

**PHOTOGRAPHIC ATLAS AND KEY
TO WINDBLOWN SEEDS OF ALPINE PLANTS
FROM NIWOT RIDGE, FRONT RANGE, COLORADO, U.S.A.**

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PREFACE

Niwot Ridge, situated in the alpine tundra zone of the Colorado Front Range, provides a unique research environment for many scientific disciplines because long-term research in climatology, botany, zoology and geology has provided the necessary foundation of data. With the support of the University of Colorado's Long-Term Ecological Research grant from the National Science Foundation, this research is continuing to strengthen and expand.

A product of this research program is this seed key and atlas for alpine plants of the Colorado Front Range, the first of its kind for the Rocky Mountain region. Seventy-five species of plants are treated in this work. The authors collected, identified, and photographed the seeds of the alpine species which produce the majority of windblown propagules, based on seed trapping experiments. As such, this key and photographic atlas should be of value to students of both modern botany and to students of recent paleobotany of the region.



Mark F. Meier
Director

ABSTRACT

The seeds and other propagules of 75 species of alpine plants were collected from the tundra zone of Niwot Ridge, Colorado Front Range. We present here a photographic atlas of these seeds, and a key to their identification.

INTRODUCTION

During the summer of 1982, seeds and other propagules were collected from 75 species of plants of the alpine tundra of Niwot Ridge in the Front Range of Colorado, as a part of the Long-Term Ecological Research (LTER) project of the Institute of Arctic and Alpine Research, University of Colorado. The species represent approximately 60% of the local alpine flora (Weber, 1976) encompassing 57 genera and 24 families (Table 1). In addition, seed trapping experiments were performed, using sticky traps set out on the tundra. These experiments suggest that the seeds represented in this atlas are the ones most commonly found on the alpine tundra of this region. A photographic atlas and key to the identification of these seeds is presented for use by other researchers who need to identify either recent or sub-fossil seeds from alpine environments of the Front Range, Colorado. This seed atlas is the first for the alpine zone of the Rocky Mountain region. Because of the wide distributions (circumpolar, circumboreal, and arctic-alpine) of many species represented, this atlas should be generally applicable in a much larger geographic region than the Front Range. The reference seed collection on which the key is based is housed at the herbarium of the Mountain Research Station of the Institute of Arctic and Alpine Research, University of Colorado.

Photographs were taken of several seed specimens of most species, and the photographs judged to be the best reproduction and most representative of each species were used in the final figures (Figures 1-7). In some cases more than one photograph of a given type of seed was used and in other cases photographs of both the naked seeds and seed-capsules were used. For some genera (e.g. Carex and Salix) the seed-form most commonly trapped was photographed, since this is the form that will most probably be found by users of the key. Photographs of pale seeds are mounted on black backgrounds, and photographs of dark seeds are mounted on a white background. The seeds fall into three size categories, as represented in the three sets of scale bars in Figures 1-2 (5 mm), 3-5 (2.5 mm), and 6-7 (1 mm), respectively. Descriptions of the shapes of seeds are based on generalized seed outlines (Fig. 8) adapted from Berggren (1969). Botanical nomenclature in the key and in Table 1 follows Weber and Johnston (1979).

The key is based, for the most part, on seed features which are characteristic of plant families and genera (after Martin and Barkley, 1973), but some key couplets are artificial. The seeds of a few species are difficult to identify through the key. Some difficult seeds can be found under more than one set of couplets.

The key leads to identifications at the species level with the exception of the genus Poa which cannot be separated by seed alone.

KEY TO NIWOT RIDGE SEEDS

1. Seed winged, large (>10 mm), brown (Fig. 2, A).....
.....Picea engelmannii
Seed not winged.....2
2. Seed with curved, hairy appendage, about 7X the length of
seed body.....3
Seed without long appendage.....5
3. Appendage approximately five times the length of seed body;
curved, very hairy....Dryas octopetala (Fig. 2, D).
Appendage shorter.....4
4. Ratio of appendage to seed body length 1.4 (-1.5) : 1.....
Acomastylis rossii (Fig. 1, A).
Ratio of appendage to seed body length 1.2 : 1.....Agrostis
borealis (Fig. 1, B).
5. Seed a caryopsis (grass seed), a specialized achene (Figs.
1, E; 2, B, C, 4, H).....6
Seed not as a caryopsis.....11
6. Caryopsis hairy.....7
Caryopsis without hairs or with only discreet rows of hairs.....8
7. Seed with a single awn, (Fig. 1, B), an appendage on
individual floret...Agrostis borealis.
Seed with two appendages (Fig. 4, G)..Phleum alpinum.
8. Caryopsis without awn (Figs. 2, B; 3, H)...Poa alpina.
Caryopsis with an awn.....9
9. Awn at acute angle to caryopsis; Awn long (Fig. 1, E)....
.....Deschampsia caespitosa.
Awn at right angle to caryopsis (Fig. 1, I; 2, C).....10
10. Caryopsis with fringe of hairs at base and along side on two
rows (Fig. 1, I)....Helicotrichon mortonianum.
Caryopsis without fringe of hairs at base or along sides
(Fig. 2, C)....Trisetum spicatum.

