AN ILLUSTRATED KEY TO SOME FOSSILIZED POST GLACIAL, CLIMATIC INDICATOR POLLENS

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INTRODUCTION

Modern pollen analysis began in 1916 with the paper by the Norwegian L. Von Post (1916). On the American side, recent work has been done by Sears (1942–64), Potzger (1941, 1956), Voss (1933), Cain (1939–44), Deevey (1957), Hanson (1947) and Wilson (1943). Much of this work has had as its objective the identification of Post Wisconsin climatic periods from stratified fossil pollen deposits accumulated in bogs and lakes. Since these bogs and lakes in the northern part of North America were established at the time of the retreat of the continental glacier, climatic periods prior to the glaciation can not be defined. In the Southern United States and Valley of Mexico (both areas free of the Wisconsin ice sheet) work by Sears (1955, 1961) has more or less established some climatic sequence for the Pleistocene in North America.

According to Sears (1961), the last major ice advance took place 16,000 to 18,000 years ago. The warm and more or less arid conditions terminating it were reversed at least twice: by the Port Huron Readvance, circa 12,000 to 13,000 years ago, and by the Valders, circa 11,700 years ago, with the Two Creeks Interval circa 11,500 years ago between them.

The Valders was followed by a prolonged of warming and desiccation extending over more than five thousand years. This was relieved by the humid Atlantic about 5,000 to 6,000 years ago. Cooler and moister conditions were initiated about two thousand years ago and fluctuations which have occured since that time await further study.

There is a need for more palynological studies of the bogs and lakes in those areas of the world which were covered by the last glaciation (approx. 12,000 years ago for N. America). Such data must be correlated with data from bogs and lakes of the same age in Europe, Asia and Eurasia to complete the post glacial climatic picture for the northern hemisphere.

To facilitate such studies, a key to the pollen types commonly found in bog peats, supported by illustrations would seem to be desirable. The key presented here features a simpler terminology for the morphology of the grains, followed by more technical descriptions in the text. Such a key may be of use to students at many levels.

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The accompanying chart gives approximate correlations of post Wisconsin climatic periods established by the palynological studies of Sears (1942–64), Deevey (1944–51), Potzger (1941, 1956) and Courtemanch and Terasmae (1959) for North America.

Post Wisconsin Climatic Periods Established By Pollen Analysis

Years Before Present	Sears	Deevey	Potzger & Courtemanch	Terasmae
2,000	V	Sub-Atlantic C-3 | Q-5 Cooler-moist		I Decline *Tsuga* & *Pinus* Increase *Picea*
3,000	IV	Xerothermic (*Quercus-Carya*) C-2		
6,000	III	Mesophytic Forest C-1 | Q-4 Warm-moist		II High *Fagus, Tsuga* Decline *Pinus, Carya.* Slight increase *Picea, Abies Betula.*
	II	*Pinus* B | Q-3		III High *Pinus* (Quercetum Mixtum.) Low *Picea, Abies.*
7,000 8,000		Increasing warmth		IV High *Pinus banksiana, Abies.* Low *Betula,* (Quercetum Mixtum). Decline *Picea.*
9,000	I	*Picea-Abies* A-3 A-2 | Q-2		V Maximum *Picea.*
11,700		Non-arboreal A-1 | Q-1		VI Low *Picea.* High *Pinus, Betula, Alnus* & Non-arboreal
11,000	Two Creeks Interval & Champlain Sea Episode			
12,000	Glaciation (Port Huron Readvance)			

MATERIALS AND METHODS

Two devices are available for sampling bog peat: the Hiller Peat Auger sold by A/B Borros, Solna, Sweden and the Davis Peat Sampler available in America. The Hiller device is prefered for sampling water-saturated loosely compacted bog peat since it can be closed longitudinally upon the sample. This permits drawing the sample to the surface intact. The Davis Sampler is suitable for the

more common moist compact bog peats. Another device, The Livingstone Sampler is prefered for sampling lakes and ponds.

Samples should be taken at one inch intervals for at least the bottom two feet. Above this, samples can be taken at greater intervals (3, 6, and 8 inch intervals, upward towards the surface of the bog). Study samples of about one cubic centimeter are extracted from the interior of the peat cores at the selected intervals and are preserved in labeled vials with 70 to 95% alcohol. This is to prevent formation of mold and concretion of the peat.

Slides of the pollen peat material are prepared by extracting a small piece of the sample with a round wooden toothpick and placing it on a slide. A few drops of 95% ethanol are added. The toothpick is then rolled and streaked simultaneously through the softened peat, distributing it in an even film upon the slide. When the ethanol has evaporated, four to five drops of melted glycerine jell is added with another clean toothpick. The cover glass is set in place and the slide is warmed slightly. A clean pair of toothpicks is used each time to avoid contamination of samples or slides.

To avoid a flow away of larger grains such as those of *Tsuga*, *Abies* and *Picea*, bits of broken cover glass can be placed under each end of the cover slip or a shallow depression slide can be used. Another way to provide for this flow away of larger grains is to place a small piece of solid glycerin jell (equal to the amount needed to mount the material on the slide) beneath the cover slip. This slide is then heated until the area of the cover slip is just filled with the melted mountant. These procedures may prove necessary to insure an accurate count of important indicator genera.

A staining and mounting medium of glycerine jelly, effective in differentially staining certain fossil pollen types is prepared as follows:

Soak 7 gm. of dry gelatine for two hours in 28 ml. of filtered water. Add 42 ml. of glycerine and 1 cc. of granulated camphor as preservative. Liquefy by warming for 15 minutes and then filter through glass wool or fine mesh in a heated glass funnel. Add minute amounts of Crystal Violet and Safranin O stains, sufficient to color *Acer* or *Betula* pollens a pale fuchia or wine color. This combination of stains allows for differential staining of untreated fossil bog pollen as follows:

Abies .....light fuchia
Picea .....deep violet to reddish purple
Pinus .....light bluish purple
Larix & *Tsuga*.....light purple

Pollen material was obtained from peat samples representing a pollen profile of a bog studied by the senior author at West Branch, Oneida County, New York. Supplementing this material, contemporary acetolized herbarium pollen was also

consulted. Besides these actual pollen materials, the standard texts of Wodehouse (1935), Erdtman (1943) and Faegri (1959) were consulted.

