less removed from the mathematical center of the grain; lamellae coarsest and finest at opposite ends of the grain, respectively.

Type 6. Inverted cone-shaped. Grain on end almost circular; slender at the hilum end (Plate 100, *Solanum tuberosum*).

Type 7. Cone-shaped. Grains on end almost circular; decidedly thicker and broader at the hilum end (Plate 35, *Scilla peruviana*).

Type 8. Wedge-shaped or compressed. Grains flattened, of equal thickness throughout,

or thicker but narrower at the hilum end than at the distal end (Plate 83, *Canna edulis*).

Type 9. Rod-shaped (Plate 63, *Iris florentina*, *I. pallida*).

III. Grains simple and structure obscure.

Type 10. Structure not fully developed, or not identified owing to diminutive size of the grains. Lamellae, hila, cavities, fissures, and clefts seldom observed (Plate 60, *Narcissus poeticus*).

B. Grains semi-compound.

Type 11. Grains semi-compound. The component part-grains are enveloped partly or wholly by a common substance (Plate 41, *Hyacinthus orientalis*).

C. Grains Compound. The component part-grains not enveloped by a common substance.

I. Composed of fused part-grains.

Type 12. Composed of fused part-grains. The part-grains are not separated by fissures, and even different grains may be fused with one another (Plate 80, *Zingiber officinale*).

II. Composed of separated part-grains. The part-grains separated by fissures.

Type 13. Grains in I or 2 rows. From 3 to 11 components arranged in I or 2 rows (Plate 10, *Polygonum fagopyrum*).

Type 14. Equally divided grains of few components. From 2 to 10 or more almost equal-size part-grains which when separated have I curved surface and 1 or more pressure facets (Plate 98, *Manihot* and Plate 100, *Batatas edulis*).

Type 15. Unequally divided grains of few components. From 2 to 10 or more unequal sized firmly united part-grains, which when separated have 1 curved surface and several flattened pressure facets (Plate 95, *Aconitum napellus*).

Type 16. Multiple grains. From 20 to many thousand firmly united part-grains which when separated are covered with pressure facets (Plate 2, *Oryza sativa*).

Type 17. Hollow spherical grains. The part-grains are arranged in a spherical layer, as if a globular shell had been divided radially (Algae, none illustrated).

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SCHLEIDEN'S (1849) CLASSIFICATION OF STARCH-GRAINS

I. Amorphous Starch.

II. Simple Grains. The majority of plants exhibit perfectly simple individual grains, among which doublets and triplets only occur as exceptions.

1. Roundish Bodies.
    - A. With the central cavity or hilum, apparently absent.
        - 1. Quite small, almost spherical granules.
        - 2. Large, irregular, knobby, often truncated multiangular grains.
    - B. With small roundish central cavities or hila.
        - (a) With a perceptible laminated formation.
            - 3. Very large, rough grains, deformed as it were.
            - 4. Ovoid granules.
            - 5. Mussel-like granules.
            - 6. Almost triangular.
        - (b) With an indistinct or deficient lamellated formation.
            - 7. Rounded-off polyhedric grains.
            - 8. Sharp-edged, polyhedric, very small grains.
        - (c) With an elongated central cavity.
            - 9. Roundish or oval grains, in a dry condition, generally showing a star-like cleft in the inner layers.
        - (d) Perfectly hollow, apparently cup-like grains.
            - 10. Very marked in the rhizome of *Iris florentina* and in kindred species.
2. Flatly compressed lenticular granules.
    - 11. Sometimes with, sometimes without, a decided lamellated formation; sometimes with a central, or eccentric, or less rounded, or more elongated, or radiated torn-up cavity or hilum.
3. Perfectly flat discs.
    - 12. With more distinct lamellae, in which it is, however, at times doubtful whether they pass entirely around or are only menisci laid over one another.
4. Elongated grains.
    - 13. With an elongated central cavity in the milk-juice of the indigenous and a few of the tropical Euphorbiaceae.
5. Very irregular grains.
    - 14. In the milky juice of many tropical Euphorbiaceae.

III. Compound Granules. Here we find a simple grain as an exception in the plant or part of the plant.

1. The separate grains in the compound grains without evident central cavity or hilum.
    15. Compounded according to the simplest types in 2, 3, or 4.
    16. Generally arranged regularly, seldom irregularly, and composed of from 2 to 6.
2. The separate grains in the compound grain having a distinct central cavity or hilum.
    (a) All the parts of the grains of nearly the same size.
        17. United according to simple types from 2 to 4. The central cavity or hilum small and roundish.
        18. Combined according to simple types from 2 to 4. The central cavity or hilum large and very beautiful, opened in a star-like form.
        19. Combined according to simple types from 2 to 4. The separate grains quite hollow, apparently cup-shaped.
        20. Firmly combined, from 2 to 12 in number, in very irregular groups.
        21. A large number, often as many as 30, of small roundish grains, very loosely grouped.
    (b) Many smaller grains grown together upon one larger one.
        22. In the pith of *Sagua rumphii*, etc., and generally in sago.

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WINTON'S CLASSIFICATION OF STARCHES

Winton (1906) records that the forms of the grains are so numerous, even in the same variety, as to forbid accurate classification, but that the following are the more striking:

1. Globular. The starch of the peanut and some grains of maize.

2. Lenticular. The large grains of wheat, rye, and barley.

3. Ellipsoidal. The starch of legumes.

4. Ovoid or pear-shaped. The starch of potato, canna, Bermuda arrowroot, yam, and banana.

5. Truncated. Most of the grains of cassava, batata, and sago.

6. Polygonal. The starch of maize, rice, oats, and buckwheat.

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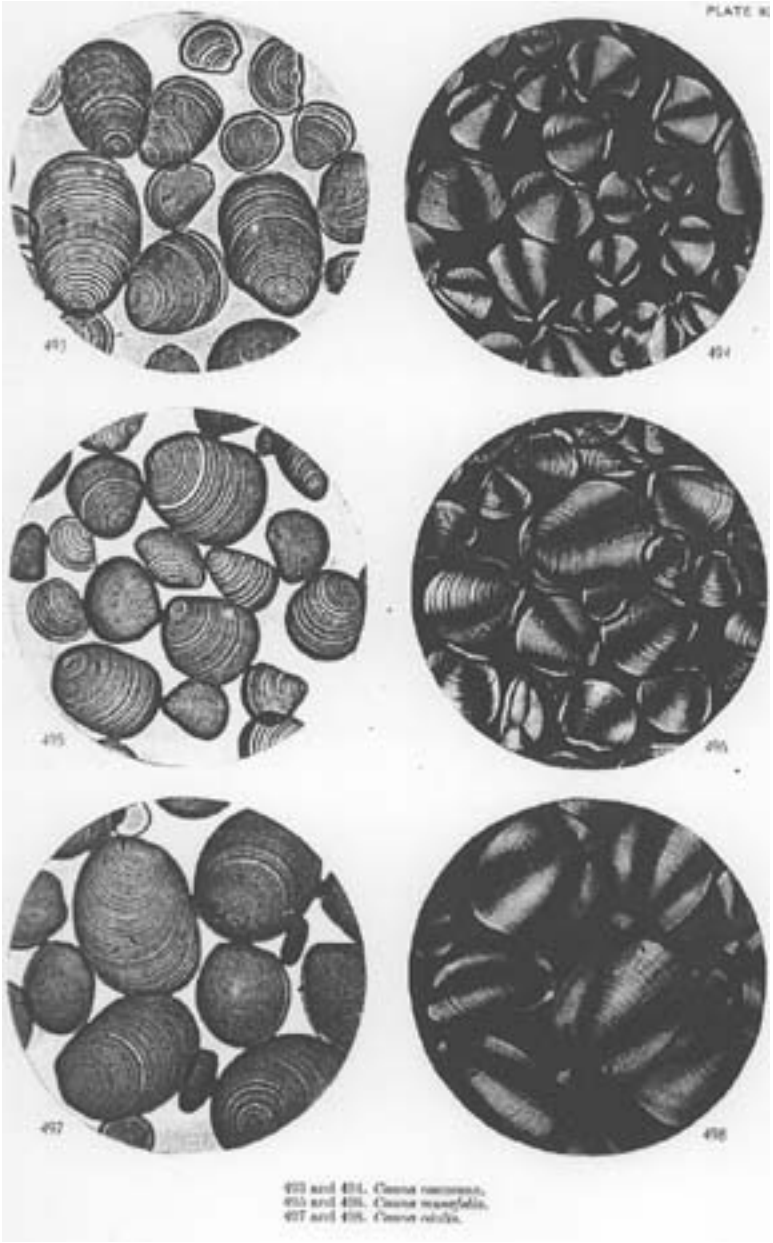

Canna Plate from Reichert (1913).
Polarized images are shown on the right.

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SEM micrograph of ancient *Solanum maglia* starch (ca. 11,000 b.c.). Specimen obtained from Monte Verde, Chile. [photo by D. Ugent]

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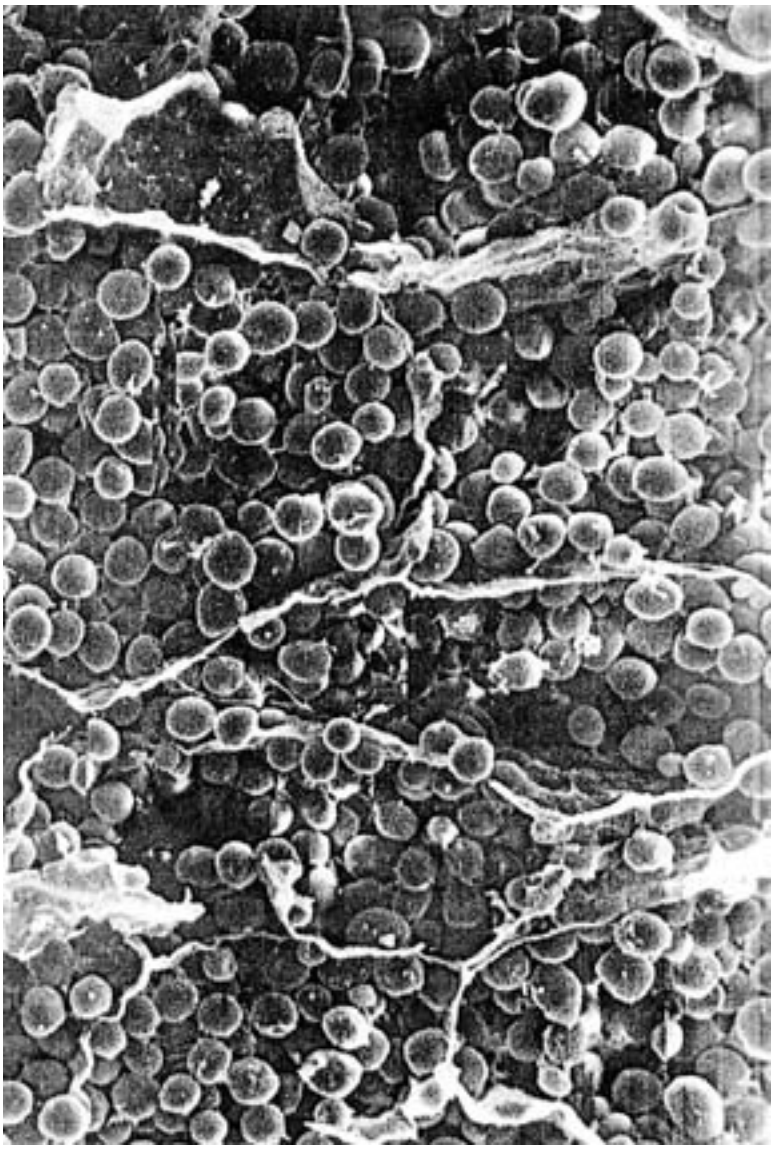

Archaeological maize starch (ca. 500 b.c.).
Peruvian specimen collected by Don Ugent
at the Paracas Necropolis.

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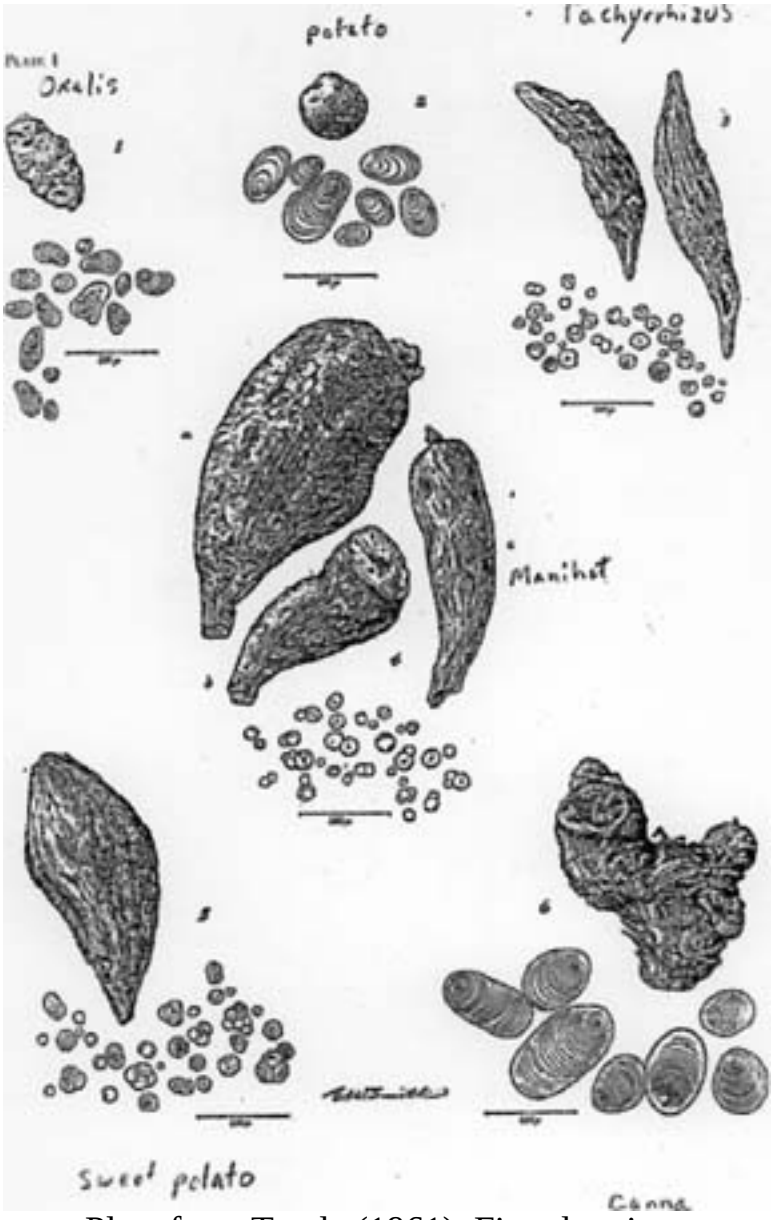

Plate from Towle (1961). First drawings of archaeological starch?

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URL: http://www.siu.edu/~ebl/towle.htm
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The Degrees of Polarization of Various Starches

Based on a scale running from 0 (or very low intensity) to 4 (very high).