11. Seed single, enclosed in a specialized achene, the perigynium (Figs. 3, H-J) 12
 Seed not enclosed in a perigynium..... 15
12. Perigynium elongate, notched at one end (see arrow, Figs. 1, K; 3, I, J) 13
 Perigynium not notched at apex (Fig. 3, H) ... Carex capillaris.
13. Each end of perigynium with broad, obliquely truncate beaks (Fig. 3, J) Carex rupestris
 Perigynium with one end narrowly elongated..... 14
14. Perigynium without longitudinal rib or carina (Fig. 1,K); seed ovate, spatulate with short stalk (Fig. 4, B) .. Kobresia myosuroides.
 Perigynium with three longitudinal ribs or carinae which converge at each end and with one end slightly notched (Fig. 3, I) ... Carex elynoides.
15. Seed with a pappus, a terminal ring of hairs or scales (Fig. 1, C, D, F-H) 16
 Seed without pappus..... 22
16. Seed body curved (Fig. 1, D) ... Brachyactis angusta.
 Seed body not curved..... 17
17. Pappus of six elongate lobes..... 18
 Pappus of many long hairs..... 19
18. Pappus lobes developing into narrow spines in apical half (Fig. 1, J) ... Hymenoxis acaulis.
 Pappus lobes only narrowly tapering at ends (Fig. 2, E) ... Hymenoxis grandiflora.
19. Pappus hairs very long in proportion to seed body length (ratio ca. 5:1) (Fig. 1, C) ... Antennaria alpina.
 Pappus hairs shorter..... 20
20. Pappus hairs covered with numerous, thin setae, giving feathered appearance (Figs. 1, F, G) 21
 Pappus hairs with fewer, broad-based setae (Fig. 1, H) ... Haplopappus pygmaeus.

21. Seed narrow. Ratio of seed body length to width 2.4 : 1
 Fig. 1, F) ... *Erigeron pinnatisectus*.
 Seed broad. Ratio of seed body length to width 2.1 : 1
 (Fig. 1, G) ... *Erigeron simplex*.
22. Seed triangular in cross-section.....23
 Seed shape otherwise.....26
23. Seed with narrow end developed into a narrow stalk; angular,
 ovate, hard, black and shiny (Fig. 3, D) ... *Bistorta bistortoides*.
 Seed without narrow stalk.....24
24. Seed ovate, hard, white (Fig. 4, A) ... *Eritrichium aretioides*.
 Seed shape otherwise.....25
25. Seed rounded, triangular; surface mottled; slightly rugose
 (Fig. 3, B) ... *Arctostaphylos uva-ursi*.
 Seed elliptic, flattened in apical two-thirds; surface finely
 rugose (Fig. 4, L) ... *Polemonium viscosum*.
26. Seed reniform (kidney)-shaped.....27
 Seed shape otherwise.....33
27. Seed lenticular-reniform; dark, shiny; with longitudinally-
 stretched cellular reticulation (Fig. 6, K) ... *Lewisia pygmaea*.
 Seed not lenticular.....28
28. Seed flat-reniform (Figs. 7, B, C, J, L).....29
 Seed otherwise reniform.....32
29. Seed with concentric rows of more-or-less minute tubercles
 (Fig. 7, J, L).....30
 Seed with cellular reticulation; rugose with truncated
 apex; white (Fig. 7, C) ... *Minuartia obtusiloba*.
30. Seed with hilum-like notch on one side (Fig. 7, J) ... *Silene acaulis*.
 Seed without such a notch.....31
31. Seed angular, with an outer region with concentric rugosities
 and an inner region with more-or-less longitudinal striations
 (Fig. 7, B) ... *Minuartia rubella*.

- Seed not angular; with no distinct inner and outer zones of sculpturing (Fig. 7, L)...*Stellaria umbellata*.
32. "Seed" convex-reniform (Fig. 2, F)...megaspore of *Selaginella densa*
 Seed shape otherwise.....33
33. Seed ovate, with shallow notch (hilum) (Fig. 5, H, I).....34
 Seed shape otherwise.....35
34. Seed ovate with long, shallow hilum; surface dull, mottled (Fig. 5, H)...*Trifolium dasypodium*.
 Seed shaped as above, but with hilum shorter, shallower; surface dull and mottled (Fig. 5, I)...*Trifolium nanum*.
35. Seed with contours showing that the embryo is bent or folded (Figs. 5, G; 6, G); surface rugose or finely reticulate and pitted.....36
 Seed without contours showing bent or folded embryo.....37
36. Seed depressed-ovate; surface finely reticulate, pitted (Fig. 6, G)...*Erysimum nivale*.
 Seed ovate; surface finely rugose (Fig. 5, G)...*Thlaspi montanum*.
37. Seed in a loose, translucent mesh-bag network of cells.....38
 Seed not in cellular mesh-bag (seed coat may be reticulate).....43
38. Seed shape triangular in outline, with longest side arcuate, rounded; elliptical in cross-section (Fig. 6, F)...*Chionophila jamesii*.
 Seed not triangular in outline.....39
39. Seed transversely elliptic, slightly angled at middle; pale (Fig. 4, F)...*Pedicularis groenlandica*
 Seed not transversely elliptic in shape.....40
40. Seed shape roughly trapezoidal (Fig. 6, D)...*Castilleja occidentalis*.
 Seed shape otherwise.....41

41. Seed globular in shape, either elongated or rounded.....42
 Seed shape otherwise.....45
42. Seed elongate-globular with truncated ends (Fig. 6, H) ...
Gentianodes algida.
 Seed rounded, body dark with white external border (Fig. 7,
 K) ...Swertia perennis.
43. Seed covered with white hairs.....44
 Seed not covered with hairs.....46
44. Seed covered with very long hairs, partially obscuring the
 seed body (Fig. 5, D)...Salix planifolia.
 Seed covered with short hairs.....45
45. Seed shape elliptic, with short tooth at base (Fig. 5, B)
 ...Salix arctica.
 Seed shape ovate, narrowed end curved at slight angle from
 seed body (Fig. 5, C)...Salix nivalis.
46. Seed circular-shaped or many-angled.....47
 Seed not circular in shape.....49
47. Seed with a narrow stalk, with crenulate edges, especially
 apically (Fig. 4, D)...Oxyria digyna.
 Seed without a stalk.....48
48. Seed flattened, reticulate (Fig. 6, A)
Androsace septentrionalis.
 Seed flattened, slightly ovate and angular, with rows of
 heavy tubercles; lateral and apical margins crenulate (Fig.
 6, E) ...Cerastium arvense.
49. Seed globular in shape, somewhat angular, with pale margins
 and darker interior (Fig. 7, F)...Primula parryi.
 Seed shape not globular.....50
50. Seed shape some form of ellipse (Fig. 8, Nos. 1-5).....51
 Seed shape some form of oval, tapered at one end (Fig. 8,
 Nos. 11-14).....63
51. Seed transversely, broadly elliptic (Fig. 8, No. 6)52