The following pollen types were studied using a 43× objective and 15× ocular by both authors. The junior author further studied all the types under oil immersion. Those species marked with asterisk indicate genera studied from herbarium material only. This was necessary because either the peat materials were deficient in these pollen types or because the identification of these pollen types in the fossilized condition was dubious.

Abies balsamea (L.) Mill.
Acer rubrum L.
A. saccharum Marsh.
Alnus rugosa (DuRoi) Spreng.
A. serrulata (Ait.) Willd.
Betula alba L.
B. alleghaniensis Britt.
B. lenta L.
B. populifolia Marsh.
Carpinus caroliniana Walt.
Carya cordiformis (Wang.) K. Koch
C. glabra (Michx.) Loud.
C. ovata (Mill.) K. Koch.
Castanea dentata (March) Borkh.*
Fagus grandifolia Ehrh.
Fraxinus americana L.*
Juglans cinerea L.
J. nigra L.
Larix laricina (DuRoi) K. Koch.
Liquidambar styraciflua L.*
Liriodendron tulipifera L.*
Magnolia virginiana L.*
Nyssa sylvatica Marsh.*
Ostrya virginiana (Mill.) K. Koch.
Plantanus occidentalis L.
Picea glauca (Moinch.) Voss.
P. mariana (Mill.) BSP
P. rubens Sarg.
Pinus banksiana Lamb.
P. resinosa Ait.
P. rigida Mill.
P. strobus L.
Prunus serotina L.*
Quercus alba L.
Q. bicolor Willd.
Q. borealis Mich.
Q. prinus L.
Tilia americana L.
Tsuga canadensis (L.) Carr.
Ulmus americana L.
U. rubra Muhl.

This key is not primarily intended for the pollen morphologist whose primary interest is in fine reticulation characters visible only under the high magnification of oil immersion, but is to be regarded as a practical tool for investigators studying fossil peat profiles, giving them assistance in the rapid identification of fossil pollen. Not withstanding, it is hoped that this key will be of use to students at all levels.

FOSSIL POLLEN KEY

a Bladders present

b Longest axis including bladders 85–150μ.; longest axis of dorsal cap 40–90μ.; angle between bladders more than 90°; marginal ridge very small or absent; bladder reticulation well defined

c Bladders dome-shaped; dorsal cap uniform in thickness; reticulation lines of bladder, anastomosing promptly from base of bladder, lines somewhat irregular or blotted; longest axis including bladders 100μ. *Picea*

cc Bladders knob-shaped; dorsal cap coarsely granular, thicker at periphery; reticulation lines of bladder parallel for a short distance from the base of the bladder before anastomosing; longest axis including bladders 150μ. *Abies*

bb Longest axis of grain including bladders less than 85μ.; longest axis of dorsal cap less than 40μ.; angles between bladders less than 90°; marginal ridge present; dorsal cap scaraboid shaped; bladder reticulation flecked or speckled; longest axis including bladders 70–85μ. *Pinus*

aa Bladders absent

b Longest diameter of grain 60–80μ.; grains non-aperturate or with a germinal slit, round, or mono-colpate, prolate

c Grains non-aperturate or with germinal slit, round globose

d Grains intact; exine very thick (8μ.) strongly reticulate-warty; germinal slit crescent shaped; 80μ. *Tsuga*

dd Grains fragmented or fractured; exine thin (less than 1μ.), smooth; non-aperturate; 65μ. *Larix*

cc Grains mono-colpate, boat-shaped, prolate

d Exine thick (1.5μ.), granulate with scattered warty nodules; 73×20×22μ. *Liriodendron*

dd Exine thin (less than 1μ.), uniformly granulate; 90×30×35μ. *Magnolia*

bb Longest diameter of grain less than 40μ.; tri- to many-colpate (with furrows)

c Furrows obvious, grains colpate

d Grains tri-colpate or tetra-colpate

e Grains tri-colpate, furrows long, gaping wide when grain is fully globose-expanded, or furrows closed inward, the grain barrel-shaped in collapse; exine finely and uniformly granulate, thin; 37×28μ. *Acer*

ee Grains tetra-colpate, furrows short; exine conspicuously reticulate, suggestive of a golf ball; 25μ. *Fraxinus*

dd Grains tri-colporate, furrows constricted, either partially closed inward and the grain 3-lobed or tightly rolled inward and the grain elliptical to the poles (never flattened at the poles and barrel-shaped)

e Exine essentially smooth, neither reticulate nor obviously granulate

f Grains small, 17×13μ. (elliptical like a football), tightly closed (the usual condition); furrows almost meeting at the poles *Castanea*

ff Grains larger, 31×25μ., subglobose to elliptical; hyaline wedge present

beneath furrow *Quercus*

ee Exine uniformly reticulated; in polar view the grains fully round, 3–lobed, or semi-triangular

f Pores beneath furrows, grains colporate

g Furrows closed inward, grain 3–lobed, or sometimes expanded, the pore visible beneath the furrow covered by edges of furrow; exine thick, rough; 40μ. *Fagus*

gg Furrows not closed inward. grain semi-triangular, flattened; pore remnant folded down from pore margins; exine thinner, somewhat reticulate; 25×35μ. *Nyssa*

cc Furrows greatly shortened or absent, grains porate or apparently so

d Exine conspicuously thickened, dark beneath pore (actually short furrows gaping like pores), these apertures 32–37μ. *Tilia*

dd Exine not thickened beneath pore; furrows absent, grains porate

e Pores aspidate, protruding in a pouting fashion, three, sometimes four, rarely five; grains semi-triangular (tetra-angular in *Alnus rugosa*) BETULACEAE

g Grains triangular in polar view, small, 20–25μ.; exine thick, 1μ. *Corylus*

gg Grains semi-triangular to globose in polar view (tetra-angular in *Alnus rugosa*); 23–38μ.