Aconitum Napellus 1
Actaea alba 1
Actaea spicata var. rubra 1
Aesculus Hippocastanum 3
Alstroemeria aurantiaca (aurea) 4
Alstroemeria brasiliensis 3
Alstroemeria brasiliensis 4
Amaryllis belladonna major 3
Andropogon Sorgham var. (Shallu) 3
Andropogon Sorghum var. (W. K. Corn) 3
Andropogon Sorghum var. (Y. B. Sorgh.) 4
Anemone apennina 1
Anemone blanda 1
Anemone fulgens 2
Anemone japonica 2
Antholyza crocosmoides 3
Antholyza paniculata 3
Arachis hypogaea 3
Arisaema triphyllum 3
Arrhenatherum elatius var. 2
Arum cornutum 3
Arum italicum 3
Arum palaestinum 2
Avena sativa var. (Clydesdale) 2
Babiana var. (Athraction) 2
Babiana var. (violacea) 2
Batatas edulis 3
Brodiaea californica 3
Brodiaea coccinea 3
Brodiaea congesta 3
Brodiaea grandiflora 3
Brodiaea ixioides var. splendens 3
Brodiaea lactea 3

Brodiaea laxa 3
Brodiaea peduncularis 3
Brodiaea Purdyi 3
Brodiaea stellaris 3
Calathea Lietzei 2
Calathea vittata 3
Calathea Wiotiana 2
Calathea Wiotiana 3
Calochortus albus 3
Calochortus Benthami 4
Calochortus Leichtlinii 4
Calochortus lilacinus 4
Calochortus luteus var. oculatus 4
Calochortus Maweanus var. major 4
Calochortus nitidus 3
Calochortus splendens 3
Canna edulis 4
Canna Roscoeana 4
Canna var. (Jean Tissot) 3
Canna var. (Konigin Charlotte)3
Canna var. (L. D. Eisele) 4
Canna var. (L. F. Baily) 3
Canna var. (Mrs. Kate Grey) 4
Canna var. (President Carnot) 3
Canna Warscewiczii 4
Castanea americana 3
Castanea pumila 3
Castanea sativa var. 3
Castanea sativa var. numbo 3
Chionodoxa Lucillae 3
Chionodoxa sardensis 3
Chionodoxa Tmolusi 3
Cimicifuga racemosa 1
Cochlearia Armoracia 2
Cochlearia Armoracia 3
Colchicum Parkinsoni 3
Convallaria majalis 2
Crinum americanum 4
Crinum fimbriatulum 4
Crocus Susianus (Cloth of Gold) 3
Crocus var. (Baron von Brunow) 3
Crocus versicolor (Cloth of Silver) 3
Curcuma longa 2

Curcuma petiolata 3
Cycas circinalis 3
Cycas revoluta 3
Cyclamen coum 3
Cyclamen repandum 3
Cypella Herberti 2
Dieffenbachia illustris (pith) 4
Dieffenbachia segaine var. maculata (cortex) 3
Dieffenbachia seguine var. irrorata (cortex) 2
Dieffenbachia seguine var. irrorata (pith) 3
Dieffenbachia seguine var. maculata (pith) 4
Dieffenbachia seguine var. nobilis (cortex) 2
Dieffenbachia seguine var. nobilis (pith) 3
Dieffenbachis illustris (cortex) 3
Dioon edule 3
Dolichos Lablab 2
Dracunculus vulgaris 3
Eranthus hyemalis 3
Erythronium americanum 3
Erythronium californicum 3
Erythronium citrinum 3
Erythronium Dens-canis 2
Erythronium Dens-canis var. grand. 3
Erythronium grandiflorum 2
Freesia refracta var. alba 3
Freesia refracta var. Leichtlinni 3
Fritillaria armena 3
Fritillaria aurea 3
Fritillaria imperialis var. Aurora 3
Fritillaria liliacea 3
Fritillaria pudica 3
Fritillaria pyrenalca 3
Fritillaria recurva 4
Galanthus Elwesii 3
Galanthus nivalis 3
Galtonia candicans 4
Gelasine azurea 3
Gesneria tubiflora 3
Gladiolus byzantinus 3
Gladiolus cardinalis (Blushing Bride) 3
Gladiolus floribundus 3
Gladiolus primulinus 3
Gloxinia var. 3

Haemanthus Katherinae 3
Hedychium coronarium 1
Hedychium Gardnerianum 0
Hippeastrum aulicum var. robustum 3
Hippeastrum equestre 3
Hippeastrum vittatum 3
Homeria collina 3
Hordeum sativum var. (Champion) 2
Hyacinthus orientalis var. alba superba 3
Hyacinthus orientalis var. albulus (Italian) 3
Hymenocallis undulata 3
Iris alata 4
Iris Bismarkiana 3
Iris caucasica 4
Iris florentina 2
Iris Histrio 4
Iris iberica 3
Iris pallida var. speciosa 3
Iris pumila var. cyanea 3
Iris reticulata 4
Iris tingitana 4
Iris xiphium var. Grand Tresorier 4
Iris xiphium var. lusitanica 4
Iris xiphium. var. Wilhelmine 4
Ixia speciosa 2
Ixia var. (Emma) 3
Ixia viridiflora 2
Jatropha Curcas 4
Lachenalia pendula 2
Lachenalia tricolor var. luteola 2
Lathyrus latifolius var. albus 3
Lathyrus magellanicus var. albus 3
Lathyrus odoratus var. Shahzada 3
Lathyrus sylvestris 2
Lens esculenta 4
Leucojum aestivum 3
Leucojum vernum 3
Lilium auratum 3
Lilium candidum 3
Lilium longiflorum var. eximium 3
Lilium longiflorum var. giganteum 3
Lilium martagon 3
Lilium Parryi 3

Lilium philadelphicum 3
Lilium rubellum 3
Lilium speciosum var. album 3
Lilium superbum 3
Lilium tenuifolium 3
Lilium tigrinum var. splendens 3
Lillum Henryi 4
Manihot utilissima 3
Maranta arundinacea 3
Maranta arundinacea var. No. 1 3
Maranta arundinacea var. No. 2 3
Maranta leuconeura 3
Maranta Massangeana 3
Maranta musaica 3
Marica gracilis 0
Moraea tristis 3
Mucuna pruriens 4
Musa Cavendishii (green fruit) 2
Musa Cavendishii 1
Muscari botryoides 3
Muscari commutatum 3
Muscari comosum 3
Muscari compactum 3
Muscari micranthum 3
Muscari paradoxum 3
Narcissus biflorus 3
Narcissus Bulbocodium 3
Narcissus Bulbocodium var. monophyllus 3
Narcissus Bulbocodium. var. conspicuus 3
Narcissus Horsfieldii 3
Narcissus incomparabilis 3
Narcissus Jonquilla 3
Narcissus Jonquilla var. Campernelli rug 3
Narcissus Jonquilla var. rugulosus 4
Narcissus maximus 3
Narcissus odorus 3
Narcissus poeticus 3
Narcissus tazetta var. orientalis 3
Nelumbo lutes 3
Nelumbo nucifera 3
Nymphaea alba 3
Nymphaea Gladstoniana 3
Nymphaea marliacea. var. albida 3

Nymphaea odorata 3
Nymphaea odorata var. rosea 3
Nymphaes marliacea var. carnea 3
Ornithogalum narbonense (pyramidale) 3
Ornithogalum nutans 3
Ornithogalum thyrsoides var. aureum 4
Ornithogalum umbellatum 3
Oryza sativa var. 2
Panicum Crus-galli var. 2
Phaseolus lunatus var. (H.'s B. Lima) 3
Phaseolus vulgaris var. (Red K. Bean) 3
Pisum sativum var. (Elec. E. Early) 3
Pisum sativum var. (Eugenie green) 1
Pisum sativum var. (Eugenie yellow) 2
Pisum sativum var. (L. W. Marrowfat) 3
Pisum sativum var. (Mam. G. Seeded) 2
Pisum sativum var. (Thos. Laxton) 1
Polygonum Fagopyrum var. (American) 3
Polygonum Fagopyrum var. (Japanese) 3
Puschkinia scilloides 3
Puschkinia scilloides var. libanotica 3
Quercus alba 3
Quercus Muhlenbergii 3
Quercus Prinus 3
Quercus rubra 2
Quercus texana 3
Ranunculus bulbosus 1
Ranunculus Ficaria 3
Richardia africana 0
Richardia albo-maculata 2
Richardia Elliotiana 2
Romulea rosea var. speciosa 3
Scilla bifolia 3
Scilla peruviana 3
Scilla sibirica 3
Secale cereale var. (Mammoth Winter) 2
Secale cereale var. (Spring) 3
Solanum tuberosum 4
Sparaxis grandiflora var. alba 3
Sparaxis var. (Albertine)3
Sprekelia formosissima 3
Sternbergia lutes 3
Stromanthe sanguinea 3

Tacca pinnatifida 3
Tigridia Pavonia var. conchiflora 1
Tigridia Pavonia var. grandiflora alba 1
Trianosperma ficifolia 3
Trillium grandiflorum 2
Trillium ovatum 2
Trillium sessile var. californicum 2
Triteleia uniflora 3
Triticum sativum var. dicoccum 1
Triticum sativum var. vulgare 1
Tritonia crocata 2
Tritonia crocata var. lilacina 3
Tritonia crocata var. rosea 3
Tritonia crocosmaeflora 3
Tritonia Pottsii 3
Tritonia securigera 3
Tulipa australis 3
Tulipa Billietiana 3
Tulipa Clusiana 3
Tulipa Clusiana var. persica 3
Tulipa Didieri 3
Tulipa Didieri var. Fransoniana 3
Tulipa Didieri var. Mauriana 3
Tulipa Greigi 3
Tulipa Hageri 3
Tulipa oculus-solis 3
Tulipa praecox 3
Tulipa sylvetris 3
Vallota purpurea 3
Vicia Faba 3
Vicia fulgens 4
Vicia Gerardi 4
Vicia sativa 3
Vicia villosa 3
Vicia villossa 4
Vucia Faba 4
Watsonia humilis 3
Watsonia iridifolia var. O'Brieni 3
Watsonia Meriana 3
Wistaria chinensis 3
Zamia integrifolia 4
Zea Mays var. everta (Golden Queen) 3
Zea Mays var. everta (White Rice) 3

Zea Mays var. indentata (H. King) 3
Zea Mays var. indentata. (E'y L'g) 3
Zea Mays var. indurata (C.'s Early) 3
Zea Mays var. indurata (N. Dakota) 3
Zea Mays var. saccharata (B. Mex.) 2
Zea Mays var. saccharata (G. B'm) 3
Zea Mays var. saccharata (S.'s E'n) 3
Zephyranthes candida 3
Zephyranthes rosea 3
Zingiber officinale var. Cochin 1
Zingiber officinale var. Jamaica No. 2 1
Zingiber officinale var. Jamaica No. I 1

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The Iodine Reaction of Various Starches

Based on a scale running from 0 (no coloration or very light) to 4 (very dark).

Aconitum Napellus 4
Actaea alba 4
Actaea spicata var. rubra 4
Adonis amurensis 3
Aesculus Hippocastanum 3
Alstroemeria aurantiaca (aurea) 4
Alstroemeria brasiliensis 4
Alstroemeria ligtu 4
Amaryllis belladonna major 3
Andropogon Sorghum var. (Shallu) 3
Andropogon Sorghum var. (W. K. Corn) 3
Andropogon Sorghum var. (Y. I. Sorgh.) 3
Anemone apennina 4
Anemone blanda 4
Anemone fulgens 4
Anemone japonica 4
Antholyza crocosmoides 1
Antholyza paniculata 1
Arachis hypogaea 3
Arisaema triphyllum 3
Arrhenatherum elatius var. 1
Arum cornutum 4
Arum italicum 3
Arum palaestinum 3
Avena sativa var. (Clydesdale) 1
Babiana var. (Athraction) 1
Babiana var. (violacea) 1
Batatas edulis 4
Brodiaea californica 3
Brodiaea candida 3
Brodiaea capitata 4
Brodiaea coccinea 4
Brodiaea congesta 3

Brodiaea grandiflora 4
Brodiaea ixioides var. splendens 3
Brodiaea lactea 4
Brodiaea laxa 4
Brodiaea peduncularis 3
Brodiaea Purdyi 4
Brodiaea stellaris 3
Calathea Lietzei 3
Calathea Vandenheckei 2
Calathea vittata 2
Calathea Wiotiana 3
Calochortus albus 4
Calochortus Benthami 4
Calochortus Howellii 4
Calochortus Leichtlinii 4
Calochortus lilacinus 4
Calochortus luteus var. oculatus 4
Calochortus Maweanus var. major 4
Calochortus nitidus 4
Calochortus splendens 4
Canna edulis 4
Canna musaefolia 3
Canna Roscoeana 4
Canna var. (J. D. Eisele) 3
Canna var. (Jean Tissot) 3
Canna var. (Konigin Charlotte) 3
Canna var. (L. E. Baily) 3
Canna var. (Mrs. Kate Grey) 4
Canna var. (President Carnot) 3
Canna Warscewiezii 3
Castanea americana 3
Castanea pumila 3
Castanea sativa var. 3
Castanea sativa var. numbo 3
Chionodoxa Lucillae 3
Chionodoxa sardensis 3
Chionodoxa Tmolusi 3
Cimicifuga racemosa 3
Cochlearia Armoracia 4
Colchicum Parkinsoni 2
Convallaria majalis 3
Crinum americanum 4
Crinum fimbriatulum 3

Crocus Susianus (Cloth of Gold) 3
Crocus var. (Baron von Brunow) 3
Crocus versicolor (Cloth of Silver) 3
Curcuma longa 1
Curcuma petiolata 2
Cycas circinalis 3
Cycas revoluta 3
Cyclamen cou 4
Cyclamen repandum 3
Cypella Herberti 3
Dieffenbachia illustris (cortex) 3
Dieffenbachia illustris (pith) 4
Dieffenbachia seg. var. irror. (cort.) 3
Dieffenbachia seg. var. irror. (pith) 3
Dieffenbachia seg. var. mac. (cort.) 4
Dieffenbachia seg. var. mac. (pith 4
Dieffenbachia seg. var. nob. (cort.) 3
Dieffenbachia seg. var. nob. (pith) 3
Dioon edule 3
Dolichos Lablab 2
Dracunculus vulgaris 4
Eranthis hyemalis 3
Erythronium americanum 3
Erythronium californicum 3
Erythronium citrinum 3
Erythronium Dens-canis 3
Erythronium Dens-canis var. grand. 3
Erythronium grandiflorum 3
Freesia refracta var. alba 3
Freesia refracta var. Leichtlinii 4
Fritillaria armena 2
Fritillaria aurea 3
Fritillaria liliacea 3
Fritillaria meleagris 3
Fritillaria pudica 3
Fritillaria pyrenaica 3
Fritillaria recurva 3
Galanthus Elwesii 4
Galanthus nivalis 3
Galtonia candicans 3
Gelasine azurea 3
Gesneria tubiflora 4
Gladiolus byzantinus 3

Gladiolus cardinalis (Blushing Bride) 3
Gladiolus floribundus 3
Gladiolus primulinus 3
Gloxinia var. 3
Haemanthus Katherinae 3
Hedychium coronarium 2
Hedychium Gardnerianum 2
Hippeastrum aulicum var. robustum 4
Hippeastrum equestre 4
Hippeastrum vittatum 4
Homeria collina 3
Hordeum sativum var. (Champion) 1
Hyacinthus orient. var. (Italian) 3
Hyacinthus orient. var. alba superb. 3
Hyacinthus orient. var. albulus (white) 3
Hymenocallis calathina 4
Hymenocallis undulata 3
Iris alata 3
Iris Bismarckidana 3
Iris caucasica 3
Iris florentina 3
Iris Histrio 3
Iris iberica 3
Iris pallida speciosa 3
Iris pumila var. cyanea 3
Iris reticulata 3
Iris tingitana 3
Iris xiphium var. Grand Tresorier 3
Iris xiphium var. lusitanica 3
Iris xiphium var. Wilhelmine 3
Ixia speciosa 3
Ixia var. (Emma) 3
Ixia viridiflora 3
Jatropha Cureas 3
Lachenalia pendula 3
Lachenalia tricolor var. luteola 3
Lathyrus latifolius var. albus 3
Lathyrus magellanicus var. albus 2
Lathyrus odoratus var. Shahzada 2
Lathyrus sylvestris 3
Lens esculenta 3
Leucojum aestivum 4
Leucojum vernum 3

Lilium auratum 3
Lilium candidum 3
Lilium Henryi 3
Lilium longiflorum var. eximium 3
Lilium longiflorum var. giganteum 3
Lilium martagon 3
Lilium pardalinum 3
Lilium Parryi 3
Lilium philadelphicum 3
Lilium puberulum 3
Lilium rubellum 3
Lilium speciosum var. album 4
Lilium superbum 4
Lilium tenuifolium 3
Lilium tigrinum var. splendens 4
Manihot utilissima 1
Maranta arundinacea 3
Maranta arundinacea var. No. 1 3
Maranta arundinacea var. No. 2 3
Maranta leuconeura 3
Maranta Massangeana 3
Maranta musaica 3
Moraea tristis 3
Mucuna pruriens 3
Musa Cavendishii (green fruit) 4
Musa Cavendishii 3
Musa ensete 4
Musa sapientum 4
Muscari botryoides 3
Muscari commutatum 3
Muscari comosum 3
Muscari compactum 3
Muscari conicum 3
Muscari micranthum 3
Muscari paradoxum 3
Muscari racemosum 3
Narcissus biflorus 4
Narcissus Bulbo var. conspicuus 4
Narcissus bulbo var. monophyllus 3
Narcissus Bulbocodium 4
Narcissus Horsfieldii 3
Narcissus incomparabilis 3
Narcissus Jonquilla 3