Seed shape some other form of ellipse.....	53
52. Seed transversely, broadly elliptic (Fig. 3, G), with a short tooth at one end, a blunt, truncate stalk at other end, and a pale, central rib contrasting with dark body... <u>Carex albonigra</u> .	
Seed similar in shape but lacking pale, central rib; uniformly dark (Fig. 3, K)... <u>Carex scopulorum</u>	
53. Seed transversely elliptic (Fig. 7, I), with long sides almost straight and with longitudinally-stretched rugosities ... <u>Sibbaldia procumbens</u> .	
Seed shape some other form of ellipse.....	54
54. Seed transversely, narrowly elliptic (Figs. 3, F; 5, E, F, K; Fig. 8, Nos. 9, 10).....	55
Seed shape some other form of ellipse.....	58
55. Seed without longitudinal ribs, flattened, spatulate, pale (Fig. 5, K)... <u>Trollius laxus</u> .	
Seed with one or more longitudinal ribs.....	56
56. Seed with one longitudinal rib, surface dark, rugose (Fig. 3, F)... <u>Caltha leptosepala</u> .	
Seed with many ribs or longitudinal rugosities.....	57
57. Wrinkled appearance from abundant longitudinal rugosities; narrow, seed length-to-width ratio 4.5 : 1 (Fig. 5, E)... <u>Rhodiola integrifolia</u>	
Seed broader, seed length-to-width ratio 3 : 1 (Fig. 5, F) otherwise similar in appearance... <u>Clementsia rhodantha</u>	
58. Seed elliptic in shape (Figs. 6, C, L; Fig. 8, Nos. 3, 4).....	59
Seed some other form of ellipse.....	60
59. Seed with short, acute, terminal appendage, cellular reticulations, shiny (Fig. 6, L)... <u>Luzula spicata</u> .	
Seed truncate at one end, with deep interior depression, pale (Fig. 6, C)... <u>Campanula uniflora</u> .	
60. Seed narrowly elliptic (Figs. 4, L; 6, J).....	61

- Seed broadly elliptic (Fig. 6, I) or biconcave-elliptic (Fig. 5, J).....62
61. Seed compressed in apical two-thirds, producing a triangular cross-section in this portion of seed (Fig. 4, L).....
Polemonium viscosum.
- Seed narrowly elliptic to narrowly ovate with paler exterior margin and darker interior region (Fig. 6, J)...Juncus triglumis.
62. Seed broadly elliptic (Fig. 6, I), flattened, shiny, surface minutely sculptured with round cells...Gentiana amarella.
- Seed biconcave-elliptic (Fig. 5, J), pale, surface mottled...
Trifolium parryi.
63. Seed narrowly ovate (Figs. 3, C; 4, I-K; 6, J; 7, D, G; Fig. 8, Nos. 11, 12).....64
- Seed shape some other form of oval.....69
64. Seed with one or more longitudinal ribs.....65
- Seed without longitudinal ribs.....67
65. Seed with one longitudinal rib extending the full length (Figs. 4, J-K)....Poa fendleriana and Poa glauca.
- Seed with numerous longitudinal ribs.....66
66. Seed with several long ribs in apical two-thirds and with two short spines (Fig. 7, D); seed case ovate, with six apical appendages (Fig. 4, E)...Paronychia pulvinata.
- Seed with numerous longitudinal ribs extending the full length of seed body (Fig. 4, I)...Poa arctica.
67. Seed truncate at narrowed end, with deep, longitudinal sulcus, surface with cellular reticulation (Fig. 3, C)...
Artemisia scopulorum.
- Seed without a deep, longitudinal sulcus.....68
68. Narrow end of oval bent sharply at apex, with dense, shallow, longitudinal carinae (Fig. 7, G)...Saxifraga rhomboidea.
- Narrow end not bent at apex, with pale margins and darker interior, surface with cellular reticulation (Fig. 6, J)...
Juncus triglumis.
69. Seed shape depressed-ovate (Figs. 4, C; 5, A, L;).....70