h Grains globose to globose-semi-triangular

i Atrium with concave walls beneath pore opening; the whole pore mount aspidate rising above the surface of the grain, slope of pore mount concave, steep; 28μ. *Betula*

ii Atrium lacking; only the pore lip aspidate rising above the surface of the grain

j Pores on equator of grain, aspidation suppressed; exine thin (less than 1μ.) grains often partially collapsed, large 33μ. *Carpinus*

jj Pores displaced from the equator, aspidation of only the pore lip pronounced; exine thicker, equal to 1/2 the diameter of the pore opening; grains smaller, 23μ. *Ostrya*

hh Grains semi-triangular or tetra-angular (pentangular)

i Aspidation pronounced, atrium walls similar to *Betula*, pores sometimes interconnected by arching lines *Alnus*

j Pores four, (five); arching lines between pores pronounced; 28μ. *A. rugosa*

jj Pores three, arching lines vague; 28μ. *A. serrulata*

ee Pores not aspidate

f Pores 3; grains oblate, semi-triangular; grains large, 45μ. *Carya*

ff Pores 5 or more than 12

g Pores more than 14, pore aperature small, 1.0–1.5μ. in diameter; 25μ. *Juglans*

gg Pores less than 14, pore aperature larger, 3.5–4μ. in diameter; exine granulate; 37μ. *Liquidambar*

Abies balsamea (L.) Mill. (Plate II, Fig. 1, 2)

Pollen grains with two bladders, the longest axis to 150μ (85 to 90μ for cap). The angle between the bladders more than 90°. Dorsal cap apparent reticulate, thicker around the periphery than in the middle. Bladder reticulate, the reticulation not anastomosing about the base of the bladder.

Acer L. (Plate IV, Fig. 6, 7)

Pollen grains 3–colpate, subprolate to spheroidal, 37×28μ. Colpi 33μ long. Sexine granulate.

Alnus rugosa (DuRoi) Spreng (Plate V, Fig. 3, 4)

Pollen grains 4–porate, tetra-hedral, 28μ. Pore more or less elevated, 3μ in diameter, 0.5μ in opening, atrium with concave wall. Exine 1μ thick. Sexine psilate.

Alnus serrulata (Ait.) Willd.

Pollen grains 3–porate, semi-triangular to triangular (other characters as *A. rugosa.*).

Betula L. (Plate VI, Fig. 5, 6)

Pollen grains 3–porate, semi-angular, 28μ. Pore 1–1.5μ in diameter. Atrium (cavity beneath opening) distinct, with concave wall. Exine 1–1.5μ thick. Sexine psilate.

Carpinus caroliniana Walt. (Plate IV, Fig. 8)

Pollen grains 3–porate, spheroidal, 33μ in diameter. Pore more or less elevated, opening 3μ in diameter. Sexine psilate.

Carya cordiformis (Wang.) K. Koch. (Plate III, Fig. 6)

Pollen grains 3–porate, semi-triangular, 46μ. Pore 3μ in diameter. Sexine psilate.

Castanea dentata (March.) Borkh. (Plate VI, Fig. 3, 4)

Pollen grains 3–colporate, prolate, 17×13μ. Colpi 14μ long. Sexine psilate.

Corylus cornuta Marsh. (Plate V, Fig. 7, 8)

Pollen grains 3–porate, triangular, 25μ. Pore 1μ in diameter, atrium (cavity beneath pore) with slightly convex wall. Exine 1μ thick, 2.5μ thick in pore area.

Fagus grandifolia Ehrh. (Plate IV, Fig. 4)

Pollen grains 3–colporate, spheroidal, to 3–lobed in polar view, 40μ. Colpi 34μ long. Sexine granulate.

Fraxinus L. (Plate IV, Fig. 5)

Pollen grains 4-colpate, spheroidal, 25μ. Sexine reticulate, lumina 1μ in diameter, muri 0.5μ wide.

Juglans L. (Plate V, Fig. 9)

Pollen grains polyporate (pores more than 14), spheroidal, 25μ in diameter. Pore 1–1.5μ in diameter. Sexine psilate

Larix laricina (DuRoi) K. Koch. (Plate III, Fig. 3)

Pollen grains non-aperturate, spheroidal, 65μ in diameter. Exine 1–1.5μ thick. Sexine psilate.

Liquidambar styraciflua L. (Plate III, Fig. 7)

Pollen grains polyporate (pores more than 10), spheroidal, 37μ in diameter. Pore 3.5μ–4μ in diameter. Sexine granulate.

Liriodendron tulipifera L. (Plate III, Fig. 4, 5)

Pollen grains monolete, prolate but tapering at both ends, 73×20×22μ. Colpi as long as the polar axis, 22μ wide when fully expanded. Exine 1.5μ thick. Sexine granulate with scattered pillae.

Magnolia virginiana L. (Plate IV, Fig. 3)

Pollen grains monolete, prolate but tapering at both ends, 65×30×35μ. Colpi as long as the polar axis. Sexine psilate.

Monocot (sedge) (Plate I, Fig. 5)

Pollen grains monoporate, ovate, 60×40μ. Pore 7–8μ in diameter. Exine 1–2μ thick. Sexine psilate.

Nyssa sylvatica Marsh. (Plate III, Fig. 1, 2)

Pollen grains 3-colporate, suboblate to oblate, 25×35μ. Colpi 20μ long. Pore 5μ in diameter, 3μ in opening. Sexine reticulate, lumina 1μ in diameter, muri 0.5μ wide.