Narcissus Jonquilla var. Campernelli rug. 4
Narcissus Jonquilla var. rugulosus 4
Narcissus maximus 4
Narcissus odorus 4
Narcissus poeticus 4
Narcissus tazetta var. orientalis 3
Nelumbo lutea 3
Nelumbo nucifera 3
Nymphaea alba 2
Nymphaea Gladstoniana 1
Nymphaea marliacea var. albida 2
Nymphaea marliacea var. carnea 2
Nymphaea odorata 2
Nymphaea odorata var. rosea 2
Ornithogalum narbonense pyrimadale 3
Ornithogalum nutans 3
Ornithogalum thyrsoides var. aureum 3
Ornithogalum umbellatum 3
Oryza sativa var. 1
Panicum Crus-galli var. 1
Phaseolus limatus var. (H.'s B. Lima) 3
Phaseolus vulgaris var. (Red K. Bean) 3
Pisum sativum var. (Elec. E. Early) 2
Pisum sativum var. (Eugenie green) 2
Pisum sativum var. (Eugenie yellow) 2
Pisum sativum var. (L. W. Marrow-fat) 3
Pisum sativum var. (Mam. G. Seeded) 3
Pisum sativum var. (Thos. Laxton) 1
Polygonum Fagopyrum var. (American) 1
Polygonum Fagopyrum var. (Japanese) 1
Pritillaria imperialis var. Auro 3
Puschkinia scil. var. libanotica 4
Puschkinia scilloides 3
Quercus alba 2
Quercus Muhlenbergii 2
Quercus Prinus 2
Quercus rubra 2
Quercus texana 2
Ranunculus bulbosus 3
Ranunculus Ficaria 4
Richardia africana 3
Richardia albo-maculata 4
Richardia Elliotiana 3

Romulea rosea var. speciosa 1
Scilla bifolia 3
Scilla peruviana 3
Scilla sibirica 3
Secale cereale var. (Mammot Winter) 3
Secale cereale var. (Spring) 3
Solanum tuberosum 4
Sparaxis grandiflora alba 3
Sparaxis var. (Albertine) 3
Sprekelia formosissima 3
Sternbergia lutea 3
Stromanthe sanguinea 1
Tacca pinnatifida 3
Tigridia Pavonia var. conchiflora 3
Tigridia Pavonia var. grand. alba 3
Trianosperma ficifolia 4
Trillium grandiflorum 3
Trillium ovatum 4
Trillium sessile var. californicum 3
Triteleia uniflora 3
Triticum sativum var. dicoccum 3
Triticum sativum var. vulgare 2
Tritonia crocata 2
Tritonia crocata var. lilacina 3
Tritonia crocata var. rosea 3
Tritonia crocosmaeflora 2
Tritonia Pottsii 1
Tritonia securigera 2
Tulipa australis 3
Tulipa Billietiana 3
Tulipa Clusiana 3
Tulipa Clusiana var. persica 4
Tulipa Didieri 3
Tulipa Didieri var. Fransoniana 3
Tulipa Greigi 4
Tulipa Hageri 3
Tulipa oculus-solis 3
Tulipa sylvestris 4
Tulips praecox 3
Tullpa Didieri var. mauriana 3
Vallota purpurea 2
Vicia Faba 3
Vicia fulgens 3

Vicia Gerardi 3
Vicia sativa 3
Vicia villosa 3
Watsonia humilis 1
Watsonia iridifolia var. O'Brieni 2
Watsonia Meriana 1
Wistaria chinensis 3
Zamia integrifolia 1
Zea Mays var. everta (Golden Queen) 3
Zea Mays var. everta (White Rice) 3
Zea Mays var. indentata (E'y L'g) 3
Zea Mays var. indentata (H. King) 3
Zea Mays var. indurata (C.'s Early) 3
Zea Mays var. indurata (N. Dakota) 3
Zea Mays var. saccharata (B. Mex.) 3
Zea Mays var. saccharata (G. B'm) 3
Zea Mays var. saccharata (S.'s E'n) 3
Zephyranthes candida 3
Zephyranthes rosea 3
Zingiber offic. var. Cochin 3
Zingiber offic. var. Jamaica No. 1 3
Zingiber offic. var. Jamaica No. 2 3
Zingiber officinale 3

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The Chloral Hydrate-Iodine Reaction of Various Starches

Relative times for gelatinization based on a scale running from 0 to 11, where 11=60 or more minutes.

Aconitum Napellus 0
Actaea alba 0
Actaea spicata var. rubra 0
Adonis amurensis 0
Aesculus Hippocastanum 1
Alstroemeria aurantiaca (aurea) 3
Alstroemeria brasiliensis 1
Alstroemeria ligtu 1
Amaryllis belladonna major 1
Andropogon Sorghum var. (Shallu) 3
Andropogon Sorghum var. (W. K. Corn) 2
Andropogon Sorghum var. (Y. B. Sorgh.) 2
Anemone apennina 0
Anemone blanda 0
Anemone fulgens 0
Anemone japonica 0
Antholyza crocosmoides 11
Antholyza paniculata 11
Arachis hypogaea 0
Arisaema triphyllurn 5
Arrhenatherum elatius var. 1
Arum cornutum 0
Arum italicum 5
Arum palaestinum 1
Avena sativa var. (Clydesdale) 1
Babiana var. (Athraction) 11
Babiana var. (violacea) 11
Batatas edulis 11
Brodiaea californica 11
Brodiaea candida 6
Brodiaea capitata 11
Brodiaea coccinea 11
Brodiaea congesta 11

Brodiaea grandiflora 11
Brodiaea ixioides var. splendens 11
Brodiaea lactea 8
Brodiaea laxa 6
Brodiaea peduncuIaris 11
Brodiaea Purdyi 11
Brodiaea stellaris 11
Calathea Lietzei 11
Calathea Vandenbeckei 11
Calathea vittata 11
Calathea Wiotiana 11
Calochortus albus 1
Calochortus Benthami 0
Calochortus Howellii 1
Calochortus Leichtlinii 1
Calochortus lilacina 0
Calochortus luteus var. oculatus 1
Calochortus Maweanus var. major 1
Calochortus nitidus 0
Calochortus splendens 1
Canna edulis 0
Canna musaefolia 1
Canna Roscoeana 0
Canna var. (J. D. Eisele) 0
Canna var. (Jean Tissot) 0
Canna var. (Konigin Charlotte) 0
Canna var. (L. E. Baily) 0
Canna var. (Mrs. Kate Grey) 0
Canna var. (President Carnot) 0
Canna Warscewiezii 0
Castanea americana 0
Castanea pumila 0
Castanea sativa var. 0
Castanea sativa var. numbo 0
Chionodoxa Lucillae 2
Chionodoxa sardensis 2
Chionodoxa Tmolusi 1
Cimicifuga racemosa 0
Cochlearia Armoracia 0
Colchicum Parldnsoni 9
Convallaria majalis 0
Crinum americanum 2
Crinum fimbriatulum 5

Crocus Susianus (Cloth of Gold) 0
Crocus var. (Baron von Brunow) 0
Crocus versicolor (Cloth of Silver) 1
Curcuma longa 1
Curcuma petiolata 1
Cycas circinalis 11
Cycas revoluta 11
Cyclamen coum 0
Cyclamen repandum 0
Cypella Herberti 5
Dieffenbachia illustris (cortex) 11
Dieffenbachia illustris (pith) 11
Dieffenbachia seg. var. irror. (cort.) 4
Dieffenbachia seg. var. irror. (pith) 7
Dieffenbachia seg. var. mac. (pith) 11
Dieffenbachia seg. var. mac. (port.) 11
Dieffenbachia seg. var. nob. (cort.) 2
Dieffenbachia seg. var. nob. (pith) 5
Dioon edule 11
Dolichos Lablab 11
Dracunculus vulgaris 1
Eranthis hyemalis 0
Erythronium americanum 0
Erythronium californicum 1
Erythronium citrinum 0
Erythronium Dens-canis 0
Erythronium Dens-canis var. grand. 0
Erythronium grandiflorum 0
Freesia refracta var. alba 11
Freesia refracts var. Leichtlinii 11
Fritillaria armena 1
Fritillaria aurea 1
Fritillaria imperialis var. Aurora 2
Fritillaria liliacea 0
Fritillaria meleagris 0
Fritillaria pudica 0
Fritillaria pyrenaica 1
Fritillaria recurva 2
Galanthus Elwesii 5
Galanthus nivalis 2
Galtonia candicans 1
Gelasine azurea 11
Gesneria tubiflora 11

Gladiolus byzantinus 11
Gladiolus cardinalis (Blushing Bride) 11
Gladiolus floribundus 2
Gladiolus primulinus 11
Gloxinia var. 0
Haemanthus Katherinae 0
Hedychium coronarium 0
Hedychium Gardnepanum 0
Hippeastrum aulicum var. robustum 9
Hippeastrum equestre 11
Hippeastrum. vittatum 11
Homeria collina 11
Hordeum sativum var. (Champion) 11
Hyacinthus orient. var. albulus 2
Hyacinthus orientalis var. alba superb. 0
Hyacinthus orientalis var. albulus (white) 0
Hymenocallis caIathina 0
Hymenocallis undulata 1
Iris alata 5
Iris Bismarckiana 0
Iris caucasica 2
Iris florentina 0
Iris Histrio 11
Iris iberica 2
Iris pallida speciosa 2
Iris pumila var. cyanea 2
Iris reticulata 7
Iris tingitans 4
Iris xiphium var. Grand Tresorier2
Iris xiphium var. lusitanica 2
Iris xiphium var. Wilhelmine 2
Ixia speciosa 5
Ixia var. (Emma) 5
Ixia viridiflora 5
Jatropha Cureas 0
Lachenalia pendula 5
Lachenalia tricolor var. luteola 8
Lathyrus latifolius var. albus 5
Lathyrus magellanicus var. albus 11
Lathyrus odoratus var. Shahzada 11
Lathyrus sylvestris 5
Lens esculenta 11
Leucojum aestivuin 5

Leucojum vernum 5
Lilium auratum 3
Lilium candidum 2
Lilium Henryi 2
Lilium longifforum var. giganteum 2
Lilium longiflorum var. eximium 1
Lilium martagon 0
Lilium pardalinum 0
Lilium Parryi 0
Lilium philadelphicum 1
Lilium puberulum 2
Lilium rubellum 1
Lilium speciosum var. album 0
Lilium superbum 1
Lilium tenuifolium 1
Lilium tigrinum var. splendens 0
Manihot utilissima 11
Maranta arundinacea 11
Maranta arundinacea var. No. 2 11
Maranta arundinacea var. No. I 11
Maranta leuconeura 11
Maranta Massangeana 11
Maranta musaica 11
Marica gracilis 11
Moraea tristis 11
Mucuna pruriens 11
Musa Cavendishii (green fruit) 0
Musa Cavendishii 0
Musa ensete 1
Musa sapientum 0
Muscari botryoides 3
Muscari commutatum 5
Muscari comosum 5
Muscari compactum 5
Muscari conicum 11
Muscari micranthum 3
Muscari paradoxum 11
Muscari racemosum 9
Narcissus biflorus 11
Narcissus Bulbocodium 11
Narcissus Bulbocodium var. conspicuus 11
Narcissus Bulbocodium. var. monophyllus 11
Narcissus Horsfieldii 11

Narcissus incomparabilis 11
Narcissus Jonquilla 8
Narcissus Jonquilla var. Campernelli rug. 11
Narcissus Jonquilla var. rugulosus 11
Narcissus maximus 11
Narcissus odorus 11
Narcissus poeticus 11
Narcissus tazetta var. orientalis 11
Nelumbo lutea 0
Nelumbo nucifera 0
Nymphaea alba 11
Nymphaea Gladstoniana 11
Nymphaea marliacea var. albida 11
Nymphaea marliacea var. carnea 11
Nymphaea odorata 11
Ornithogalum narbonense (pyramidale) 1
Ornithogalum nutans 1
Ornithogalum thyrsoides var. aureum 0
Ornithogalurn umbellatum 1
Oryza sativa 3
Panicum Crus-galli var. 2
Phaseolus lunatus var. (H.'s B. Lima) 11
Phaseolus vulgaris var. (Red K. Bean) 11
Pisum sativum var. (Eugenie green) 0
Pisum sativum var. (L. W. Marrowfat) 11
Pisum sativum var. (Mam. G. Seeded) 11
Pisum sativum. var. (Elec. E. Early) 11
Pisum sativum. var. (Eugenie yellow) 0
Pisum sativum. var. (Thos. Laxton) 0
Polygonum Fagopyrum var. (Japanese) 0
Polygonum. Fagopyrum var. (American) 0
Puschldnia scilloides 1
Puschldnia scilloides var. libanoti 2
Quercus alba 0
Quercus Muhlenbergii 1
Quercus Prinus 0
Quercus rubra 0
Quercus texana 0
Ranunculus bulbosus 0
Ranunculus Ficaria 0
Richardia africana 0
Richardia albo-maculata 1
Richardia Elliotiana 3

Romulea rosea var. speciosa 11
Scilla bifolia 2
Scilla peruviana 2
Scilla sibirica 2
Secale cereale var. (Mammoth Winter) 3
Secale cereale var. (spring)1
Solanum tuberosum 8
Sparaxis grandiflora alba 0
Sparaxis var. (Albertine) 0
Sprekelia formosissima 1
Sternbergia lutea 11
Stromanthe sanguinea 2
Tacca pinnatifida 11
Tigridia Pavonia var. conchiflora 1
Tigridia Pavonia var. grand. alba 2
Trianosperma ficifolia 0
Trillium grandiflorum 0
Trillium ovatum 0
Trillium sessile var. californicum 0
Triteleia uniflora 11
Triticum sativum var. vulgare 11
Triticum sativum. var. dicoccum 11
Tritonia crocata 4
Tritonia crocata var. lilacina 5
Tritonia crocata var. rosea 4
Tritonia crocosmaeflora 11
Tritonia Pottsii 11
Tritonia securigera 5
Tulipa australis 1
Tulipa Billietiana 2
Tulipa CIusiana 1
Tulipa Clusiana var. pergica. 1
Tulipa Didieri 3
Tulipa Didieri var. Fransoniana 2
Tulipa Didieri var. mauriana 3
Tulipa Hageri Tulipa Greigi 1
Tulipa oculus-solis 1
Tulipa praecox 3
Tulipa sylvestris 2
Vallota purpurea 11
Vicia Faba 11
Vicia fulgens 11
Vicia Gerardi 11

Vicia sativa 11
Vicia villosa 11
Watsonia humilis 3
Watsonia iridifolia var. O'Brieni 2
Watsonia Meriana 3
Wistaria chinensis 0
Zamia integrifolia 11
Zea Mays var. everta (Golden Queen) 0
Zea Mays var. everta (White Rice) 0
Zea Mays var. indentata (E'y L'g) 1
Zea Mays var. indentata (H. King) 1
Zea Mays var. indurata (C.'s Early) 1
Zea Mays var. indurata (N. Dakota) 1
Zea Mays var. saccharata (B. Mex.) 1
Zea Mays var. saccharata (G. B'm) 1
Zea Mays var. saccharata (S.'s E'n) 1
Zephyranthes candida 11
Zephyranthes rosea 11
Zingiber officinale 0
Zingiber officinale var. Cochin 11
Zingiber officinale var. Jamaica No. 1 11
Zingiber officinale var. Jamaica No. 2 1

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The Purdy's Solution (KOH) Reactions of Various Starches

Based on a graduated scale running from 0 to 11, where 11=60 or more minutes for gelatinization.