Seed shape some other form of oval.....	73
70. Seed not particularly flattened, with a broad, notched stalk, surface rugose (Fig. 5, L)... <u>Vaccinium scoparium</u> .	
Seed noticeably flattened.....	71
71. Seed beaked at base of style, with a rib along the narrower margin (Fig. 5, A)... <u>Ranunculus adoneus</u> .	
Seed not beaked.....	72
72. Seed somewhat angular, dark (Fig. 4, C)... <u>Lloydia serotina</u> .	
Seed arched, pale, shiny (Fig. 7, E)... <u>Potentilla rubricaulis</u> .	
73. Seed angular-ovate (Figs. 3,A; 6, E; 7, A).....	74
Seed ovate (Figs. 1, L; 3, E; 6, B; 7, H).....	75
74. Seed with rows of heavy tubercles (Fig. 6, E)... <u>Cerastium arvense</u> .	
Seed with surface rugose and pitted, almost triangular in outline (Fig. 7, A)... <u>Mertensia viridis</u> .	
75. Seed with many longitudinal rugosities or carinae (Figs. 3, A; 7, H).....	76
Seed without numerous longitudinal rugosities or carinae.....	77
76. Seed surface with wrinkled appearance due to many longitudinal rugosities, surface with cellular reticulations (Fig. 3, A)... <u>Allium geyeri</u> .	
Seed surface with many longitudinal carinae, but lacking wrinkled appearance (Fig. 7, H); narrow end pale, contrasting with darker seed body... <u>Sedum lanceolatum</u> .	
77. Seed with central, longitudinal sulcus, with narrowed, pointed end (Fig. 1, L)... <u>Penstemon secundiflorus</u> .	
Seed without central longitudinal sulcus.....	78
78. Seed with broad, external ridge separated by sulcus from oval-shaped interior region (Fig. 6, B)... <u>Arenaria fendleri</u> .	
"Seed" (bulbet) without outer, elevated ridge; broader half darker, narrower end paler (Fig. 3, E)... <u>Bistorta vivipara</u> .	

GLOSSARY OF TERMS ¹

Achene - A small, dry, one-seeded fruit having a thin ovary wall (pericarp) that is free from the seed and not split open.

Awn - A bristle-like appendage, such as occurs on the back or at tip of glumes (scale-like bracts at the base) or lemmas (bracts that usually enclose a flower) of many grasses.

Caryopsis - A specialized achene. The fruit of grasses, seed-like, with a thin ovary wall (pericarp) adherent to the seed.

Crenulate - With small, rounded, marginal teeth (After Weber, 1976).

Floret - A little flower, in grasses including the lemma (see awn, above).

Hilum - A scar on a seed marking the point of attachment of the funiculus, or stalk.

Lenticular - Lens-shaped, biconvex with two edges.

Pappus - The modified calyx (outer part of floral envelope) of the family Asteraceae (Compositae), arising from the summit of the achene (see above), and consisting of hairs, bristles, scales, or awns.

Perigynium - The so-called flask or papery sheath that envelops the achene of sedges (Carex spp., after Lawrence, 1969).

Reniform - Kidney-shaped, broader than long, with rounded ends and with a wide basal sinus.

Reticulate - Like a network of ridges or veins.

Rugose - Wrinkled.

Seta (Setae, plural) - A bristle.

Spatulate - Rounded and broad at the top, attenuate at base (from Torre-Bueno, 1978).

Sulcus - A groove.

¹Definitions after Porter, 1967, except as noted otherwise.

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TABLE 1.
LIST OF PLANT SPECIES REPRESENTED IN THE SEED KEY AND PHOTOGRAPHIC ATLAS

PTERIDOPHYTA

SELAGINELLACEAE

Selaginella densa Rydb.

SPERMATOPHYTA

GYMNOSPERMAE

PINACEAE

Picea engelmannii Parry ex Engelm.

ANGIOSPERMAE

DICOTYLEDONEAE

BORAGINACEAE

Eritrichum aretioides Cham., DC.

Mertensia viridis A. Nels.

CAMpanulaceae

Campanula uniflora L.

CARYOPHYLLACEAE

Arenaria fendleri A. Gray

Cerastium arvense L.

Minuartia obtusiloba Rydb., House

Minuartia rubella Wahlenb., Graebner

Paronychia pulvinata A. Gray

Silene acaulis L.

Stellaria umbellata Turcz.

COMPOSITAE (ASTERACEAE)

Antennaria alpina L., Gaertn.

Artemisia scopulorum A. Gray

Brachyactis angusta Lindl., Britt.

Erigeron pinnatisectus (A. Gray) A. Nels.

Erigeron simplex Greene

Hymenoxys acaulis Pursh., Parker

Hymenoxys grandiflora T. & G., Parker

CRASSULACEAE

Clementsia rhodantha A. Gray, Rose

Rodiola integrifolia Raf.

Sedum lanceolatum Torr.

CRUCIFERAE

Erysimum nivale Greene, Rydb.

Thlaspi montanum L.

ERICACEAE

Arctostaphylos uva-ursi L., Spreng.

Vaccinium scoparum Leibig.

Table 1, Continued

GENTIANACEAE

Gentiana amarella L., Boerner
Gentianodes algida Pallas, Loeve & Loeve
Swertia perennis L.

LEGUMINOSAE

Trifolium dasypodium T. & G.
Trifolium nanum Torr.
Trifolium parryi A. Gray

POLEMONIACEAE

Polemonium viscosum Nutt.

POTUOLACACEAE

Lewisia pygmaea A. Gray, Robinson

POLYGONACEAE

Bistorta bistortoides Pursh., Small
Bistorta vivipara L., S. F. Gray
Oxyria digyna L., Hill

PRIMULACEAE

Androsace septentrionalis L.
Primula parryi A. Gray

RANUNCULACEAE

Caltha leptosepala DC.
Ranunculus adoneus A. Gray
Trollius laxus Salisb.

ROSACEAE

Acomastylis rossii R. Br., Greene
Dryas octopetala L.
Potentilla rubricaulis Lehm.
Sibbaldia procumbens L.

SALICACEAE

Salix arctica Pall.
Salix nivalis Hook.
Salix planifolia Pursh

SAXIFRAGACEAE

Saxifraga rhomboidea Greene

Table 1, Continued

SCROPHULARIACEAE

Castilleja occidentalis Torr.
Pedicularis groenlandica Retz.
Penstemon secundiflorus Benth. in DC.

MONOCOTYLEDONEAE

ALLIACEAE

Allium geyeri S. Wats.