Ostrya virginiana (Mill.) K. Koch. (Plate VI, Fig. 1, 2)

Pollen grains 3-porate, spheroidal to semi-triangular, 23μ in diameter. Pore more or less elevated, opening 2μ in diameter. Exine 1–2μ thick. Sexine psilate.

Picea A. Dietr. (Plate II, Fig. 3)

Pollen grains with two bladders, the longest axis 100μ (70μ cap), the angle between the bladders 90° or more. Body without pronounced dorsal cap, with deep germinal aperature between the bladders. Dorsal cap uniformly thick, reticulate. Bladder reticulate, the reticulation anastomosing over the whole surface.

Pinus L. (Plate I, Fig. 1, 2)

Pollen grains with two bladders, the longest axis 85μ. The angle between the bladders less than 90°. Dorsal cap pronounced, marginal ridge present around the dorsal cap. Germinal aperature pronounced, thick. Bladder reticulate, lumina of uniform area.

Quercus L. (Plate V, Fig. 5, 6)

Pollen grains 3-colporate, subprolate to spheroidal, 31×25μ. Colpi 20μ long. Exine 2–2.5μ thick. Sexine granulate, thicker than nexine.

Tilia americana L. (Plate V, Fig. 1, 2)

Pollen grains 3-porate, spheroidal, 37μ in diameter. Pore 1–1.5μ in diameter (opening), costae margin 3μ wide. Exine 2.5μ thick, or 5μ thick in pore area. Sexine reticulate, lumina 1μ in diameter, muri 0.5μ wide, thicker than nexine.

Tsuga canadensis (L.) Carr. (Plate I, Fig. 3, 4)

Pollen grains non-aperturate, or with a germinal slit, spheroidal, 80μ in diameter. Exine 8μ thick. Sexine prominently reticulate to coarse granulate.

Ulmus americana L. (Plate IV, Fig. 1, 2)

Pollen grains penta-porate, penta-hedral, 27μ. Pore 1μ in diameter. Exine 1.5–2μ thick. Sexine striate to ornate.

DISCUSSION

Certain genera are difficult to separate (diagnose) at magnifications lower than 60×: *Acer, Fraxinus, Prunus, Quercus,* and *Castanea.* Higher magnifications are needed to compensate for such factors as the grains varying in size or being in a state of expansion or collapse and having their surface reticulations corroded.

The grains of *Quercus* are best identified at 40–60× magnifications, on the basis of their shape and size. Measuring approximately 31 microns from pole to pole, they usually appear collapsed and strongly elliptical. Secondarily (at high power) they can be determined from their furrow and reticulation character.

The grains of *Acer* when collapsed, usually exceed 37 microns when measured from pole to pole, and are elliptical and somewhat flattened at the poles and thus have a characteristic "barrel shape" (cf. Plate IV, Fig. 6). When expanded, the furrows are wide-gaping and extend from pole to pole. The exine is thin, perhaps thinner than that of *Quercus* at the same magnification. *Acer* when stained and mounted as suggested above, had the same pale pink color as does *Betula.* The latter which usually occurs with *Acer* on the sample slide, is readily distinguished on the basis of several characters.

The grains of *Picea* and *Abies* in the fossil condition resemble each other very strongly. The larger grains of *Picea* can be mistaken for *Abies* and abnormally smaller grains of *Abies* can be mistaken for *Picea.*

The bladder reticulation and shape of the bladders of these two genera are noteworthy. *Picea* has "dome-shaped" bladders and reticulation lines anastomosing over the whole surface of the bladder, even to the base of the bladders. *Abies,* on the other hand, has "knob-shaped" bladders and reticulation lines that are parallel to each other near the base of the bla lder. Further up, they anastomose like *Picea.* (cf. Plate II, Fig. 1).

The grains of *Pinus* with its marginal ridge is usually easily identified. This ridge character may be evanescent. In view of this, the following secondary characters may assume diagnostic importance at the lower magnifications: "speckled" reticulation on the bladders, a greater proximity of one bladder to the other than in *Picea* or *Abies* (i. e. a smaller angle of divergence), the "scaraboid shape" of the dorsal cap (i.e. resembling the back of a beetle). Finally, the suggested staining and mounting medium gives to *Pinus* a bluer color than to the obviously larger grains of *Picea* and *Abies*. The grains of *Larix*, essentially thin walled and without reticulation, do not fossilize intact, and if found, they are more likely to be fragmented or collapsed. Such fragile fragmented grains are more to be expected near the surface of the bog where compaction of the peat is less. In the deeper peat, they are not to be expected and in fact are seldom found.

The grains of *Nyssa* are readily segregated from *Fagus*, *Nyssa* being subtriangular while *Fagus* is fully round in polar view or at least tri-lobed.

In the Betulaceae, the "atrium" character of the pores of *Betula* and *Alnus* is unique (cf. Plate VI, Fig. 6). The pores of *Betula* and *Corylus* are always strongly aspidate or nozzle-like. The pores of *Alnus* also have an atrium, but the walls of the atrium are not as concave as those of *Betula*. *Alnus* is also distinguished from *Betula* by its more angular shape, i.e. the grain of *Betula* is more spheroidal. The arching lines from pore to pore cited for *Alnus rugosa* (DuRoi) Spreng. (Wodehouse 1935) may not be easily distinguished in fossil material.

The grains of *Ostrya*, unlike *Alnus* and *Betula* have pores which are only weakly aspidate and lack the atrium character. The pore lip alone protrudes without any apparent basal mount from the surface of an essentially globose grain (cf. Plate VI, Fig. 1, 2). The grains of *Carpinus*, of greater size and thinner exine than the rest of the Betulaceae, tend to collapse and be deformed in the fossilized condition.