Aconitum Napellus 0
Actaea alba 0
Actaea spicata var. rubra 0
Adonis amurensis 0
Aesculus Hippocastanum 3
Alstroemeria aurantiaca (aurea) 0
Alstroemeria brasiliensis 0
Alstroemeria ligtu 0
Amaryllis belladonna major 2
Andropogon Sorghum var. (Shallu) 11
Andropogon Sorghum var. (W. K. Corn) 11
Andropogon Sorghum var. (Y. B. Sorgh.) 11
Anemone apennina 0
Anemone blanda 0
Anemone fulgens 0
Anemone japonica 0
Antholyza crocosmoides 11
Antholyza paniculata 11
Arachis hypogaea 3
Arisaema triphyllum 11
Arrhenatherum elatius var. 11
Arum cornutum 11
Arum italicum 11
Arum palaestinum 11
Avena sativa var. (Clydesdale) 11
Babiana var. (Athraction) 1
Babiana var. (violacea) 3
Batatas edulis 11
Brodiaea californica 11
Brodiaea candida 11
Brodiaea capitata 11
Brodiaea coccinea 11
Brodiaea congesta 11

Brodiaea grandiflora 11
Brodiaea ixioides var. splendens 11
Brodiaea lactea 11
Brodiaea laxa 11
Brodiaea peduncularis 11
Brodiaea Purdyi 11
Brodiaea stellaris 11
Calathea Lietzei 3
Calathea Vandenheckei 7
Calathea vittata 1
Calathea Wiotiana 1
Calochortus albus 0
Calochortus Benthami 0
Calochortus Howellii 0
Calochortus Leichtlinii 0
Calochortus lilacinus 0
Calochortus luteus var. oculatus 0
Calochortus Maweanus var. major 0
Calochortus nitidus 0
Calochortus splendens 0
Canna edulis 3
Canna musaefolia 3
Canna Roscoeana 2
Canna var. (J. D. Eisele) 2
Canna var. (Jean Tissot) 3
Canna var. (Konigin Charlotte) 2
Canna var. (Mrs. Kate Grey) 2
Canna var. (President Carnot) 1
Canna Warscewiczii Canna var. (L. E. Baily) 4
Castanea americans 0
Castanea pumila 0
Castanea sativa var. 0
Castanea sativa var. numbo 0
Chionodoxa Lucillae 0
Chionodoxa sardensis 0
Chionodoxa Tmolusi 1
Cimicifuga racemosa 0
Cochlearia Armoracia 0
Colchicum Parkinsoni 11
Convallaria majalis 0
Crinum americanum 11
Crinum fimbriatulum 11
Crocus Susianus (Cloth of Gold) 5

Crocus var. (Baron von Brunow) 11
Crocus versicolor (Cloth of Silver) 11
Curcuma longa 0
Curcuma petiolata 0
Cycas circinalis 7
Cycas revoluta 11
Cyclamen couni 2
Cyclamen repandum 1
Cypella Herberti 11
Dieffenbachia illustris (cortex) 11
Dieffenbachia illustris (pith) 11
Dieffenbachia seg. var. irror. (cort.) 11
Dieffenbachia seg. var. irror. (pith) 11
Dieffenbachia seg. var. mac. (cort.) 11
Dieffenbachia seg. var. mac. (pith) 11
Dieffenbachia seg. var. nob. (cort.) 11
Dieffenbachia seg. var. nob. (pith) 11
Dioon edule 0
Dolichos Lablab 11
Dracunculus vulgaris 11
Eranthis hyemalis 0
Erythronium americanum 0
Erythronium californicum 0
Erythronium citrinum 0
Erythronium Dens-canis 0
Erythronium Dens-canis var. grand. 0
Erythronium grandiflorum 0
Freesia refracta var. alba 11
Freesia refracta var. Leichtlinii 11
Fritil1aria pyrenaica 0
Fritillaria armena 0
Fritillaria aurea 0
Fritillaria imperialis var. Aurora 1
Fritillaria liliacea 0
Fritillaria meleagris 0
Fritillaria pudica 0
Fritillaria recurva 0
Galanthus Elwesii 11
Galanthus nivalis 11
Galtonia candicans 0
Gelasine azurea 11
Gesneria tubiflora 2
Gladiolus byzantinus 11

Gladiolus cardinalis (Blushing Bride) 11
Gladiolus floribundus 11
Gladiolus primulinus 11
Gloxinia var. 0
Haemanthus Katherinae 11
Hedychium coronarium 8
Hedychium Gardnerianum 8
Hippeastruin aulicum var. robustum 11
Hippeastrum equestre 11
Hippeastrum vittatum 11
Homeria collina 11
Hordeum sativum var. (Champion) 11
Hyacinthus orientalis var. albulus (Italian) 11
Hyacinthus orientalis var. albus (White) 11
Hyacinthus orientalis var. albus superb. 5
Hymenocallis calathina 11
Hymenocallis undulata 11
Iris alata 2
Iris Bismarckiana 11
Iris caucasica 1
Iris florentina 11
Iris Histrio 0
Iris iberica 11
Iris pallida speciosa 11
Iris pumila var. cyanea 11
Iris reticulata 2
Iris tingitana 11
Iris xiphium var. Grand Tresorier 11
Iris xiphium var. lusitanica 11
Iris xiphium var. Wilhelmine 11
Ixia speciosa 1
Ixia var. (Emma) 3
Ixia viridiflora 2
Jatropha Cureas 1
Lachenalia pendula 11
Lachenalia tricolor var. luteola 11
Lathyrus latifolius var. albus 5
Lathyrus magellanicus var. albus 11
Lathyrus odoratus var. Shahzada 11
Lathyrus sylvestris 5
Lens esculenta 11
Leucojum aestivum 11
Leucojum vernum 11

Lilium auratum 0
Lilium candidum 0
Lilium Henryi 0
Lilium longiflorum var. eximium 0
Lilium longiflorum var. giganteum 0
Lilium martagon 0
Lilium pardalinum 0
Lilium Parryi 0
Lilium philadelphicum 0
Lilium puberulum 0
Lilium rubellum 0
Lilium speciosum var. album 0
Lilium superbum 0
Lilium tenuifolium 0
Lilium tigrinum var. splendens 0
Manihot utilissima 4
Maranta arundinacea 0
Maranta arundinacea var. No. 1 0
Maranta arundinacea var. No. 2 0
Maranta leuconeura 0
Maranta Massangeana 1
Maranta musaica 1
Marica Herberti 11
Moraea tristis 11
Mucuna pruriens 11
Musa Cavendishii (green fruit) 1
Musa Cavendishii 2
Musa ensete 1
Musa sapientum 1
Muscari botryoides 11
Muscari commutatum 11
Muscari comosum 11
Muscari compactum 11
Muscari conicum 11
Muscari micranthum 11
Muscari paradoxum 11
Muscari racemosum 11
Narcissus biflorus 11
Narcissus Bulbocodium 11
Narcissus Bulbocodium var. conspicuus 11
Narcissus Bulbocodium var. monophyllus 11
Narcissus Horsfieldii 11
Narcissus incomparabilis 11

Narcissus Jonquilla 11
Narcissus Jonquilla var. Campernelli rug. 11
Narcissus Jonquilla var. rugulosus 11
Narcissus maximus 11
Narcissus odorus 11
Narcissus poeticus 11
Narcissus tazetta var. orientalis 11
Nelumbo lutea 0
Nelumbo nucifera 3
Nymphaea alba 2
Nymphaea Gladstoniana 11
Nymphaea marliacea var. albida 11
Nymphaea marliacea var. carnea 4
Nymphaea odorata 4
Nymphaea odorata var. rosea 2
Ornithogalum narbonense (pyramidale) 0
Ornithogalum nutans 0
Ornithogalum thyrsoides var. aureum 1
Ornithogalum umbellatum 0
Oryza sativa var. 11
Panicum Crus-galli var. 11
Phaseolus lunatus var. (H.'s B. Lirna) 11
Phaseolus vulgaris var. (Red K. Bean) 11
Pisum sativum var. (Elec. E. Early) 11
Pisum sativum var. (Eugenie yellow) 5
Pisum sativum var. (L. W. Marrow-fat) 11
Pisum sativum var. (Mam. G. Seeded) 11
Pisum sativum var. (Thos. Laxton) 5
Pisum sativum. var. (Eugenie green) 5
Polygonum Fagopyrum var. (American) 11
Polygonum Fagopyruni var. (Japanese) 11
Puschkinia scilloides 2
Puschkinia scilloides var. libanotica 3
Quercus alba 0
Quercus Muhlenbergii 11
Quercus Prinus 5
Quercus rubra 11
Quercus texana 11
Ranunculus bulbosus 1
Ranunculus Ficaria 5
Richardia africana 11
Richardia albo-maculata 11
Richardia Elliotiana 11

Romulea rosea var. speciosa 11
Scilla bifolia 0
Scilla peruviana 0
Scilla sibirica 2
Secale cereale var. (Mammoth Winter) 11
Secale cereale var. (Spring) 11
Solanum tuberosum 2
Sparaxis grandiflora alba 0
Sparaxis var. (Albertine) 0
Sprekelia formosissima 11
Sternbergia lutea 11
Stromanthe sanguinea 3
Tacca pinnatifida 11
Tigridia Pavonia var. conchiflora 3
Tigridia Pavonia var. grand. alba 4
Trianosperma ficifolia 0
Trillium grandiflorum 1
Trillium ovatum 2
Trillium sessile var. californicum 4
Triteleia uniflora 11
Triticum sativum var. dicoccum 2
Triticum. sativum var. vulgare 4
Tritonia crocata 11
Tritonia crocata var. lilacina 11
Tritonia crocosmaeflora 11
Tritonia Pottsii 11
Tritonia securigera 11
Tulip& Didieri var. mauriana 0
Tulipa australis 0
Tulipa Billictiana 0
Tulipa Clusiana 0
Tulipa Clusiana var. persica 0
Tulipa Didieri 0
Tulipa Didieri var. Fransoniana 0
Tulipa Greigi 0
Tulipa Hageri 0
Tulipa oculus-solis 0
Tulipa praecox 0
Tulipa sylvestris 0
Vallota purpurea 11
Vicia Faba 2
Vicia fulgens 11
Vicia Gerardi 4

Vicia sativa 11
Vicia villosa 3
Watsonia humilis 11
Watsonia iridifolia var. O'Brieni 11
Watsonia Meriana 11
W'istaria chinensis 11
Zamia integrifolia 11
Zea Mays var. everta (Golden Queen) 11
Zea Mays var. everta (White Rice) 11
Zea Mays var. indentata (E'y L'g) 11
Zea Mays var. indurata (C.'s Early) 11
Zea Mays var. indurata (N. Dakota) 11
Zea Mays var. saccharata (B. Mex.) 11
Zea Mays var. saccharata (G. B'm) 11
Zea Mays var. saccharata (S *' s E'n) 11
Zephyranthes candida 11
Zephyranthes rosea 11
Zingiber officinale 0
Zingiber officinale var. Cochin 1
Zingiber officinale var. Jamaica No. 1 1
Zingiber officinale var. Jamaica No. 2 1

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The Pyrogallic Acid Reaction of Various Starches

Based on a graduated scale running from 0 to 11, where 11=60 or nore minutes for gelatinization.

Aconitum Napellus 0
Actaea alba 0
Actaea spicata var. rubra 0
Adonis amurensis 0
Aesculus Hippocastanum 0
Alstroemeria aurantiaca (aures) 0
Alstroemeria brasiliensis 0
Alstroemeria ligtu 0
Amaryllis belladonna major 0
Andropogon Sorghum var. (Shallu) 0
Andropogon Sorghum var. (W. K. Corn) 0
Andropogon Sorghum var. (Y. B. Sorgh.) 0
Anemone apennina 0
Anemone blanda 0
Anemone fulgens 0
Anemone Japonica 0
Antholyza crocosmoides 0
Antholyza paniculata 0
Arachis hypogaea 0
Arimona triphyllum 4
Arrhenatherum elatius var. 0
Arum cornuturn 5
Arum italicum 1
Arum palaestinum 2
Avena sativa var. (Clydesdale) 0
Babiana var. (Athraction) 1
Babiana var. (violacea) 3
Batatas edulis 8
Brodiaea californica 8
Brodiaea candida 0
Brodiaea capitata11
Brodiaea coccinea 11
Brodiaea congesta 11

Brodiaea grandiflora 11
Brodiaea ixioides var. splendens 0
Brodiaea lactea 0
Brodiaea laxa 0
Brodiaea peduncularis 1
Brodiaea Purdyi 11
Brodiaea stellaris 7
Calathea Lietzei 11
Calathea vittata 3
Calathea Wiotiana 11
Calathes Vandenheckei 11
Calochortus albus 0
Calochortus Benthami 0
Calochortus Howellii 0
Calochortus Leichtlinii 1
Calochortus lilacinus 0
Calochortus luteus var. oculatus 1
Calochortus Maweanus var. major 1
Calochortus nitidus 0
Calochortus splendens 0
Canna edulis 3
Canna musaefolia 11
Canna Roscoeana 11
Canna var. (J. D. Eisele) 2
Canna var. (Jean Tissot) 2
Canna var. (Konigin Charlotte) 7
Canna var. (L. E. Baily) 5
Canna var. (Mrs. Kate Grey) 3
Canna var. (President Carnot) 2
Canna Warscewiezii 11
Castanea americana 0
Castanea pumila 0
Castanea sativa var. 0
Castanea sativa var. numbo 0
Chionodoxa Lucillae 0
Chionodoxa sardensis 0
Chionodoxa Tmolusi 0
Cimicifuga racemosa 0
Cochlearia Armoracia 0
Colchicum Parkinsoni 0
Convallaria majalis 0
Crinum americanum 0
Crinum fimbriatulum 0

Crocus Susianus (Cloth of Gold) 0
Crocus var. (Baron von Brunow) 0
Crocus versicolor (Cloth of Silver) 0
Curcuma longa 5
Curcuma petiolata 11
Cycas circinalis 4
Cycas revoluta 5
Cyclamen coum 0
Cyclamen repandum 0
Cypella Herberti 0
Dieffenbachia illustris (pith) 1
Dieffenbachia seg. var. irror. (cort.) 1
Dieffenbachia seg. var. irror. (pith) 1
Dieffenbachia seg. var. mac. (cort.) 1
Dieffenbachia seg. var. mac. (pith) 1
Dieffenbachia seg. var. nob . (pith) 0
Dieffenbachia seg. var. nob. (cort.) 0
Dieffenbachis illustris (cortex) 2
Dioon edule 0
Dolichos Lablab 3
Dracunculus vulgaris 2
Eranthis hyemalis 0
Erythronium americanum 0
Erythronium californicum 0
Erythronium citrinum 0
Erythronium Dens-canis 0
Erythronium Dens-canis var. grand. 0
Erythronium grandiflorum 0
Freesia refracta var. alba 11
Freesia refracta var. Leichtlinii 11
Fritillaria armena 0
Fritillaria aurea 0
Fritillaria imperialis var. Aurora 0
Fritillaria liliacea 0
Fritillaria meleagris 0
Fritillaria pudica 0
Fritillaria pyrenaica 0
Fritillaria recurva 0
Galanthus EIwesii 8
Galanthus nivalis 2
Galtonia candicans 0
Gelasine azurea 11
Gesneria tubiflora 5

Gladiolus byzantinus 5
Gladiolus cardinalis (Blushing Bride) 4
Gladiolus floribundus 2
Gladiolus primulinus 6
Gloxinia var. 0
Haemanthus Katherinae 0
Hedychium coronarium 11
Hedychium Gardnerianum 11
Hippeastrum equestre 6
Hippeastrum vittatum 5
Hippeastrum. aulicum var. robustum 3
Homeria collina 11
Hordeum sativum var. (Champion) 0
Hyacinthus orientalis var. albulus (Italian) 0
Hyacinthus orientalis var. albulus (White) 0
Hyacinthus orientalis var. albus superb. 0
Hymenocallis calathina 0
Hymenocallis undulata 0
Iris alata 0
Iris Bismarckiana 0
Iris caucasica 0
Iris florentina 0
Iris Histrio 0
Iris iberica 0
Iris pallida speciosa 0
Iris pumila var. cyanea 0
Iris reticulata 0
Iris tingitana 0
Iris xiphium var. Grand Tresorier 0
Iris xiphium var. lusitanica 0
Iris xiphium var. Wilhelmine 0
Ixia speciosa 1
Ixia var. (Emma) 3
Ixia viridiflora 3
Jatropha Curcas 0
Lachenalia pendula 0
Lachenalia tricolor var. luteola 0
Lathyrus latifolius var. albus 0
Lathyrus magellanicus var. albus 0
Lathyrus odoratus var. Shahzada 0
Lathyrus sylvestris 0
Lens esculenta 0
Leucojum aestNum 0

Leucojum vernum 0
Lilium auratum 0
Lilium candidum 0
Lilium Henryi 0
Lilium longiflorum var. eximium 0
Lilium martagon 0
Lilium pardalinum 0
Lilium Parryi 0
Lilium philadelphicum 0
Lilium puberulum 0
Lilium rubellum 0
Lilium speciosum var. album 0
Lilium superbum 0
Lilium tenuifolium 0
Lilium tigrinum var. splendens 0
Lilium. longiflorum var. giganteum 0
Manihot utilissima 0
Maranta arundinacea 0
Maranta arundinacea var. No. 1 0
Maranta arundinacea var. No. 2 0
Maranta leuconeura 0
Maranta Massangeana 0
Maranta musaica 0
Marica gracilis 0
Moraea tristis 11
Mucuna pruriens 2
Musa Cavendishii (green fruit) 8
Musa Cavendishii 8
Musa ensete 2
Musa sapientum 8
Muscari botryoides 0
Muscari commutatum 4
Muscari comosum 1
Muscari compactum 0
Muscari conicum 6
Muscari micranthum 1
Muscari paradoxum 3
Muscari racemosum 5
Narcissus billorus 4
Narcissus Bulbocodium 8
Narcissus Bulbocodium var. conspicuus 3
Narcissus Bulbocodium var. monophyllus 2
Narcissus Horsfieldii 11