CYPERACEAE

Carex albonigra Mack. in Rydb.
Carex capillaris L.
Carex elynoides Holm
Carex rupestris All.
Carex scopulorum Holm
Kobresia myosuroides Vill., Fiori & Paol.

GRAMINEAE (POACEAE)

Agrostis borealis Hartm.
Deschampsia cespitosa L., P. Beauv.
Phleum alpinum L.
Poa alpina L.
Poa arctica R. Br.
Poa fendleriana Steud., Vasey
Poa glauca M. Vahl.

JUNCACEAE

Juncus triglumis L.

TABLE 2.
ALPHABETICAL LIST OF PLANT SPECIES IN THE SEED KEY AND PHOTOGRAPHIC ATLAS

TAXON	FAMILY
<u>Acomastylis rossii</u>	Rosaceae
<u>Agrostis borealis</u>	Gramineae
<u>Allium geyeri</u>	Alliaceae
<u>Adrosace septentrionalis</u>	Primulaceae
<u>Antennaria alpina</u>	Compositae
<u>Arctostaphylos uva-ursi</u>	Ericaceae
<u>Arenaria fendleri</u>	Caryophyllaceae
<u>Artemisia scopulorum</u>	Compositae
<u>Bistorta bistortoides</u>	Polygonaceae
<u>Bistorta vivipara</u>	Polygonaceae
<u>Brachyactis angusta</u>	Compositae
<u>Caltha leptosepala</u>	Ranunculaceae
<u>Campanula uniflora</u>	Campanulaceae
<u>Carex albonigra</u>	Cyperaceae
<u>Carex capillaris</u>	Cyperaceae
<u>Carex elynoides</u>	Cyperaceae
<u>Carex ruprestris</u>	Cyperaceae
<u>Carex scopulorum</u>	Cyperaceae
<u>Castilleja occidentalis</u>	Scrophulariaceae
<u>Cerastium arvense</u>	Caryophyllaceae
<u>Clementsia rhodantha</u>	Crassulaceae
<u>Deschampsia cespitosa</u>	Gramineae
<u>Dryas octopetala</u>	Rosaceae
<u>Erigeron pinnatisectus</u>	Compositae
<u>Erigeron simplex</u>	Compositae
<u>Eritrichium aretioides</u>	Boraginaceae
<u>Erysimum nivale</u>	Cruciferae
<u>Gentiana amarella</u>	Gentianaceae
<u>Gentianodes algida</u>	Gentianaceae
<u>Hymenoxys acaulis</u>	Compositae
<u>Hymenoxys grandiflora</u>	Compositae
<u>Juncus triglumus</u>	Juncaceae
<u>Kobresia myosuroides</u>	Cyperaceae
<u>Lewisia pygmaea</u>	Portulaceae
<u>Mertensia viridis</u>	Boraginaceae
<u>Minuartia obtusiloba</u>	Caryophyllaceae
<u>Minuartia rubella</u>	Caryophyllaceae
<u>Oxyria digyna</u>	Polygonaceae
<u>Paronychia pulvinata</u>	Caryophyllaceae
<u>Pedicularis groenlandica</u>	Scrophulariaceae
<u>Penstemon secundiflorus</u>	Scrophulariaceae
<u>Phleum alpinum</u>	Gramineae
<u>Picea engelmannii</u>	Pinaceae
<u>Poa alpina</u>	Gramineae
<u>Poa arctica</u>	Gramineae

Table 2, Continued

TAXON	FAMILY
<u>Poa fendleriana</u>	Gramineae
<u>Poa glauca</u>	Gramineae
<u>Polemonium viscosum</u>	Polemoniaceae
<u>Potentilla rubricaulis</u>	Rosaceae
<u>Primula parryi</u>	Primulaceae
<u>Ranunculus adoneus</u>	Ranunculaceae
<u>Rodiola integrifolia</u>	Crassulaceae
<u>Salix arctica</u>	Salicaceae
<u>Salix nivalis</u>	Salicaceae
<u>Salix planifolia</u>	Salicaceae
<u>Saxifraga rhomboidea</u>	Saxifragaceae
<u>Sedum lanceolatum</u>	Crassulaceae
<u>Selaginella densa</u>	Selaginellaceae
<u>Sibbaldia procumbens</u>	Rosaceae
<u>Silene acaulis</u>	Caryophyllaceae
<u>Stellaria umbellata</u>	Caryophyllaceae
<u>Swertia perennis</u>	Gentianaceae
<u>Thlaspi montanum</u>	Cruciferae
<u>Trifolium dasypodium</u>	Leguminaceae
<u>Trifolium nanum</u>	Leguminaceae
<u>Trifolium parryi</u>	Leguminaceae
<u>Trollius laxus</u>	Ranunculaceae
<u>Vaccinium scoparium</u>	Ericaceae

THE PHOTOGRAPHIC ATLAS

FIGURE CAPTIONS

Fig.1. A - Acomastylis rossii; B - Agrostis borealis;
C - Antennaria alpina D - Brachyactis angusta;
E - Deschampsia caespitosa; F - Erigeron pinnatisectus;
G - Erigeron simplex; H - Haplopappus pygmaeus;
I - Helictotrichon mortonianum; J - Hymenoxys acaulis;
K - Kobresia myosuroides; L - Penstemon secundiflorus. Scale bar equals 5 mm.

Fig.2. A - Picea engelmannii; B - Poa alpina; C - Trisetum
D - Dryas octopetala ssp. hookeriana;
C - Hymenoxys grandiflora; F - Megaspores (7) of Selaginella densa. Scale bar equals 5 mm.