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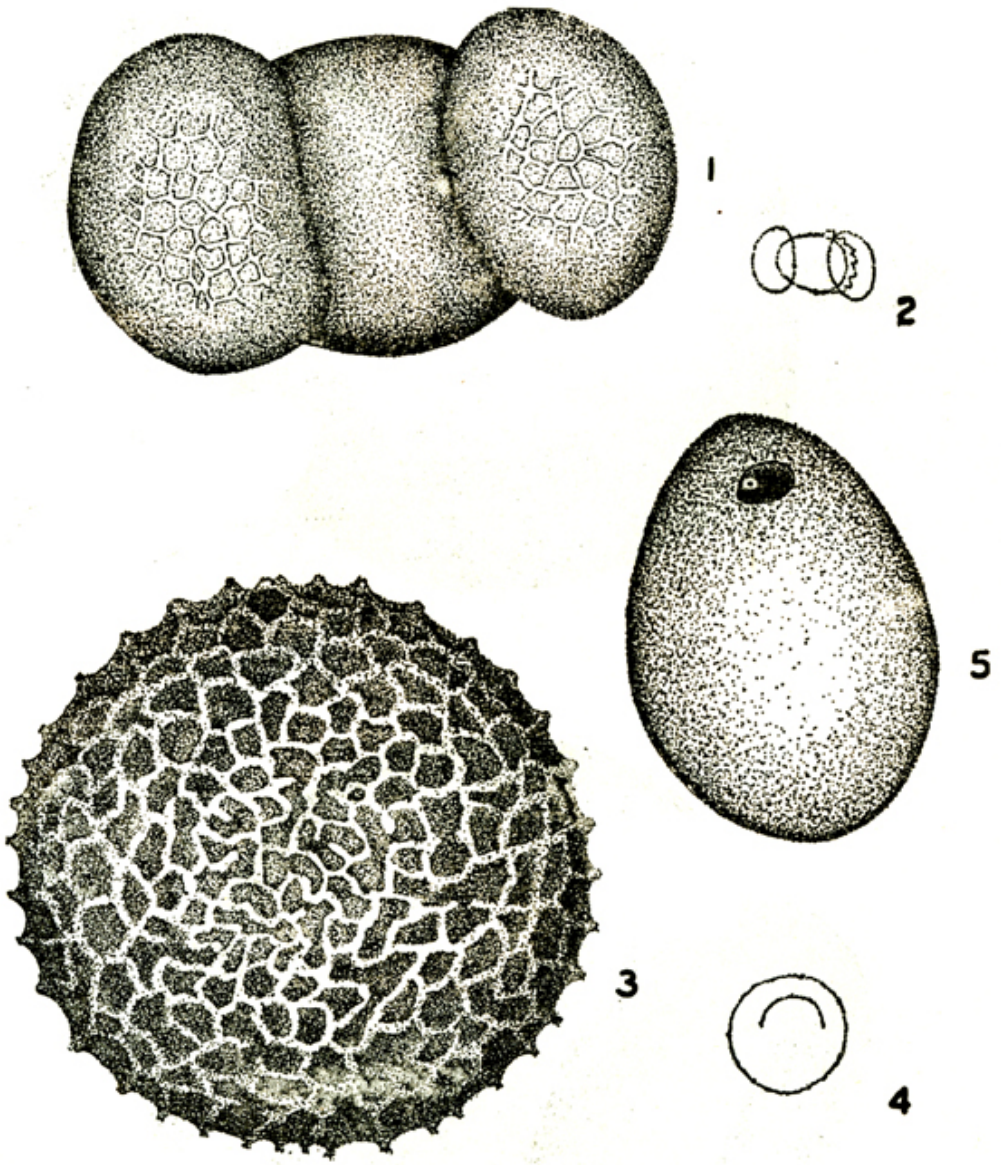

Plate I: Pollen grains of 1. *Pinus* sp., the longest axis 85μ, ventral view. 1,000× 2. *Pinus* sp., same grain as 1, seen in transparent fashion, showing the marginal ridge, 200× 3. *Tsuga canadensis*, 80μ in diameter, 1,000× 4. *Tsuga canadensis*, same grain as 3, showing the germinal slit, 200× 5. sedge (monocot), 60×40μ, 1,000×