Narcissus incomparabilis 5
Narcissus Jonquilla 11
Narcissus Jonquilla var. Campernelli rug. 11
Narcissus Jonquilla var. rugulosus 2
Narcissus maximus 6
Narcissus odorus 11
Narcissus poeticus 11
Narcissus tazetta var. orientalis 11
Nelumbo lutea 0
Nelumbo nucifera 0
Nymphaea alba 0
Nymphaea Gladstoniana 1
Nymphaea marliacea var. albida 1
Nymphaea marliacea var. carnea 0
Nymphaea odorata 0
Nymphaea odorata var. rosea 0
Ornithogalum narbonense (pyramidale) 0
Ornithogalum nutans 1
Ornithogalum thyrsoides var. aureum 0
Ornithogalum umbellatum 0
Oryza sativa var. 1
Panicum Crus-galli var. 1
Phaseolus lunatus var. (H.'s B. Lim) 0
Phaseolus vulgaris var. (Red K. BeRD) 0
Pisum sativum var. (Eugenie green) 11
Pisum sativum var. (Eugenie yellow) 11
Pisum sativum var. (L. W. Marrowfat) 0
Pisum sativum var. (Mam. G. Seeded) 0
Pisum sativum var. (Thos. Laxton) 11
Pisum sativum. var. (Elec. E. Early) 0
Polygonum Fagopyrum var. (Japanese) 0
Polygonum Fagopyrum var. (American 0
Puschkinia scilloides 0
Puschkinia scilloides var. libanotica 0
Quercus alba Quercus Prinus 0
Quercus rubra 0
Quercus texana 0
Ranunculus bulbosus 0
Ranunculus Ficaria 0
Richardia africana 11
Richardia albo-maculata 11
Richardia Elliotiana 11
Romulea rosea. var. speciosa 11

Scilla bifolia 0
Scilla peruviana 0
Scilla sibirica 0
Secale cereale var. (Mammoth Winter) 0
Secale cereale var. (Spring) 0
Solanum tuberosum 4
Sparaxis grandiflora alba 0
Sparaxis var. (Albertine) 0
Sprekelia formosissima 0
Sternbergia lutea 4
Stromanthe sanguinea 1
Tacca pinnatifida 0
Tigridia Pavonia var. conchiflora 0
Tigridia Pavonia var. grand. alba 0
Trianosperma ficifolia 0
Trillium grandiflorum 0
Trillium ovatum 0
Trillium sessile var. californicum 0
Triteleia uniflora 0
Triticum sativum var. dicoccum 0
Triticum sativum var. vulgare 0
Tritonia crocata 11
Tritonia crocata var. lilacina 11
Tritonia crocata var. rosea 11
Tritonia crocosmaeflora 2
Tritonia Pottsii 2
Tritonia securigera 11
Tulipa australis 0
Tulipa Billietiana 0
Tulipa Clusiana 0
Tulipa Clusiana var. persica 0
Tulipa Didieri 0
Tulipa Didieri var. Fransoniana 0
Tulipa Didieri var. mauriana 0
Tulipa Greigi 0
Tulipa Hageri 0
Tulipa oculus-solis 0
Tulipa praecox 0
Tulipa sylvestris 0
Vallota purpurea 4
Vicia Faba 1
Vicia fulgens 0
Vicia Gerardi 0

Vicia sativa 0
Vicia villosa 0
Watsonia humilis 2
Watsonia iridifolia var. O'Brieni 1
Watsoniii Meriana 2
Wistaria chinensis 1
Zamia integrifolia 1
Zea Mays var. everta (Golden Queen) 0
Zea Mays var. everta (White Rice) 0
Zea Mays var. indentata (E'y L'g) 0
Zea Mays var. indurata (C.'s Early) 0
Zea Mays var. indurata (N. Dakota) 0
Zea Mays var. saccharata (B. Mex.) 0
Zea Mays var. saccharata (G. B'm) 0
Zea Mays var. saccharata (S.'s E'n) 0
Zen Mays var. indentata (H. King) 0
Zephyranthes candida 6
Zephyranthes rosea 5
Zingiber officinale 11
Zingiber officinale var. Cochin 4
Zingiber officinale var. Jamaica No. 1 11
Zingiber officinale var. Jamaica No. 2 11

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The Chromic Acid Reaction of Various Starches

Based on a scale running from 0 to 13 or more minutes for gelatinization.

Aconitum Napellus 0
Actaea alba 0
Actaea spicata var. rubra 0
Adonis amurensis 0
Aesculus Hippocastanum 0
Alstroemeria brasiliensis 0
Alstroemeria ligtu 0
Amaryllis belladonna major 2
Andropogon Sorghum var. (Shallu) 2
Andropogon Sorghum var. (W. K. Corn) 2
Andropogon Sorghum var. (Y. B. Sorgh.) 3
Anemone apennina 0
Anemone blanda 0
Anemone fulgens 0
Anemone japonica 0
Antholyza crocosmoides 2
Antholyza paniculata 1
Arachis hypogaea 1
Arisaema triphyllum 4
Arrhenatherum elatius var. 0
Arum cornutum 5
Arum italicum 4
Arum palaestinum 9
Astroemeria aurantiaca (aurea) 1
Avena sativa var. (Clydesdale) 0
Babiana var. (Athraction) 1
Babiana var. (violacea) 1
Batalas edulis 6
Brodiaea candida3
Brodiaea capitata 9
Brodiaea coccinea 5
Brodiaea congesta 4
Brodiaea grandiflora 9

Brodiaea ixioides var. splendens 5
Brodiaea lactea 3
Brodiaea laxa 1
Brodiaea peduncularis 9
Brodiaea Purdyi 9
Brodiaea stellaris 9
Calathea Lietzei 5
Calathea Vandenheckei 4
Calathea vittata 4
Calathea Wiotiana 5
Calochortus albus 0
Calochortus Benthami1
Calochortus Howellii 0
Calochortus Leichtlinii 0
Calochortus lilacinus 0
Calochortus luteus var. oculatus 0
Calochortus Maweanus var. major 0
Calochortus nitidus 0
Calochortus splendens 0
Canna edulis 2
Canna musaefolia 3
Canna Roscoeana 2
Canna var. (J. D. Eisele) 1
Canna var. (Jean Tissot) 2
Canna var. (Konigin Charlotte) 1
Canna var. (L. E. Baily) 1
Canna var. (Mrs. Kate Grey) 1
Canna var. (President Carnot) 1
Canna Warscewiezii 1
Castanea americana 0
Castanea pumila 0
Castanea sativa var. 0
Castanea sativa var. numbo 0
Chionodoxa Lucillae 1
Chionodoxa sardensis 1
Chionodoxa Tmolusi 1
Cimicifuga racemosa 0
Cochlearia Armoracia 0
Colchicum Parkinsoni 1
Convallaria majalis 0
Crinum americanum 9
Crinum fimbriatulum 13
Crocus Susianus (Cloth of Gold) 0

Crocus var. (Baron von Brunow) 1
Crocus versicolor (Cloth of Silver) 2
Curcuma longa 9
Curcuma petiolata 8
Cycas circinalis 3
Cycas revoluta 4
Cyclamen coum 0
Cyclamen repandum 0
Cypella Herberti 2
Dieffenbachia illustris (cortex) 3
Dieffenbachia illustris (pith) 3
Dieffenbachia seg. irror. (pith) 3
Dieffenbachia seg. var. irror. (cort.) 1
Dieffenbachia seg. var. mac. (cort.) 4
Dieffenbachia seg. var. mac. (pith) 5
Dieffenbachia seg. var. nob. (cort.) 3
Dieffenbachia seg. var. nob. (pith) 3
Dioon edule 1
Dolichos Lablab 6
Dracunculus vulgaris 6
Eranthis hyemalis 0
Erythronium americanum 0
Erythronium californicum 0
Erythronium citrinum 0
Erythronium Dens-canis 0
Erythronium Dens-canis var. grand. 0
Erythronium grandiflorum 0
Freesia refracta var. alba 3
Freesia refracta var. Leichtlinii 2
Fritillaria armena 0
Fritillaria aurea 0
Fritillaria imperialis var. Aurora 0
Fritillaria liliacea 0
Fritillaria meleagris 0
Fritillaria pudica 0
Fritillaria pyrenaica 0
Fritillaria recurva 0
Galanthus Elwesii 7
Galanthus nivalis 1
Galtonia candicans 0
Gelasine azurea 11
Gesneria tubiflora4
Gladiolus byzantinus 6

Gladiolus cardinalis (Blushing Bride) 3
Gladiolus floribundus 3
Gladiolus primulinus4
Gloxinia var. 0
Haemanthus Katherinae 6
Hedychium coronarium 10
Hedychium Gardnerianum 4
Hippeastrum aulicum var. robustum 5
Hippeastrum equestre 5
Hippeastrum vittatum 5
Homeria collina 13
Hordeum sativum var. (Champion)2
Hyacinthus orientalis var. albulus (Italian) 2
Hyacinthus orientalis var. albulus (White) 2
Hyacinthus orientalis var. albus superb. 1
Hymenocallis calathina 2
Hymenocallis undulata 4
Iris alata 2
Iris Bismarckiana 0
Iris caucasica 1
Iris florentina 0
Iris Histrio 3
Iris iberica 1
Iris pallida speciosa 1
Iris pumila var. cyanea 2
Iris reticulata 1
Iris tingitana 2
Iris xiphium var. Grand Tresorier 0
Iris xiphium. var. Wilhelmine 1
Iris ziphium var. lusitanica 1
Ixia speciosa 1
Ixia var. (Emma) 1
Ixia viridiflora 1
Jatropha Curcas 0
Lachenalia pendula 4
Lathyrus latifolius var. albus 3
Lathyrus magellanicus var. albus 4
Lathyrus odoratus var. Shahzada 9
Lathyrus sylvestris 1
Lens esculenta 12
Leucojum aestivum 4
Leucojum vernum 3
Lilium candidum 0

Lilium Henryi 0
Lilium longiflorum var. eximium 0
Lilium longiflorum var. giganteum 0
Lilium martagon 0
Lilium pardalinum 0
Lilium Parryi 0
Lilium philadelphicum 0
Lilium puberulum 0
Lilium rubellum 0
Lilium speciosum var. album 0
Lilium superbum 0
Lilium tenuifolium 0
Lilium tigrinurn var. splendens 0
Lilium. auratum 1
Manihot utilissirna 1
Maranta arundinacea 3
Maranta arundinacea var. No. 1 1
Maranta arundinacea var. No. 2 1
Maranta leuconeura 1
Maranta Massangeana 2
Maranta musaica 7
Marica gracilis 5
Moraea tristis 3
Mucuna pruriens 6
Musa Cavendishii (green fruit) 2
Musa Cavendishii 4
Musa ensete 0
Musa sapientum 1
Muscari botryoides 3
Muscari commutatum 1
Muscari comosum 2
Muscari compactum 2
Muscari conicum 3
Muscari micranthum 1
Muscari paradoxum3
Muscari racemosum2
Nacissus incomparabilis 5
Narcissus biflorus 4
Narcissus Bulbocodium 7
Narcissus Bulbocodium var. conspicuus 5
Narcissus Bulbocodium. var. monophyllus 4
Narcissus Horsfieldii 13
Narcissus Jonquilla 9

Narcissus Jonquilla var. Campernelli rug. 6
Narcissus Jonquilla var. rugulosus 3
Narcissus maximus 4
Narcissus odorus 4
Narcissus poeticus 8
Narcissus tazetta var. orientalis 7
Nelumbo lutea 0
Nelumbo nucifera 1
Nymphaea alba 1
Nymphaea Gladstoniana 2
Nymphaea marliacea var. albida 3
Nymphaea marliacea var. carnea 0
Nymphaea odorata 2
Nymphaea odorata var. rosea 1
Ornithogalum narbonense (pyramidale) 0
Ornithogalum nutans 0
Ornithogalum thyrsoides var. aureum 1
Ornithogalum umbellatum 0
Oryza sativa var. 3
Panicum Crus-galli var. 1
Phaseolus lunatus var. (H.'s B. Lima) 7
Phaseolus vulgaris var. (Red IL Bean) 7
Pisum sativum var. (Eugenie green) 2
Pisum sativum var. (Eugenie yellow) 5
Pisum sativum var. (L. W. Marrow fat) 4
Pisum sativum var. (Thos. Laxton) 4
Pisum sativum. -var. (Elec. E. Early) 5
Pisum sativurn var. (Mam. G. Seeded)3
Polygonum Fagopyrum var. (American) 0
Polygonurn Fagopyrum var. (Japanese) 0
Puschkinia scilloides 0
Puschkinia scilloides var. libanotica 0
Quercus alba 0
Quercus Muhlenbergii 0
Quercus Prinus 1
Quercus rubra 0
Quercus texana 0
Ranunculus bulbosus 0
Ranunculus Ficaria 0
Richardia africana 3
Richardia albo-maculata 9
Richardia Elliotiana 4
Romulea rosea var. speciosa 3

Scilla bifolia 1
Scilla peruviana 1
Scilla sibirica 0
Secale cereale var. (Mammoth Winter) 2
Secale cereale var. (Spring) 1
Solanum tuberosum 5
Sparaxis grandiflora alba 1
Sparaxis var. (Albertine) 0
Sprekelia formosissima 9
Sternbergia lutea 6
Stromanthe sanguinea 4
Taca pinnatifida 3
Tigridia Pavonia var. conchiflora 0
Tigridia Pavonia var. grand. alba 0
Trianosperma ficifolia 1
Trillium grandiflorum 0
Trillium ovatum 0
Trillium sessile var. californicarn 0
Triteleia uniflora 3
Triticum sativum var. dicoccum 1
Triticum sativum var. vulgare 2
Tritonia crocata 13
Tritonia crocata var. lilacina 13
Tritonia crocata var. rosea 13
Tritonia crocosmaeflora 3
Tritonia Pottsii 3
Tritonia securigera 13
Tulipa australis 0
Tulipa Billietiana 0
Tulipa Clusiana 0
Tulipa Clusiana var. persica 0
Tulipa Didieri var. mauriana 0
Tulipa Didieri var.Fransoniana 0
Tulipa Greigi 0
Tulipa Hageri 0
Tulipa oculus-solis 0
Tulipa praecox 0
Tulipa sylvestris 0
Vallota purpurea 4
Vicia Faba 2
Vicia fulgens 2
Vicia Gerardi 1
Vicia sativa 4

Vicia villosa 2
Watsonia humilus 4
Watsonia iridifolia var. O'Brieni2
Watsonia Meriana 4
Wistaria chinensis 0
Zamia integrifolia 5
Zea Mays var. everta (Golden Queen) 1
Zea Mays var. everta (White Rice) 1
Zea Mays var. indentata (H. King) 0
Zea Mays var. indurata (C.'s Early) 3
Zea Mays var. indurata (N. Dakota) 3
Zea Mays var. saccharata (B. Mex.) 0
Zea Mays var. saccharata (G. B'm) 1
Zea Mays var. saccharata (S.'s E'n) 2
Zephyranthes candida 5
Zephyranthes rosea 5
Zingiber officinale 1
Zingiber officinale var. Cochin 10
Zingiber officinale var. Jamaica No. 1 13
Zingiber officinale var. Jamaica No. 2 12

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The Ferric Chloride Reaction of Various Starches

Based on a scale running from 0 to 11, where 11=60 or more minutes for gelatinization.