Fig.3. A - Allium geyeri; B - Arctostaphylos uva-ursi;
C - Artemisia scopulorum; D - Bistorta bistortoides;
E - Bistorta vivipara; F - Caltha leptosepala;
G - Carex albonigra; H - Carex capillaris;
I - Carex elynoides; J - Carex rupestris;
K - Carex scopulorum; L - Erigeron pinnatisectus;
Scale bar equals 2.5 mm.

Fig.4. A - Eritrichium aretioides; B - Kobresia myosuroides; C - Lloydia serotina; D - Oxyria digyna;
E - Paronychia pulvinata; F - Pedicularis groenlandica;
G - Phleum alpinum; H - Poa alpina; I - Poa arctica;
J - Poa fendleriana; K - Poa glauca; L - Polemonium viscosum. Scale bar equals 2.5 mm.

Fig.5. A - Ranunculus adoneus; B - Salix arctica;
C - Salix nivalis; D - Salix planifolia;
E - Rhodiola integrifolia; F - Sedum rhodanthum;
G - Thlaspi montanum; H - Trifolium dasypodium;
I - Trifolium nanum; J - Trifolium parryi;
K - Trollius laxus; L - Vaccinium scoparium.
Scale bar equals 2.5 mm.

Fig.6. A - Androsace septentrionalis; B - Arenaria fendleri;
C - Campanula uniflora; D - Castilleja occidentalis;
E - Cerastium arvense; F - Chionophila jamesii;
G - Erysimum nivale; H - Gentianodes algida;
I - Gentiana amarella; J - Juncus triglumis;
K - Lewisia pygmaea; L - Luzula spicata.
Scale bar equals 1 mm.

Figure Captions, Continued

Fig.7. A - Mertensia viridis; B - Minuartia rubella;
C - Minuartia obtusiloba; D - Paronychia pulvinata;
E - Potentilla rubricaulis; F - Primula parryi;
G - Saxifraga rhomboidea; H - Sedum lanceolatum;
I - Sibbaldia procumbens; J - Silene acaulis;
K - Swertia perennis; L - Stellaria umbellata.
Scale bar equals 1 mm.

Fig.8. Generalized seed-shape outlines (after Berggren, 1969). 1, 2 : Narrowly elliptic; 3, 4 : Elliptic; 5: Broadly elliptic; 6: Transversely, broadly elliptic; 7, 8: Transversely elliptic; 9, 10: transversely, narrowly elliptic; 11, 12: narrowly ovate; 13, 14 : ovate; 15, 16: depressed ovate; 17 : trapezoidal; 18: circular.