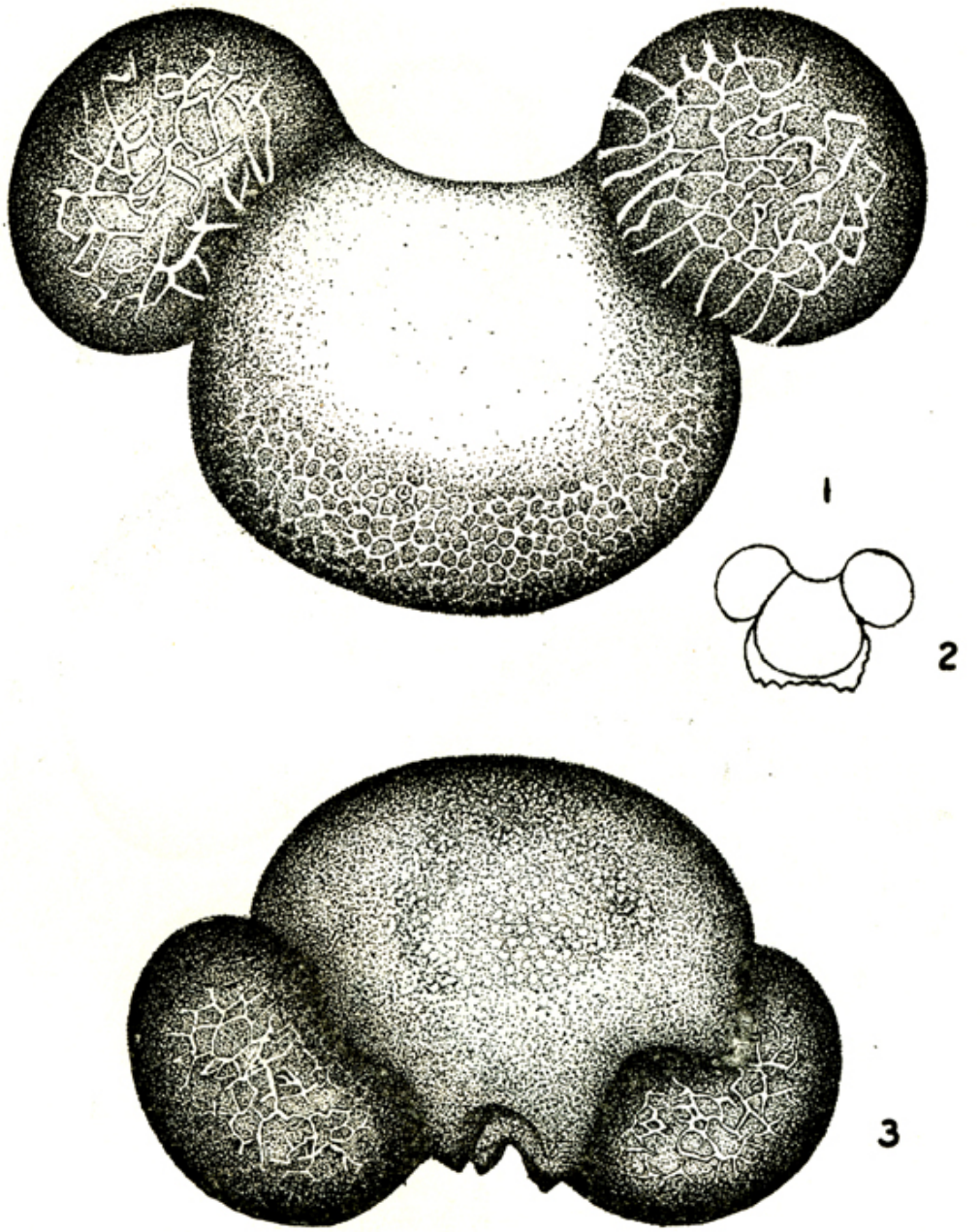

Plate II: Pollen grains of 1. *Abies balsamea*, the longest axis 150 μ, equatorial view. 1,000× 2. *Abies balsamea*, same grain as 1, seen in transparent fashion, showing the marginal ridge. 200× 3. *Picea* sp., the longest axis 100 μ, equatorial view, 1,000×.

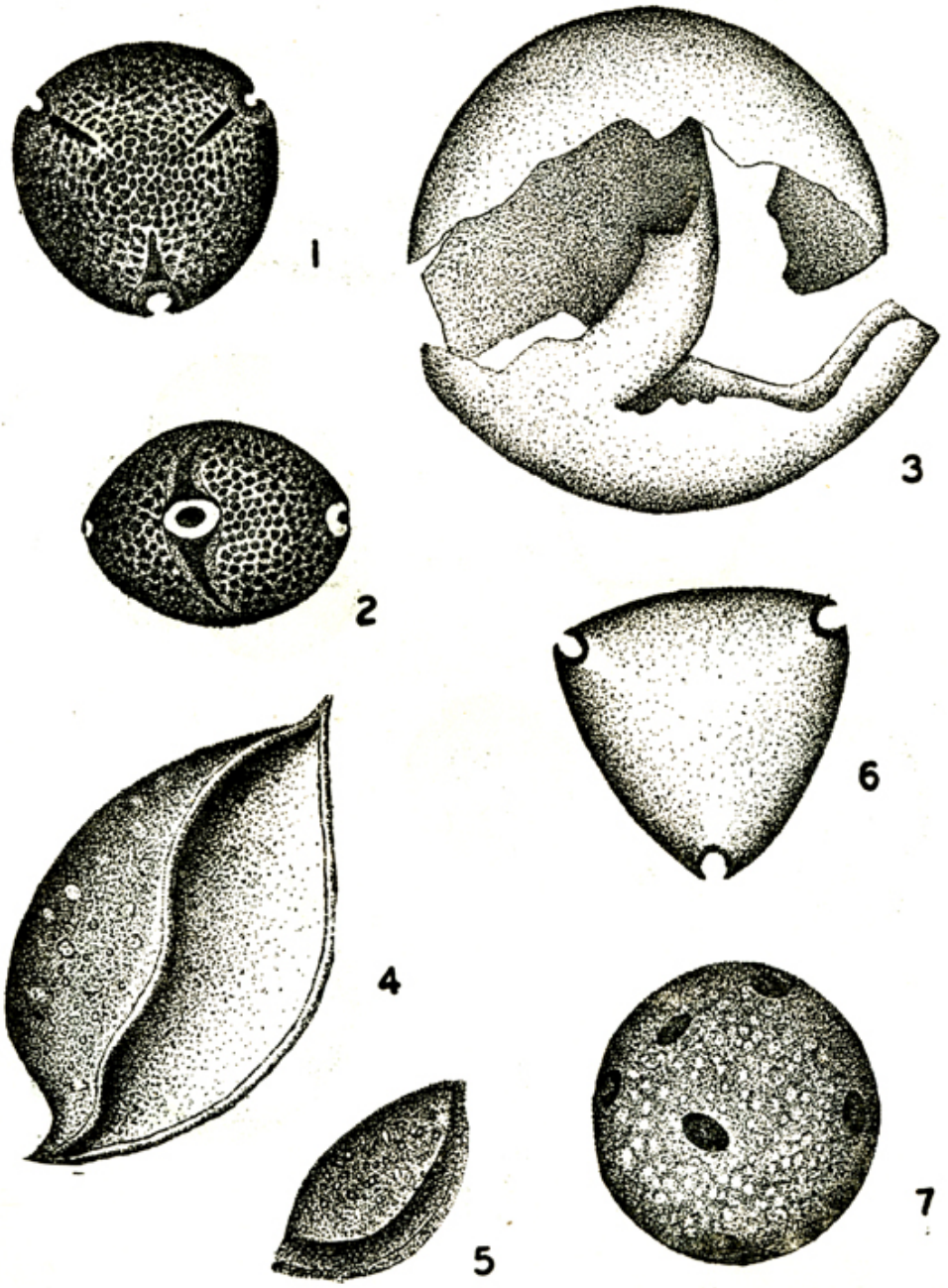

Plate III: Pollen grains of 1. *Nyssa sylvatica*, 35 μ, polar view 2. *Nyssa sylvatica*, 25 × 35 μ, equatorial view. 3. *Larix laricina*, 65 μ in diameter, more or less fossilized. 4. *Liriodendron tulipifera*, 73 × 20 × 22 μ, showing the furrow fully expanded. 5. *Liriodendron tulipifera*, showing the furrow not expanded. 200× 6. *Carya cordiformis*, 46 μ, polar view. 7. *Liquidambar styraciflua*, 37 μ in diameter. All figures except 5 at 1,000× magnifications.