Aconitum Napellus 0
Actaea alba 0
Actaea spicata var. rubra 1
Adonis amurensis 0
Aesculus Hippocastanum 0
Alstroemeria aurantiaca (aurea) 3
Alstroemeria brasiliensis 2
Alstroemeria ligtu 2
Amaryllis belladonna major 3
Andropogon Sorghum var. (Shallu) 2
Andropogon Sorghum var. (W. K. Corn) 3
Andropogon Sorghum var. (Y. B. Sorgh.) 2
Anemone apennina 0
Anemone blanda 0
Anemone fulgens 0
Anemone japonica 0
Antholyza crocosmoides 7
Antholyza paniculata 4
Arachis hypogaea 2
Arisaema triphyllum 5
Arrhenatherum elatius var. 1
Arum cornutum 2
Arum italicum 1
Arum palaestinum 5
Avena sativa var. (Clydesdale) 1
Babiana var. (Athraction) 3
Babiana var. (violacea) 2
Batatas edulis 0
Brodiaea calif ornica 11
Brodiaea candida 5
Brodiaea capitata 11
Brodiaea coccinea 4
Brodiaea congesta 11

Brodiaea grandiflora 11
Brodiaea ixioides var. splendens 9
Brodiaea lactea 7
Brodiaea laxa 8
Brodiaea peduncularis 11
Brodiaea Purdyi 11
Brodiaea stellaris 11
Calathea Lietzei 2
Calathea Vandenheckei 11
Calathea vittata 11
Calathea Wiotiana 11
Calochortus albus 1
Calochortus Benthami 0
Calochortus Howellii 0
Calochortus Leichtlinii 1
Calochortus lilacinus 0
Calochortus luteus var. oculatus 1
Calochortus Maweanus var. major 1
Calochortus nitidus 0
Calochortus splendens 1
Canna edulis 8
Canna musaefolia 4
Canna Roscoeana 1
Canna var. (J. D. Eisele) 3
Canna var. (Jean Tissot) 4
Canna var. (Konigin Charlotte) 3
Canna var. (L. E. Baily) 4
Canna var. (Mrs. Kate Grey)3
Canna var. (President Carnot) 2
Canna Warscewiczii 2
Castanea americana 0
Castanea pumila 0
Castanea sativa var. 0
Castanea sativa var. numbo 0
Chionodoxa Lucillae 5
Chionodoxa sardensis1
Chionodoxa Tmolusi 1
Cimicifuga racemosa 0
Cochlearia Armoracia 0
Colchicum Parkinsoni 5
Convallaria majalis 0
Crinum americanum 5
Crinum fimbriatulum 11

Crocus Susianus (Cloth of Gold) 1
Crocus var. (Baron von Brunow) 2
Crocus versicolor (Cloth of Silver) 2
Curcuma longa 1
Curcuma petiolata 1
Cycas circinalis 4
Cycas revoluta 4
Cyclamen coum 0
Cyclamen repandum 0
Cypella Herberti 5
Dieffenbachia illustris (cortex) 3
Dieffenbachia illustris (pith) 5
Dieffenbachia seg. var. irror. (pith) 2
Dieffenbachia seg. var. mac. (cort.) 4
Dieffenbachia seg. var. mac. (cort.) 5
Dieffenbachia seg. var. mac. (pith) 4
Dieffenbachia seg. var. nob. (cort.) 1
Dieffenbachia seg. var. nob. (pith) 3
Dioon eduIe 1
Dolichos Lablab 11
Dracunculus vulgaris 8
Eranthus hyernalis 1
Erythronium americanum 0
Erythronium californicum 0
Erythronium citrinum 0
Erythronium Dens-canis 0
Erythronium Dens-canis var. grand. 0
Erythronium grandiflorum 0
Freesia refracta var. Leichtlinii 5
Freesia refracts var. alba 5
Fritillaria armena 1
Fritillaria aurea 1
Fritillaria imperialis var. Aurora 2
Fritillaria liliacea 2
Fritillaria meleagris 2
Fritillaria pudica 3
Fritillaria pyrenaica 1
Fritillaria recurva 2
Galanthus nivalis 11
Galtonia candicans 0
Gelasine azurea 11
Gesneria tubiflora 1
Gladiolus byzantinus 8

Gladiolus cardinalis (Blushing Bride) 8
Gladiolus floribundus 4
Gladiolus primulinus 4
Gloxinia var. 1
Haemanthus Katherinae 9
Hedychium Gardnerianum 0
Hedychiurn coronarium 1
Hippeastruin aulicum var. robustum 7
Hippeastrum equestre 9
Hippeastrum vittatum 10
Homeria collina 11
Hordeum sativum var. (Champion) 11
Hyacinthus orient. var. albulus (Italian) 2
Hyacinthus orientalis var. albulus (White) 1
Hyacinthus orientalis var. albus superb. 1
Hymenocallis calathina 5
Hymenocallis undulata 11
Iris alata 5
Iris Bismarckiana 0
Iris caucasica 7
Iris florentina 1
Iris Histrio 9
Iris iberica 2
Iris pallida speciosa 2
Iris pumila var. cyanea 2
Iris reticulata 6
Iris tingitana 3
Iris xiphium var. Grand Tresorier2
Iris xiphium var. lusitanica 2
Iris xiphium var. Wilhelmine 1
Ixia iridiflora 2
Ixia speciosa 1
Ixia var. (Emma) 3
Jatropha Curcas 3
Lachenalia pendula 3
Lachenalia tricolor var. luteola 3
Lathyrus Iatifolius var. albus 11
Lathyrus magellanicus var. albus 11
Lathyrus odoratus var. Shahzada 11
Lathyrus sylvestris 11
Lens esculenta 11
Leucojum aestivum 11
Leucojum vernum 11

Lilium auratum 1
Lilium candidum 4
Lilium Henryi 5
Lilium longiflorum var. eximium 1
Lilium longiflorurn var. giganteum 3
Lilium Martagon 2
Lilium pardalinum 3
Lilium Parryi 2
Lilium philadelphicum 2
Lilium puberulum 3
Lilium rubellum 3
Lilium speciosum var. album 3
Lilium superbum 1
Lilium tenuifolium 3
Lilium tigrinum var. splendens 1
Manihot utilissima 3
Maranta arundinacea 0
Maranta arundinacea var. No. 1 1
Maranta arundinacea var. No. 2 2
Maranta leuconeura 1
Maranta Massangeana 2
Maranta musaica 11
Marica gracilis 8
Moraea tristis 8
Mucuna pruriens 11
Musa Cavendishii (green fruit) 0
Musa Cavendishii 1
Musa ensete 1
Musa sapientum 1
Muscari botryoides 7
Muscari commutatum 6
Muscari comosum 6
Muscari compactum 6
Muscari conicum 11
Muscari micranthum 2
Muscari paradoxum 8
Muscari racemosurn 4
Narcissus biflorus 11
Narcissus Bulbocodium 8
Narcissus Bulbocodium var. monophyllus 8
Narcissus Bulbocodiurn var. conspicuus 11
Narcissus Horsfieldii 11
Narcissus incomparabilis 8

Narcissus Jonquilla 7
Narcissus Jonquilla 7
Narcissus Jonquilla var. Campernelli rug. 8
Narcissus maximus 11
Narcissus odorus 9
Narcissus poeticus 11
Narcissus tazetta var. orientalis 11
Nelumbo lutea 1
Nelumbo nucifera 2
Nymphaea alba 2
Nymphaea Gladstoniana 8
Nymphaea marliacea var. albida 9
Nymphaea marliacea var. carnea 4
Nymphaea odorata 3
Nymphaea odorata var. rosea 6
Ornithogalum narbonense (pyramidale) 1
Ornithogalum nutans 2
Ornithogalum umbellatum 2
Ornithogalurn thyrsoides var. aureum 2
Oryza sativa var. 1
Panicum Crus-galli var. 4
Phaseolus lunatus var. (H.'s B. Lima) 11
Phaseolus vulgaris var. (Red K. Bean) 11
Pisum sativum var. (Elec. E. Early) 11
Pisum sativum var. (Eugenie green) 5
Pisum sativum var. (Eugenie yellow) 5
Pisum sativum var. (L. W. Marrowfat) 11
Pisum sativum var. (Thos. Laxton) 5
Pisum sativurn var. (Mam. G. Seeded) 11
Polygonum Fagopyrum var. (American) 6
Polygonum Fagopyrum var. (Japanese) 3
Puschkinia scilloides 3
Puschkinia scilloides var. libanotica 3
Quercus alba 5
Quercus Muhlenbergii 8
Quercus Prinus 5
Quercus rubra 2
Quercus texana 2
Ranunculus bulbosus 0
Ranunculus Ficaria 0
Richardia africana 7
Richardia albo-maculata 11
Richardia Elliotiana 6

Romulea rosea var. speciosa 11
Scilla bifolia 3
Scilla peruviana 3
Scilla sibirica 2
Secale cereale var. (Mammoth Winter) 11
Secale cereale var. (Spring) 11
Solanum tuberosum 4
Sparaxis grandiflora alba 0
Sparaxis var. (Albertine) 0
Sprekelia formosissima 4
Sternbergia lutea 11
Stromanthe sanguinea 6
Tacca pinnatiflda 6
Tigridia Pavonia var. conchiflora 2
Tigridia Pavonia var. grand. alba 2
Trianosperma ficifolia 0
Trillium grandiflorum 0
Trillium ovatum 0
Trillium sessile var. californicum 1
Triteleia uniflora 10
Triticum sativum var. dicoccuin 11
Triticum sativum var. vulgare 11
Tritonia crocata 7
Tritonia crocata var. lilacina 11
Tritonia crocata var. rosea 8
Tritonia crocosmaeflora 8
Tritonia Pottsii 7
Tritonia securigera 6
Tulipa australis 0
Tulipa Billietiana 1
Tulipa Clusiana 0
Tulipa Clusiana var. persica 2
Tulipa Didieri 1
Tulipa Didieri var. Fransoniana 2
Tulipa Didieri var. mauriana 1
Tulipa Greigi 1
Tulipa Hageri 0
Tulipa oculu&-solis 1
Tulipa praecox 1
Tulipa sylvestris 1
Vallota purpurea 10
Vicia Faba 11
Vicia fulgens 11

Vicia Gerardi 8
Vicia sativa 11
Vicia villosa 7
Watsonia humilis 7
Watsonia iridifolia var. O'Brieni 8
Watsonia Meriana 8
Wistaria chinensis 3
Zamia integrifolia 11
Zea Mays var. aaccharata (S.'s E'n) 1
Zea Mays var. everta (Golden Queen) 1
Zea Mays var. everta (White Rice) 1
Zea Mays var. indentata (E'y L'g) 2
Zea Mays var. indentata (H. King) 1
Zea Mays var. indurata (C.'s Early) 2
Zea Mays var. indurata (N. Dakota) 2
Zea Mays var. saccharata (G. B'm) 1
Zephyranthes candida 7
Zephyranthes rosea 9
Zingiber officinale 0
Zingiber officinale var. Cochin 10

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The Temperature of Gelatinization of Various Starches In Degrees Centigrade

Aesculus Hippocastanum 69.00
Alstroemeria aurantiaca, (aurea) 54.75
Alstroemeria brasiliensis 57.75
Alstroemeria ligtu 58.50
Amaryllis belladonna major 74.00
Andropogon Sorghum 66.90
Andropogon Sorghum var. (White Kaffir) 68.00
Andropogon Sorghum var. (Yellow Branching) 70.00
Antholyza crocommoides 74.00
Antholyza paniculata 72.00
Arachis hypogaea 66.50
Arisaema triphyllum 70.00
Arrhenatherum elatina var 60.25
Arum cornutum 70.00
Arum italicum 72.00
Arum palaestinum 70.50
Avena, sativa var. (Clydesdale) 63.00
Babiana var. (Athraction) 82.00
Babiana var. violacea 80.00
Brodiaea californica 67.30
Brodiaea candida 62.00
Brodiaea capitata 65.57
Brodiaea coccinea, 70.00
Brodiaea congesta 69.25
Brodiaea grandiflora 65.90
Brodiaea lactea 64.50
Brodiaea laxa 61.00
Brodiaea peduncularis 68.50
Brodiaea Purdyi 67.00
Brodiaea stellaris 68.10
Brodinea ixioides var. splendens 61.75
Calochortus albus 53.00
Calochortus Benthami 61.50
Calochortus Howelli 50.50

Calochortus Leichtlinii 63.00
Calochortus lilacinus 59.00
Calochortus luteus var. oculatus 58.10
Calochortus Maweanus var. major 59.50
Calochortus nitidus 54.75
Calochortus splendens 55.10
Canna edulis 67.50
Canna musaefolia 70.50
Canna Roscoeana 69.50
Canna var. (J. D. Eisele) 62.50
Canna var. (Jean Tissot) 70.00
Canna var. (Konigin Charlotte) 65.25
Canna var. (L. E. Baily) 69.00
Canna var. (Mrs. Kate Grey) 62.50
Canna var. (Scilla peruviana 65.50
Canna Warscewiczii 69.00
Castanea americana 59.25
Castanea pumila 59.75
Castanea sativa var 61.00
Castanea sativa var. numbo 60.00
Chionodoxa Lucillae 60.00
Chionodoxa sardensis 61.10
Chionodoxa Tmolusi 62.35
Colchicum Parkinsoni 61.25
Convallaria majalis 61.00
Crinum americanum 77.00
Crinum fimbriatulum 76.00
Crocus Susianus (Cloth of Gold) 70.00
Crocus var. (Baron von Brunow) 74.00
Crocus versicolor (Cloth of Silver) 75.00
Curcuma longa 82.50
Curcuma petiolata 82.50
Cypella Herberti 55.00
Dieffenbachia illustris (cortex) 70.00
Dieffenbachia illustris (pith) 69.50
Dieffenbachia seguine var. irrorata (cortex) 68.75
Dieffenbachia seguine var. maculata (cortex) 70.60
Dieffenbachia seguine var. maculata (pith) 70.60
Dieffenbachia seguine var. nobilis (pith) 69.00
Dieffenbachia seguine, var. nobilis (cortex) 69.00
Dieffenbachia. seguine var. irrorata (pith) 69.00
Dolichos Lablab 79.50
Dracunculus vulgaris 64.25

Erythronium americanum 63.45
Erythronium californicum 57.90
Erythronium citrinum 50.45
Erythronium Dens-canis 52.65
Erythronium Dens-caniz var. grandiflorum 54.00
Erythronium grandiflorum 53.00
Freesia refracta var. alba 76.75
Freesia refracta var. Leichtlinii 77.25
Fritillaria armena 66.60
Fritillaria imperialis var. Aurora 68.40
Fritillaria liliacea 55.10
Fritillaria meIeagris 59.50
Fritillaria pudica 49.60
Fritillaria recurva 58.7
Fritillaria, pyrensica 63.15
Fritillaris, aurea 62.76
Galanthus Elwesii 70.00
Galanthus nivalis 66.50
Galtonia candicans 58.60
Gelasine azurea 73.50
Gladiolus byzantinus 78.50
Gladiolus cardinalis (Blushing Bride) 76.50
Gladiolus floribundus 81.00
Gladiolus primulinus 80.50
Haemanthus Katherinae 80.00
Hedychium coronarium 72.30
Hedychium Gardnerianum 71.15
Hippeastrum aulicum var. robustum 71.75
Hippeastrum equestre 72.50
Hippeastrum vittatum 72.00
Homeria collina 72.50
Hordeum sativum var. (Champion) 61.00
Hyacinthus orientalis var. albulus (Ital) 69.50
Hyacinthus orientalis var. albulus (White) 69.00
Hyacinthus orientalis var. albus super 67.00
Hymenocallis calathina 68.50
Hymenocallis undulata 71.50
Iris alata 66.50
Iris Bismarckiana 72.00
Iris caucasica 64.50
Iris florentina 71.50
Iris Histrio 65.50
Iris iberica 78.10

Iris pallida speciosa 74.50
Iris pumila var. cyanea 73.25
Iris reticulata 66.25
Iris tingitans 65.50
Iris xiphium var. Grand Tresorier 65.50
Iris xiphium var. lusitanica 67.00
Iris xiphium var. Wilhelmine 66.50
Ixia speciosa 84.00
Ixia var. (Emma) 84.50
Ixia viridiflora 83.00
Lachenalia pendula 60.65
Lachenalia tricolor var. luteola 73.10
Lathyrus latifolius var. albus 63.00
Lathyrus magellanicua var. albus 69.00
Lathyrus odoratus var. Shahzada 68.50
Lathyrus sylvestris 58.00
Lens esculenta 72.25
Leucojum aestivum 72.50
Leucojum vernum 71.50
Lilium auratum 58.60
Lilium candidum 61.65
Lilium Henryj 56.00
Lilium longiflorum var. eximium 65.60
Lilium longiflorum var. giganteum 62.55
Lilium martagon 59.10
Lilium pardalinum 63.30
Lilium Parryi 52.60
Lilium philadelphicum 63.90
Lilium rubellum 63.95
Lilium speciosum var. album 64.35
Lilium superbum 61.60
Lilium tenuifolium 67.30
Lilium tigrinum var. splendens 62.15
Maranta arundinacea 77.00
Maranta arundinacea var. No. 2 72.00
Maranta leuconeura 74.00
Maranta Massangeana 69.00
Maranta smindinacea var. No. I 72.50
Marica gracilis 70.00
Moraea tristis 70.00
Mucuna pruriens 74.00
Musa Cavendishii 67.75
Musa Cavendishii (green fruit) 67.50