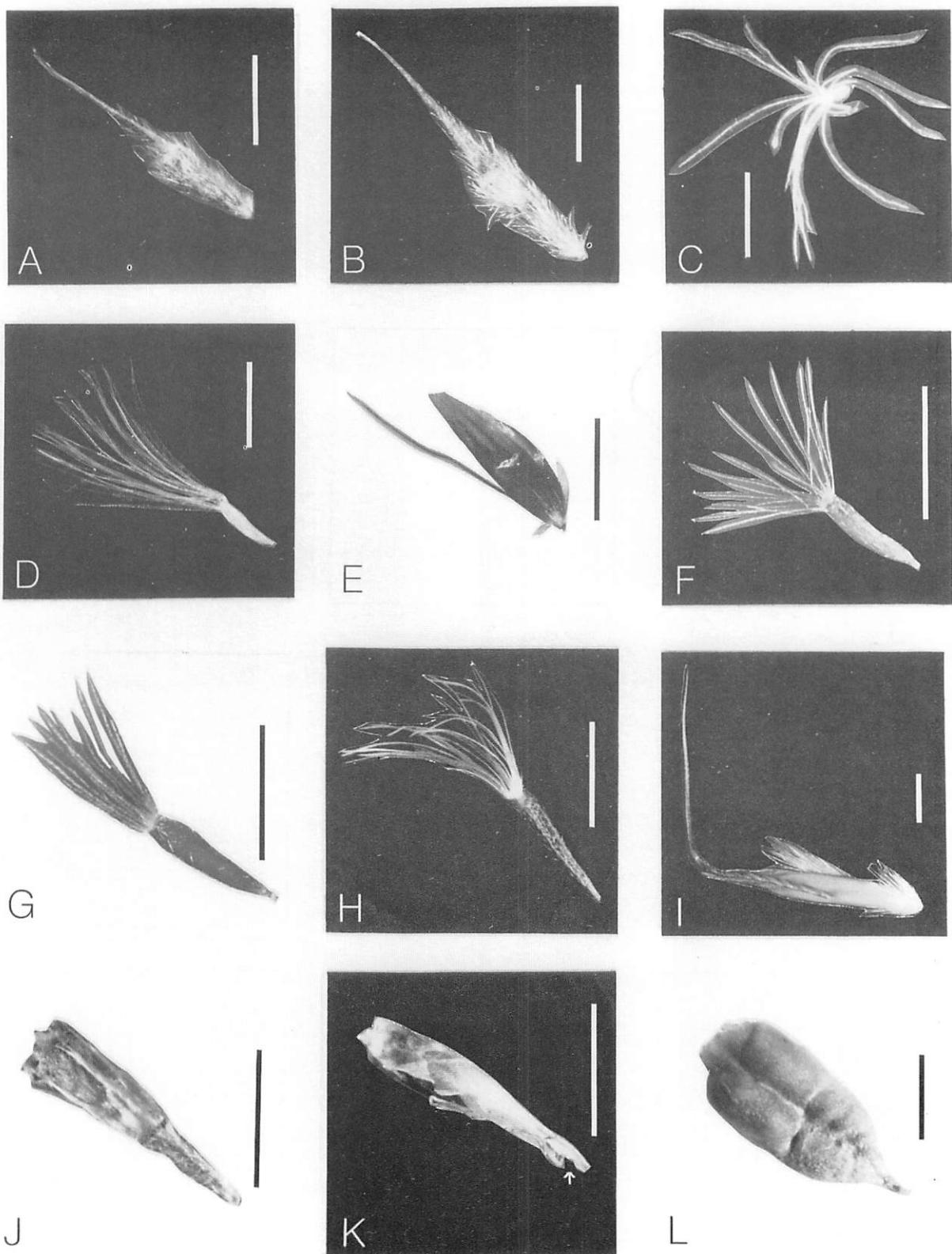


Figure 1

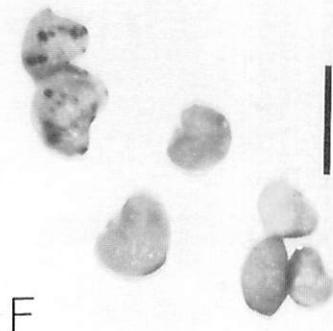
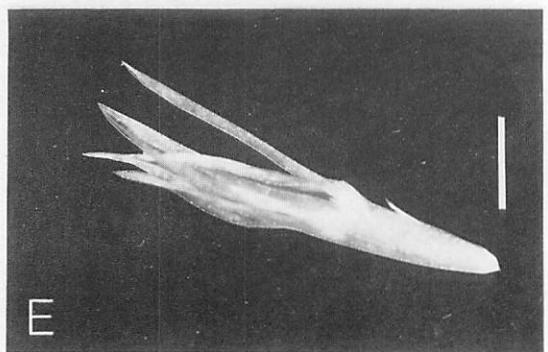
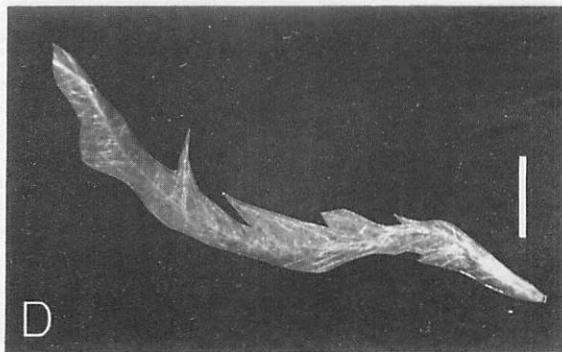
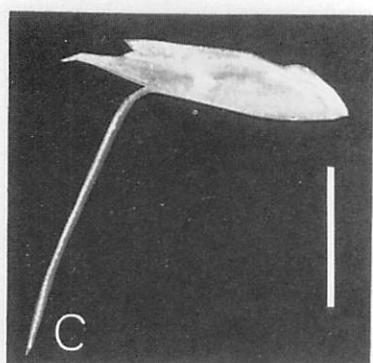
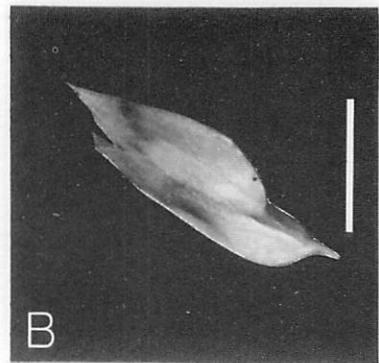
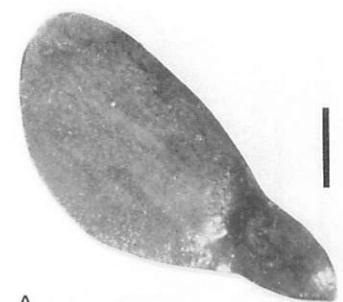