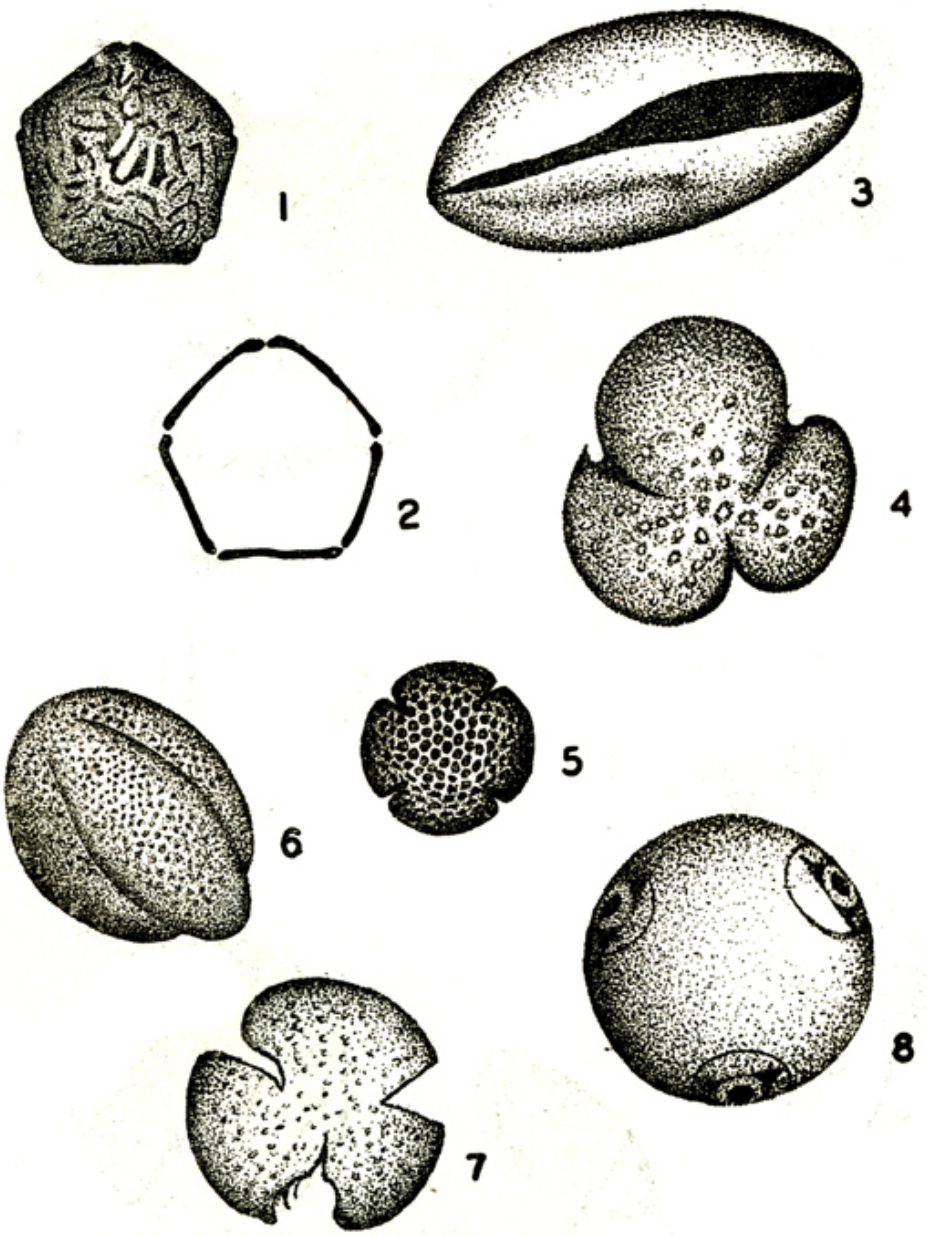

Plate IV: Pollen grains of 1. *Ulmus americana*, 27 μ 2. *Ulmus americana*, same grain as 1, showing the thickness of exine 3. *Magnolia virginiana*, $65 \times 30 \times 35\,\mu$, equatorial view. 4. *Fagus grandifolia*, 39 μ, polar view 5. *Fraxinus* sp., 24 μ, polar view. 6. *Acer* sp., $37 \times 28\,\mu$, equatorial view 7. *Acer* sp., 37 μ, polar view 8. *Carpinus caroliniana*, 33 μ in diameter. All figures at 1,000× magnifications.