Musa ensete 63.00
Musa sapienturn 68.00
Muscari botryoides 71.00
Muscari commutatum 72.00
Muscari comosum 68.00
Muscari compactum 70.00
Muscari conicum 73.00
Muscari micranthurn 69.75
Muscari paradoxam 73.00
Muscari racemosum 74.75
Narcissus biflorus 75.00
Narcissus Bulbocodium 72.00
Narcissus Bulbocodium var. conspicuus 72.75
Narcissus Bulbocodium var. monophyllus 74.00
Narcissus Horsfieldii 74.00
Narcissus incomparabilis 76.25
Narcissus Jonquilla 76.00
Narcissus Jonquilla Campernelli rugulosus 76.50
Narcissus Jonquilla rugulosus 75.25
Narcissus maximus 75.25
Narcissus odorus 74.50
Narcissus poeticus 73.25
Narcissus tazetta var. orientalis 77.00
Ornithogalum narbonense (pyramidale) 55.50
Ornithogalum nutans 61.25
Ornithogalum thyrsoides var. aureum 66.00
Ornithogalum umbellatum 56.75
Oryza sativa var 74.75
Panicum Crus-galli var 75.25
Phaseolus lunatus var. (Henderson's Bush Lima) 79.75
Phaseolus vulgaris var. (Red Kidney Bean) 74.50
Pisum sativum var. (Electric Extra Early) 70.00
Pisum sativum var. (Eugenie, green) 74.50
Pisum sativum var. (Eugenie, yellow) 73.50
Pisum sativum var. (Large White Marrowfat) 68.50
Pisum sativum var. (Mammoth Gray Seeded) 70.50
Pisum sativum var. (Thomas Larton) 73.25
Polygonum Fagopyrum var. (American) 63.50
Polygonum Pagopyrum var. (Japanese) 64.75
Puschkinia scilloides 56.35
Puschkinia scilloides var. libanotica 56.70
Quercus alba 60.75
Quercus Muhlenbergii 63.75

Quercus Prinus 64.75
Quercus rubra 63.00
Quercus texana 64.25
Richardia africana 75.00
Richardia albo-maculata 77.50
Richardia Elliotiana 76.00
Romulea rosea var. speciosa 73.50
Scilla bifolia 64.75
Scilla sibirica 66.00
Secale cereale var. (Mammoth Winter) 61.00
Secale cereale var. (spring) 62.00
Sparaxis grandiflora alba 71.50
Sparaxis var. (Albertine) 72.50
Sprekelia formosissima 77.00
Sternbergia lutea 75.50
Tacca pinnatifida 68.00
Tigridia Pavonia var. conchiflora 60.00
Tigridia Pavonia, var. grandiflora alba 61.00
Trillium grandiflorum 58.00
Trillium ovatum 56.75
Trillium sessile var. californicum 55.00
Triteleia uniflora 69.45
Triticum sativum var. dicoccum 62.90
Triticum sativum var. vulgare 64.00
Tritonia crocata 82.50
Tritonia crocata var. lilacina 81.75
Tritonia crocata var. rosea 81.50
Tritonia crocosmaeflora 73.00
Tritonia Pottsii 72.50
Tritonia securigera 81.00
Tulipa australis 51.15
Tulipa Billietiana 55.25
Tulipa Clusiana var. persica 54.75
Tulipa Didieri 50.75
Tulipa Didieri var. Fransoniana 54.85
Tulipa Didieri var. mauriana 50.95
Tulipa Greigi 50.30
Tulipa Hageri 56.90
Tulipa Clusiana 57.10
Tulipa sylvestris 57.15
Tulipa oculus-solis 53.75
Tulipa praecox 55.80
Vallota purpurea 74.25

Vicia fulgens 72.00
Vicia Gerardi 71.00
Vicia sativa 72.50
Vicia villosa 66.00
Vida Faba 65.00
Watsonia humilis 75.50
Watsonia iridifolia var. O'Brieni 74.50
Watsonia Meriana 76.25
Wistaria chinensis 71.50
Zea Mays var. everta (Golden Queen) 63.25
Zea Mays var. everta (White Rice) 63.25
Zea Mays var. indentata (Early Learning) 66.50
Zea Mays var. indentata (Hickory King) 66.75
Zea Mays var. indurata (Compton's Early) 68.50
Zea Mays var. indurata (North Dakota) 68.00
Zea Mays var. saccharata (Black Mexican) 65.00
Zea Mays var. saccharata (Stowell's) 66.85
Zea Mays var. saccharata (Golden Bantam) 66.60
Zephyranthes candida 73.00
Zephyranthes rosea 76.00
Zingiber officinale 73.86
Zingiber officinale var. Cochin 90.00
Zingiber officinale var. Jamaica No. 1 82.25
Zingiber officinale var. Jamaica No. 2 85.90

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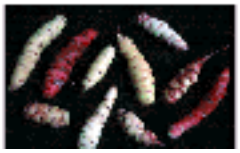

Agriboard

Agriboard, lumber substitutes made from plant fibers, are revolutionizing how plant wastes are used and has potential for far ranging impact on agriculture, forestry and conservation. Typing agriboard into a search engine brings up nearly 100 web pages. Three of these pages have been reviewed and are offered here for your examination.

The first is an in-depth report from Environmental Building News, Vol. 4 (No. 3) and offers an excellent, balanced overview on the use of wheat straw lumber in homebuilding.

The second article reviewed by *EBL*, Environmental Building News, Vol. 4 (No. 6), is a brief commentary on this topic including reaction to use of this material by an architect.

Third is an excerpt written by David Morris, from the book, 'Non-woody Fibers and the Future of Rural Economics," edited by J. Janick., discussing general use of plant fibers for building materials. This last entry is of particular interest as it discusses cellulose for construction, from non-timber sources, in a broad sense.

That opens the door to using native prairie grasses and other native plant resources to provide income from restored land . This is especially important for land which would otherwise be converted to cash crops and for areas which have lain fallow for several years but recently lost set aside status. It has also been pointed out that most areas loosing set aside status are eligible for organic certification. Production of agriboard fiber has potential to stand alone or easily dovetail with organic agriculture to aid conservation.

MKVZant

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Last updated: 17-May-98 / du

Ethnobotanical Leaflets

Inclusive Herbaria

EDGAR ANDERSON
Missouri Botanical Garden, St. Louis, Missouri, U.S.A.

TEXT ONLY (from Indian Journal of Genetics & Plant Breeding 11(1): 1-3)

IN the earliest days of Systematics more attention was paid to cultivated plants and weeds than to wild species. The great herbals of the sixteenth century were largely given over to field and garden crops and everyday weeds. Until well after the time of Linnaeus, taxonomists included both cultivated plants and wild species in their botanical gardens, in their herbaria and in their writings. Only by slow degrees was there general recognition that the methods which are so effective for the bulk of the world's flora do not yield results of comparable efficiency when applied to cultivated plants and weeds. This perception came into being so gradually, that taxonomy as a whole drifted into its present position without any one taxonomist being aware of the drift and with only a few lone workers (Oakes Ames, L. H. Bailey, O. Stapf, D. Chatterjee) attempting to fight against the current. We now find ourselves in an anomalous position. Ninety-nine per cent of taxonomic effort is devoted to the plants least interesting and least important to man. Surely matters are out of balance when in many of the world's great herbaria there is not a single taxonomist who is devoting himself to the classification of cultivated plants and when the taxonomy of many of the world's most important genera (Phaseolus, Coffea, Brassica, Cinchona, Hevea, etc.) is so imperfect as to be of little practical use.

The gradual decision of orthodox taxonomists to avoid the classification of cultivated plants wherever possible was originally sound. Wild species could efficiently be understood by their methods; cultigens could not. Since the development of the so-called "New Systematics" such avoidance is no longer necessary. The special methods of this modern development in taxonomy are as useful in working out the complicated interrelationships of cultivated plants as they are in determining the course of evolution in natural populations. While it is usually assumed that the New Systematics derived its newness from the introduction of such techniques as cytology and pedigree culture from the experimental sciences, it would be more accurate to ascribe the change to new attitudes. The old taxonomy was satisfied if it discriminated between species; the new, desired to illuminate them as well. It wanted to know not only to which pigeonhole each entity belonged, but what kind of an entity it was. Was it diploid or polyploid, or did it include both diploid and polyploid races? Was it partially or wholly apomictic? Did it include

many highly differentiated local races of no nomenclatorial significance but of great biological interest? The New Systematics in other words interested itself in forces as much as in forms and in populations as well as in individuals.

The development of these techniques and attitudes makes it possible for us now to approach the classification of cultivated plants with some prospect of success. Relatively simple modifications and additions to previous herbarium techniques can produce an herbarium record which is efficient even with our most difficult cultivated plants. The resulting specimens resemble orthodox herbarium specimens in that they are mounted on the same size sheets and are stored in the same kind of steel or wooden cases. In other ways they are more like a loose leaf note book than herbarium specimen. They are different enough in purpose and in appearance that it may be well to christen them with a name of their own, and designate a collection of such specimens as AN INCLUSIVE HERBARIUM.

The inclusive herbarium has a more difficult job to perform than the ordinary herbanum. Therefore a more complete record of the plant is required. Knowing exactly what to include for the most efficient record of any particular cultigen is in itself something of a research problem; only by considerable experience with a crop plant or a weed can one determine exactly which features are most useful in working out its taxonomic relationships. One may summarize the necessary information under two heads (1) As complete a record of the plant as can be obtained, using pressed fragments, notes (morphological, ethnological, cytological), charts, and photographs to scale. (2) Information not only about the individual but of the population from which it came and the population to which it gives rise. This is essential either for cross-pollinated crops or for heterogenous native varieties of self-pollinated crops.

Two guiding principles need to be stressed. (1) Compactness is essential. A record of a single plant should not occupy more than one herbarium sheet if possible. Combinations of photographs and fragments will do a better job and take less space than a complete herbarium specimen. With Zea Mays, for instance, it has been found that while a pressed specimen of the entire male infloresence is useful, that a photograph, to scale, of such an inflorescence plus the pressed central spike and lowest secondary branch plus a simple diagram of the numbers and positions of branches at each node takes less space and is more useful. (2) Accuracy is more important than appearance. Provided field notes are legible it is better to mount the original notes directly on the sheet than to run the risk of having them altered during the copying process. For the same reason the name and number of each plant or plant portion which is photographed is taken directly on the photograph so that there need be no chance of mixing negatives or prints. If the material to be photographed is of any size, a permanent background is efficient. It should be set up in a well-lighted place but out of direct sunlight since strong shadows destroy the accuracy of the pictures. A set of deheaded nails down the middle of the board are useful in holding plants in position while the photograph is being taken. The background is painted flat white with black lines (horizontal or vertical or both) at regular intervals. Though it has to be renewed at frequent inter vals, adhesive lantern slide tape is convenient in making the black lines on the white background. Numerals giving the year are affixed to one side of the board and removable stencilled letters (heavy black on white cards) give the name and number of each culture which is photographed.

The exact record to be made will vary with every crop and with the extent to which its most salient variables have been determined by previous study. After ten years' work with maize the following optimum record (see Plate I) may be recommended. (1) A photograph of an entire plant taken against a scaled background and a similar but more enlarged photograph of the tassel (male inflorescence). (2) An internode diagram showing the lengths of successive internodes and the number of developed and undeveloped ears (Anderson and Schregardus 1944). (3) The sheath and lower blade of the leaf below the ear, slit in half longitudinally and pressed. (4) The central spike and the lowest secondary branch from the main tassel. (5) A sample of the kernels from which the plant was raised. (6) Notes as to silk and anther colour and plant colour. (7) Notes as to the numbers and positions of the knobs on the pachytene chromosomes. (8) Notes and statistics as to the variation of sibling plants. (9) Diagram of the tassel node by node, showing the number of secondary branches at each node and their relative positions. For making a record of field samples of a mature crop of maize see, Anderson, 1947.

For Phaseolus, the following schedule has been worked out. (1) Pressed specimens of an average leaf, an inflorescence, and a mature seed pod. (2) Samples of the mature seeds. (3) Notes describing flower colour in the keel, wings and standard of the flower. (4) Notes and measurements as to the extent the cotyledons remain above or below ground after germination. (5) A photograph of an entire mature plant showing its branching habit.

An inclusive herbarium, carefully assembled, is of wide usefulness. Since it makes an accurate record of the plants most closely associated with man, the results obtained from studying the collection may be of significance for the study of man as well for the study of his economic plants. Frequently they will be found to yield precise data for such diverse disciplines as plant breeding, ethnology, prehistory, anthropology, ethnobotany or archaeology.

References

Anderson, E. and Schregardus, D. (1944). A method for recording and analysing variations of internode pattern. Ann. Mo. bot. Gdn., 34: 241-47.

Anderson, E. (1947). Field studies of Guatemalan maize. Ann. Mo. bot Gdn., 34: 433-67.

EXPLANATION OF PLATE [see original article]

Photograph showing a typical sheet from an inclusive maize herbarium. Upper left, male inflorescence photographed against a scaled background, below it the ear from which this plant and its siblings were grown. Upper centre, entire plant photographed against a scaled background. (All three of these photographs have the name, number and dates of the culture photographed on the negatives but it has been trimmed off in mounting). Upper right, diagram showing arrangement, node by node of the secondary branches of the male inflorescence. Center of sheet, lowermost secondary branch and central spike of male inflorescence mounted on the sheet. Lower left, notes and measurements on the 14 siblings from which the photographed plant was selected. These are stapled to the sheet (staples shown

as two lines at the base). Behind these notes can be seen the upper portion of an internode diagram of the above plant. Center below, notes as to pachytene knobs, etc. and B chromosomes, written directly on the sheet.

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The Species Problem

Selected Definitions
(Presented in Chronological Order)

Compiled by Donald Ugent
3/28/96

John Ray. 1704. "*Nulla certior occurit quam distincta propagations ex semine*." (Nothing is more certain to distinguish species than the criterion that true species faithfully reproduce their kind by seed.) "Plants which derive their origin from the same seed, and again propagate themselves in sowing, we may consider as belonging to a single species...Thus as to plants of specific conformity: there is certainty that they came from the seed of the same plant, whether as species or individual. For those which differ as species preserve their species in perpetuity, and one does not arise from the seed of the other, or vice versa." (*Historia Plantarum*. Chapt XXI).

Linnaeus, C. 1731. "All species number their origin first from the hand of the Omnipotent Creator: for species having been created, the Author of Nature has imposed the eternal law of generation and multiplication within the species itself...there is never a metamorphosis from one species into another." (*Critica Botanica* Sect. 271). "There are as many species as there were originally created diverse forms." (*Classes Plantarum* 1738). "That species of plants were created by God at the beginning of the world and do not change into other species, and are therefore natural, and that they remain unchanged to the present day no sane person will doubt; the confusion which would arise from the change of one species into another, to the detriment of mankind, would not be allowed by the most provident Maker." (Ortega's 1792 edition of Linneaus, *Philosophia Botanica*. 410).

John Lindley. 1832. "A species is an assemblage of individuals agreeing with each other in all essential characters of vegetation and fructification, capable of reproducing perfect seed from which progeny can be reared." In J. Heslop-Harrison, 1960. *New Concepts in Flowering Plant Taxonomy*, Harvard Univ. Press. p. 4).

Charles Darwin. 1859. "Nor shall I here discuss the various definitions which have been given of the

term species. No one definition has satisfied all naturalistists; yet every naturalist knows vaguely what he means when he speaks of a species." Also, "In determining whether a form should be ranked as a species or as a variety, the opinion of naturalists having sound judgment and wide experience seems the only guide to follow." (*Origin of Species*, London).

George Bentham. 1874. "It would seem, therefore, that at this stage of our progress .....the systematic botanist could already look towards that summit, upon reaching which his labours in aid of the general advance of the science might come to a close. But there was a rock ahead which had been looming in the distance, and which on a nearer approach posed a formidable obstacle, to most minds apparently insurmountable. What is a species? and what is the meaning of those natural affinities according to which species are to be classed? were questions which in 1859 it was generally thought vain to discuss.... We were taught, and some may still believe, that every species...was an original creation, perpetuated through every generation within fixed limits which never have been and never will be transgressed." (On the Recent Progress and Present State of Systematic Botany. *Report of the British A.A.Sc.*).

Asa Gray. 1887. "Each individual owes its existence to a parent, and produces similar individuals in its turn. So each individual is a link of a chain; and to this chain the natural-historian applies the name of Species. All the descendants from the same stock therefore compose one species. And it was from our observing that the several sorts of plants or animals steadily reproduce themselves, or, in other words, keep up a succession of similar individuals, that the idea of species originated. There are few species, however, in which man has actually observed the succession for many generations. It could seldom be proved that all the white pine trees or white oaks of any forest came from the same stock. But observation having familiarized us with the general fact that individuals proceeding from the same stock are essentially alike, we infer from their close resemblance that these similar individuals belong to the same species. That is, we infer it when the individuals are as much like each other as those are which we know, or confidently suppose, to have sprung from the same stock." Again, "Species are the units in classification. Varieties, although of utmost importance in cultivation and of considerable consequence in the flora of any country, are of less botanical significance. For they are apt to be indefinite and to shade off one form into another. But species, the botanist expects to be distinct. Indeed, the practical difference to the botanist between species and varieties is the definite limitation of the one and the indefiniteness of the other. The botanist's determination is partly a matter of observation, partly of judgment." (*The Elements of Botany*, Am. Book Co., NY).

R.V. Wettstein. 1901, "One may call species the totality of individuals which agree among each other and with their progeny in all characters which seem essential to the observer." (*Handbuch der Systematischen Botanik*, Wien. p. 13).

J.P. Lotsy. 1916. "A species consists of the total of individuals of identical constitution unable to form more than one kind of gametes." (*Evolution by Means of Hybridization*, The Hague. p. 23).

Alexis Jordan. (*ex* Lotsy, 1916). "The Linnean species is no species."

G.E. Du Rietz. 1930. "Species are the smallest natural populations permanently separated from each other by a distinct discontinuity in the series of biotypes". (The fundamental units of biological taxonomy, *Svensk. Bot. Tiolskr. 24:333-428*).

N.I. Vavilov. 1935. "The study of several hundered cultivated crops conducted by a large body of scientific workers has led us to a conception of the Linnaean species including the cultivated plants, as a definite *heterogeneous system*. As we interpret it, *the species represents a more or less distinct heterogeneous and variable morpho-physiological system, the origin of which is associated with a particular environment and area*." (The Origin, Variation, Immunity and Breeding of Cultivated Plants, Page 17, Translated by K. Starr Chester, In *Chronica Botanica 13(1): 1-366. 1951*.

Webster's Collegiate Dictionary. 1940. "*Biol.* A category of classifcation lower than a genus or subgenus and above a subspecies or variety, a group of animals or plants which possess in common one or more distinctive characters, and do or may interbreed and reproduce their characters in their offspring; a distinct kind or sort of animal or plant."

W.B. Turrill. 1940. "No single absolute test for a species is yet known, and it is debatable if such is ever likely to be found, but as a working hypothesis the following criteria should be considered: a species is morphologically definable in that it has a sum-total of characters, and every individual within it has constant resemblances with every other individual within it, and constant differences from every individual of other species, even when the individuals are grown under diverse conditions; species are isolated one from another, sometimes geographically, sometimes by habitat preferences, sometimes by having different flowering periods, usually by not crossing naturally to produce completely fertile offspring; species may show chromosomal differences. A species is an isolated group of individuals whose sum of characters tends to keep constant by natural inbreeding." (*Experimental and synthetic plant taxonomy*. In Huxley, J. ed. *The New Systematics*, Oxford Univ. Press. p. 62).

N.W. Timofeeff-Ressovsky. 1940. "A species is a group of individuals that are morphologically and physiologically similar (although comprising a number of groups of the lowest taxonomic category), which has reached an almost complete biological isolation from similar neighboring groups of individuals inhabiting the same or adjacent territories. Under biological isolation we understand the impossiblilty or non-occurrence of normal hybridization under natural conditions." (*Mutations and geographical variation*. In Huxley, J. ed. *The New Systematics*, Oxford University Press. pp. 91-92).

Mayr, E. 1942. "A species consists of a group of populations which replace each other geographically or ecologically, and of which the neighboring ones intergrade or interbreed wherever they are in contact or which are potentially capable of doing so (with one or more of the populations) in those cases where contact is prevented by geographical or ecological barriers." "Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." (*Systematics and the origin of species*, Columbia Univ. Press).

W.H. Camp and C.L. Gilly. 1943. "There are even some among us who have advocated that we discard

the concept of a species altogether. Therefore, the question which the systematist should seek first to answer is not: Upon what criteria should the concept of a species-unit be based? Rather, he must enquire: Does the species-unit deserve to be a fundamental philosophical concept? This, perhaps fortunately for his own peace of mind, has long ago been decided for him. The concept of species or kind, as a unit, has become so firmly entrenched in the mind of man--so much a part of his awareness, so necessary to his basic philosophy--that it remains only for the systematist to interpret this unit . . ." (The structure and origin of species, *Brittonia 4: 325-385*).

Alfred Emerson. l947. "A species is an evolved or evolving, genetically distinctive, reproductively isolated, natural population. All of these attributes are necessary, and no others would seem to be essential." (*Encycl. Brit.*).

M.L. Fernald. 1950. "The species is conceived as a series of individuals (usually numberless) occupying, until disturbed by man's activity, a natural geographic area and having essentially identical morphological characters of flower, fruit, or reproductive structure, somewhat exemplifying the biblical definition 'It is by their fruits ye shall know them', for most critical taxonomic study starts, when possible, with flower, fruit, seed or spore." (*Gray's Manual ed. 8*, p. vii).

G.L. Stebbins. 1950. "Species are separated from each other by gaps of genetic discontinuity in morphological and physiological characteristics which are maintained by the absence or rarity of gene interchange between members of different species." (p. 190). "In order... to make valid inferences as to the specific status of allopatric, as well as sympatric, population systems, one must determine not only whether they can cross and produce fertile hybrids under the optimum conditions of a cultivated garden plot but, in addition, whether they could coexist in the same territory and hybridize under natural conditions." Also, "The wisest course would seem to avoid defining species too precisely and to be tolerant of somewhat different species concepts held by other workers. The one principle which is unavoidable is that species are based on discontinuities in the genetic basis of the variation pattern rather than on the amount of difference in their external appearance between extreme or even 'typical' individual variants." Again, "If we accept this latitude in our species definitions, then we can recognize the existence as species-isolating mechanisms of purely spatial isolation, strictly ecological isolation of sympatric forms, or various combinations of these two isolating factors. And the latter are by far the most common in nature." (p. 204). (*Variation and Evolution in Plants*, Columbia University Press. Chapter IV: 189-250).

Henry A. Gleason. 1952. "A genus is a taxon of higher rank than a species. It ordinarily includes several or many species which resemble each other in important features of structure and which differ from other genera in equally important characters." (*Illustrated Flora of the Northeastern United States and Adjacent Canada*).

Andrewartha and Birch. 1954. "The species is the most inclusive Mendelian population; its chief characteristic is that its members do not (no matter how good may be the opportunity) interbreed with members of other Mendelian populations. Populations whose members do not interbreed because they

are kept apart by geographic barriers may not be classed as species on this evidence alone; for example, a number of Mendelian populations living on several widely separated oceanic islands may all belong to one species, even though there is virtually no chance of interbreeding in nature because of the distances separating the islands. On the other hand, if it were found, when they still did not interbreed, then they would be correctly classed as separate species."

Verne Grant. 1957. "...a community of cross fertilizing individuals linked together by bonds of mating and isolated reproductively from other species by barriers to mating." (*The plant species in theory and practice*. In E. Mayr (ed.), *The species problem: 39-80*, Amer. Assoc. Adv. Sci., Washington, D.C.).

D.H. Valentine and Askell Love. 1958. "The species of the biosystematist, for which it is convenient to use the term ecospecies, is defined in terms of gene- exchange. If two populations are capable of exchanging genes freely under either natural or artificial conditions, they belong to the same ecospecies; but if internal barriers to gene-exchange exist (e.g. in the form of incompatibility or hybrid infertility), then the populations are ecospecifically distinct. This definition is apparently simple, and it provides an objective criterion of a species, something which can be determined by experiment; and it also has a biological meaning in that it marks a certain stage in the process of evolutionary divergence." (Taxonomic and Biosystematic Categories. *Brittonia 10 (4): 153-166*).

Clausen and Hiesey. 1958. "Species are composed of genetically distinguishable ecological races and morphological subspecies, each of which is adjusted to its own kind of environment and controlled by interacting systems of genes loosely held together through genetic coherence." (*Carnegie Inst. of Washington Publ. Experimental Studies on the Nature of Species IV*).

V.H. Heywood. 1959. "It needs to be stressed that a fundamental tenet of taxonomy is that rules cannot be made about delimiting species: the most that can be done is to lay down general guiding principles. There must always be an element of judgment (involving experience and perhaps intuition) in any taxonomic decision. Non-taxonomists may deplore this, but it is unavoidable. For this reason no precise definition of the species is possible." (in *Fedde Repert. 63: 180*).

George Gaylord Simpson. 1961. "An evolutionary species is a lineage (an ancestral-descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies." (*Principles of Animal Taxonomy*, p. 153).

S.T. Cowan. 1962. ". . . just as no two observers see the same rainbow, so no two biologists conceive exactly the same species." (In G.C. Ainsworth & P.H.A. Sneath, ed., *Microbial Classification*, pp. 433-455).

Lyman Benson. 1962. "Definition of the term species is an ellusive goal only if an attempt to limit the category is included. Leaving out criteria for distinguishing species from each other, the problem narrows down to the question of what kind of entity is being classified. A working definition must take into account the following elements: 1) The species discussed in this book are composed of living

organisms. 2) A species is able to reproduce itself. 3) A species is ordinarily a natural population or system of populations, rarely an individual. 4) The individuals composing a species are genetically closely related." Also, "A living natural species is a reproducing population or system of populations of genetically closely related individuals." (*Plant Taxonomy.*, The Ronald Press Company, N.Y. pp. 289-290).

P.H. Davis and V.H. Heywood. 1963. "Many evolutionary taxonomists believe that species are formed as a result of the evolutionary processes. It is an act of faith for both Linnaean and evolutionary taxonomists that their task is to go out into nature and find these creations. The *concepts* covering these and other groups called species are, however, constructions of the human mind and cannot be defined. (P.89). And, on another page "...we may regard species as morphologically definable units, made up of groups of individuals (populations), which it is assumed are usually interbreeding, the containers and expression of one or more gene pools." (P. 98). (*Principles of Angiosperm Taxonomy*, D. Van Nostrand Company, Inc. N.Y.).

Carl L. Wilson and Walter E. Loomis. 1967. "Many difficulties are involved in the study of species and of their origin. Some species are sharply defined. but others grade into related species through intermediate forms. Some of these intermediate forms may represent incipient species, for species are arising today as in the past. Most evolutionary changes take place so slowly, however, that they do not become evident within any easily recorded period of time and so the problem is attacked indirectly. By growing plants in experimental gardens, by studying their mutations and their chromosomes, by collecting them and studying their distribution, it is frequently possible to make reasonable inferences concerning their evolutionary history. Although there is no general agreement on the definition of a species, it may be defined ideally as a group of individuals that are morphologically distinguishable from related kinds, and that will not cross or that cross with difficulty with related species. All existing species have come from pre-existing species, but so complex are environmental factors and living organisms that species are believed to have arisen in different ways; there is no one solution to the problem of their origin. The chief principles involved in the formation of new plant species may, according to modern views, be grouped under two main heads: (1) reproductive isolation and (2) species hybridization." (*Botany, 4th Ed.*, Holt, Rinehart and Winston, NY).

Arthur Cronquist. 1968. "An exact definition of the species is impossible, and the more precise one attempts to be, the larger number of species which do not fit the definition. Still, the basic concept is simple enough. A species is the smallest population which is permanently (in terms of human time) distinct and distinguishable from all others. It is the smallest unit which simply cannot be ignored in the scheme of classification. It is the primary taxonomic unit, and it may also be thought of as the basic evolutionary unit." And, "The line between strong varieties and weak species is necessarily an arbitrary one, involving subjective taxonomic judgment. The weak species of one taxonomist may be the strong varieties (or subspecies) of another." (*The Evolution and Classification of Flowering Plants*," Houghton Mifflin Co., Boston. P. 29).

George H.M. Lawrence. 1970. "The species (i.e., the ecospecies), as conceived by the biosystematist, is a group of interbreeding or potentially interbreeding individuals reproductively isolated from other

groups of individiuals. It is a unit delimited primarily by genetical criteria and secondarily by criteria derived from ecological and morphological evidence." (*Taxonomy of Vascular Plants*, the MacMillan Co., NY. p. 182).

Oswald Tippo and William L. Stern. 1977. "1. A species is a kind of plant (or animal). White oak (*Quercus alba*, Figure 3.11), red maple (*Acer rubrum*, Figure 3.15), white pine (*Pinus strobus*, Figures 16.9 and 16.10), coconut palm *Cocos nucifera*, Figure 11.12), tobacco (*Nicotiana tabacum*), are species or kinds of plants. 2. Each individual of a species is related to other individuals of the same species because they have common ancestors; they have evolved from the same sources. 3. Individuals of the same species are similar in structure, more so to each other than to other kinds of plants. 4. Species maintain themselves in nature; they do not change appreciably from generation to generation over short periods of time. 5. Individuals of a species interbreed and produce fertile offspring." (*Humanistic Botany*, W.W. Norton & Co., NY).

Clive A. Stace. 1980. "There have been many attempts to define a species, none totally successful. This difficulty has led to the cynical definition of a species as a group of individuals sufficiently distinct from other groups to be considered by taxonomists to merit specific rank. The crux of the question does of course, lie in the term 'sufficiently distinct', since, from what has been said above, there is no magic formula to decide the issue. Most taxonomists use one or more of four main criteria. 1. The individuals should bear a close resemblance to one another such that they are always readily recognizable as members of that group. 2. There are gaps between the spectra of variation exhibited by related species; if there are no such gaps then there is a case for amalgamating the taxa as a single species. 3. Each species occupies a definable geographical area (wide or narrow) and is demonstrably suited to the environmental conditions which it encounters. 4. In sexual taxa, the individuals should be capable of interbreeding with little or no loss of fertility and there should be some reduction in the level or success (measured in terms of hybrid fertility) of crossing with other species. As discussed elsewhere in this book. none of these criteria is absolute and frequently it is left to the taxonomist to apply his judgement. Often he does this by attempting to recognize as species units that are of comparable significance in whatever terms are being applied." (*Plant Taxonomy and Biosystematics*, Edward Arnold, London).

Webster's New World Dictionary (2nd Concise Edition). 1982. Species (-shez, -sez) *n., pl.* -cies [L., appearance, shape, kind, etc.] 1. a distinctive kind; sort; variety; class 2. *Biol.* a group of highly similar plants or animals that is part of a genus and that can reproduce fertile offspring only among themselves 3. *Logic* a class of things with distinctive attributes, grouped with similar classes in a genus.

Warren H. Wagner, Jr. 1984. ". . . a convenient taxonomic category that defines a unit of organismic diversity in a given time frame and composed of individual organisms that resemble one another in all or most of their structural and functional characters, that reproduce true by any means, sexual or asexual, and constitute a distinct phylogenetic line that differs consistently and persistently from populations of other species in gaps in character state combinations including geographical, ecological, physiological, morphological, anatomical, cytological, chemical, and genetic, the character states of a number and kind ordinarily used for species discrimination in the same and related genera, and if partially or wholly

sympatric and coexistent with related species in the same habitats, unable to cross or, if able to cross, able to maintain the special distinction." (A Comparison of Taxonomic Methods in Biosystematics, In *Plant Biosystematics*, ed. W.F. Grant, pp. 643-54, Academic Press, Canada).

H. Crum. 1985. "A species cannot be fully defined, nor can it be intuitively sensed. Although subjectivity is involved in decision making, a species is only as good as the knowledge and insights used in its delimitation. Certain methodologies help. So do good sense and good judgement based on meaningful experiences, and the more the better." (Traditional make-do taxonomy, *Bryologist* 88: 221).

Peter H. Raven and George B. Johnson. 1986. "In Chapter 21 we reviewed the nature of species and saw that there are no absolute criteria that can be applied to the definition of this category. Individuals that belong to a given species, for example, dogs (Figure 22-5), may look very unlike one another. Nevertheless, they are generally capable of hybridizing with one another, and the different forms can appear in the progeny of a single mated pair. On the other hand, the members of a given species often cannot hybridize with those of a second species. For example, dogs are not capable of interbreeding with foxes, which, although they are generally similar to dogs, are members of another, completely distinct, group of mammals. In contrast, dogs can and do form fully or partly fertile hybrids with related species such as wolves and coyotes, which are also members of the genus *Canis*. The transfer of characteristics between these species has, in some areas, changed the characteristics of both of the interbreeding units. About the only points that can be made about species generally are that they differ from one another in at least one characteristic and that they generally do not interbreed freely where their ranges overlap in nature. In some groups of organisms, including bacteria and many eukaryotes, asexual reproduction predominates and classification systems clearly do not have a genetic basis. Biologists agree, in general, on the kinds of units that they classify as species, but these units share no biological characteristics uniformly. Species differ from one another in at least one characteristic and generally do not interbreed freely with one another where their ranges overlap in nature." (*Biology*, Times Mirror/Mosby College Publishing, St. Louis).

Author and date unknown: "A species is what a good taxonomist calls a species."

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