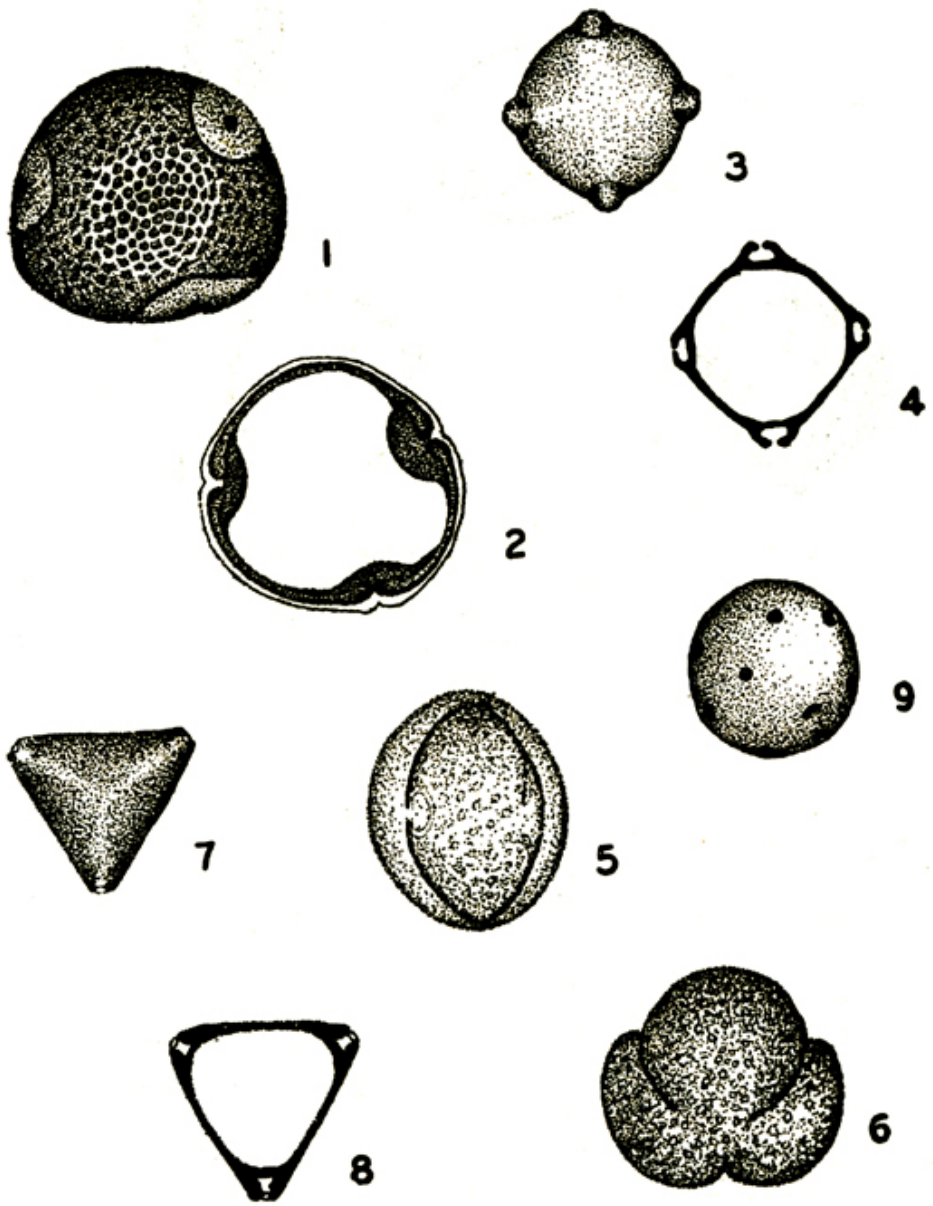

Plate V: Pollen grains of 1. *Tilia americana*, 37 μ in diameter 2. *Tilia americana*, seen in transparent fashion, showing the thickness of exine. 3. *Alnus rugosa*, 28 μ, polar view 4. *Alnus rugosa*, seen in transparent fashion, showing the thickness of exine and the atrium of the pore. 5. *Quercus* sp., 31 × 25 μ, equatorial view. 6. *Quercus* sp., 31 μ, polar view. 7. *Corylus cornuta*, 25 μ, polar view 8. *Corylus cornuta*, seen in transparent fashion, showing the thickness of exine and atrium of pore. 9. *Juglans* sp., 25 μ in diameter. All figures at 1,000× magnifications.

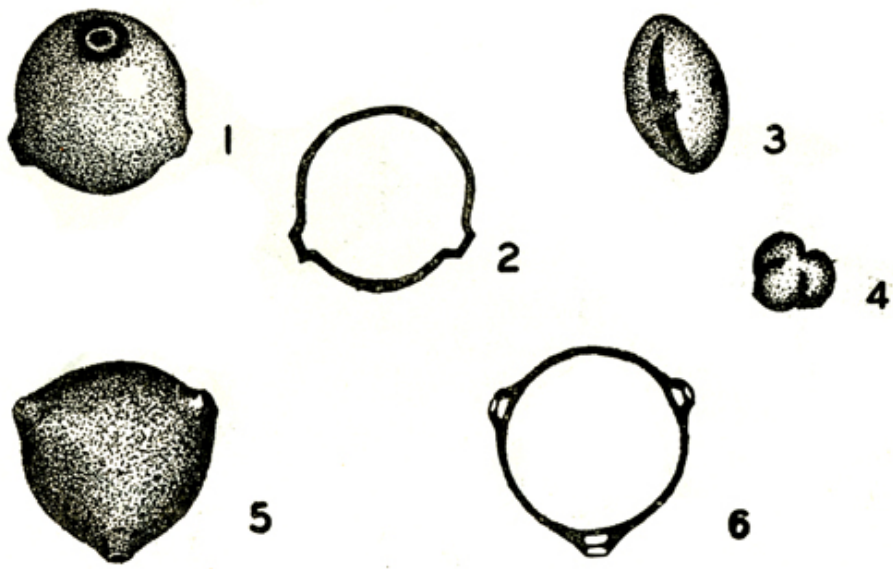

Plate VI: Pollen grains of 1. *Ostrya* sp., 23 μ, partly equatorial view. 2. *Ostrya* sp., seen in transparent fashion, showing the thickness of exine. 3. *Castanea dentata*., 17×13 μ, equatorial view. 4. *Castanea dentata*, 13 μ, polar view. 5. *Betula* sp., 28 μ, polar view. 6. *Betula* sp., seen in transparent fashion, showing the thickness of exine and atrium of pore. All figures at 1,000× magnifications.

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