Figure 2

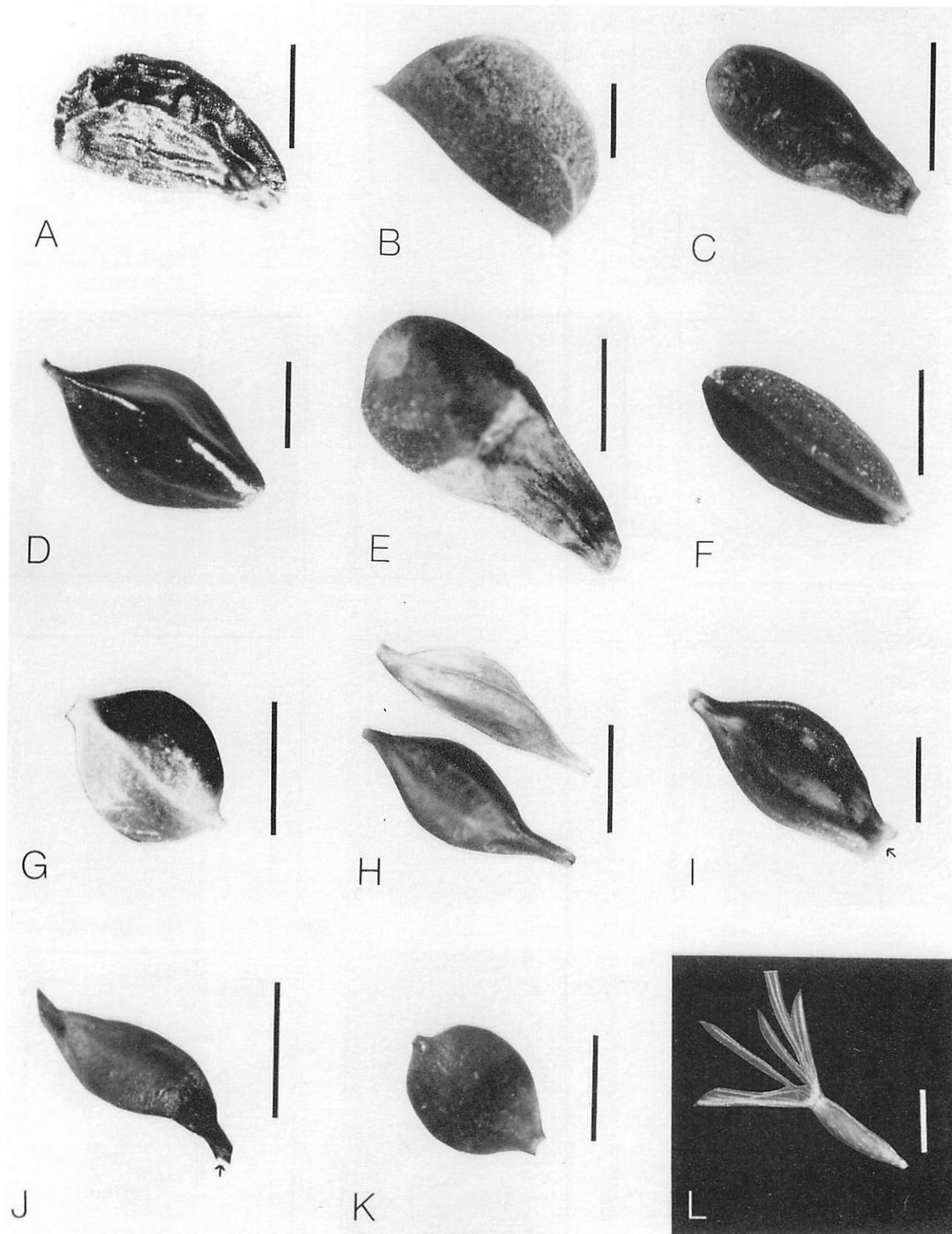


Figure 3

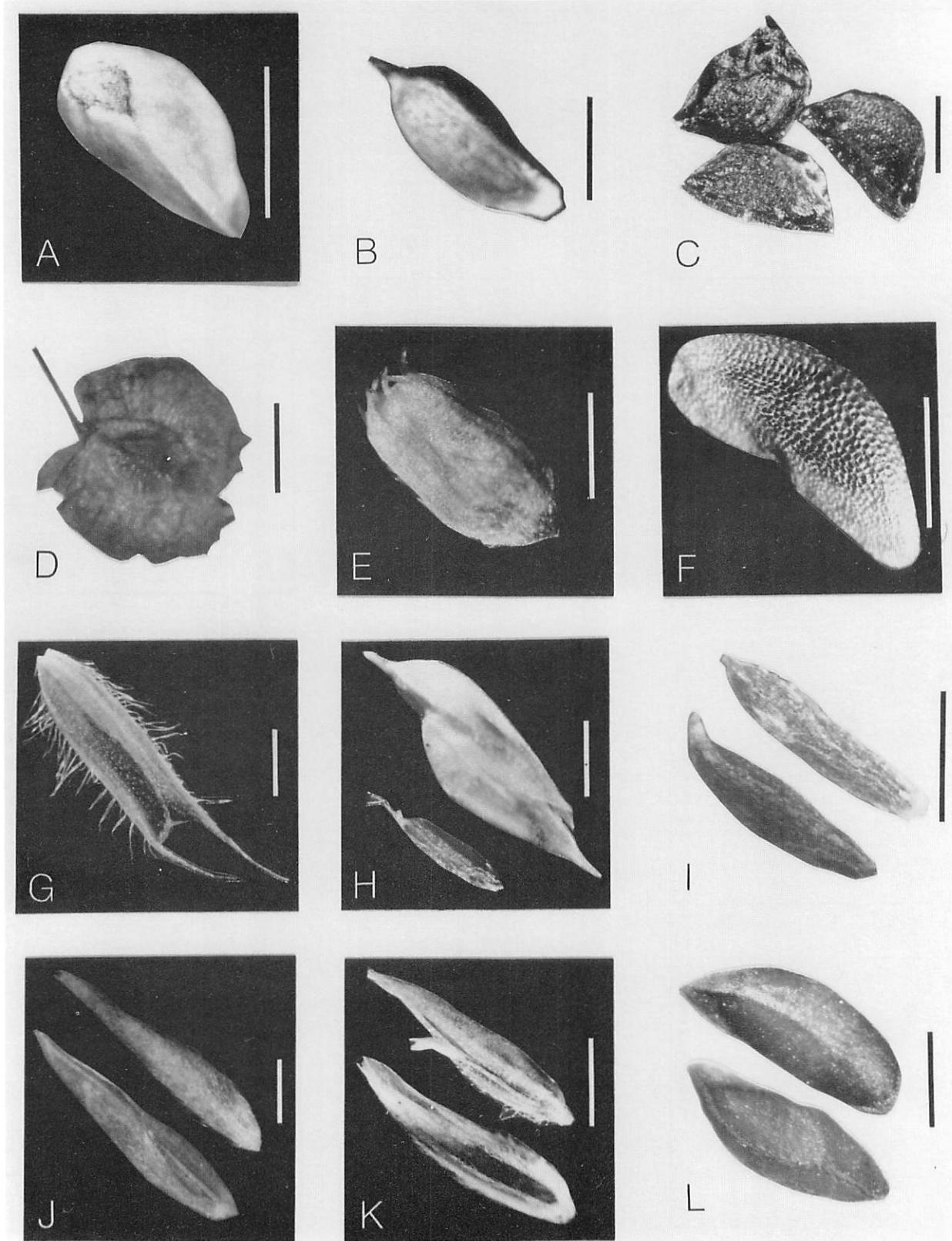


Figure 4

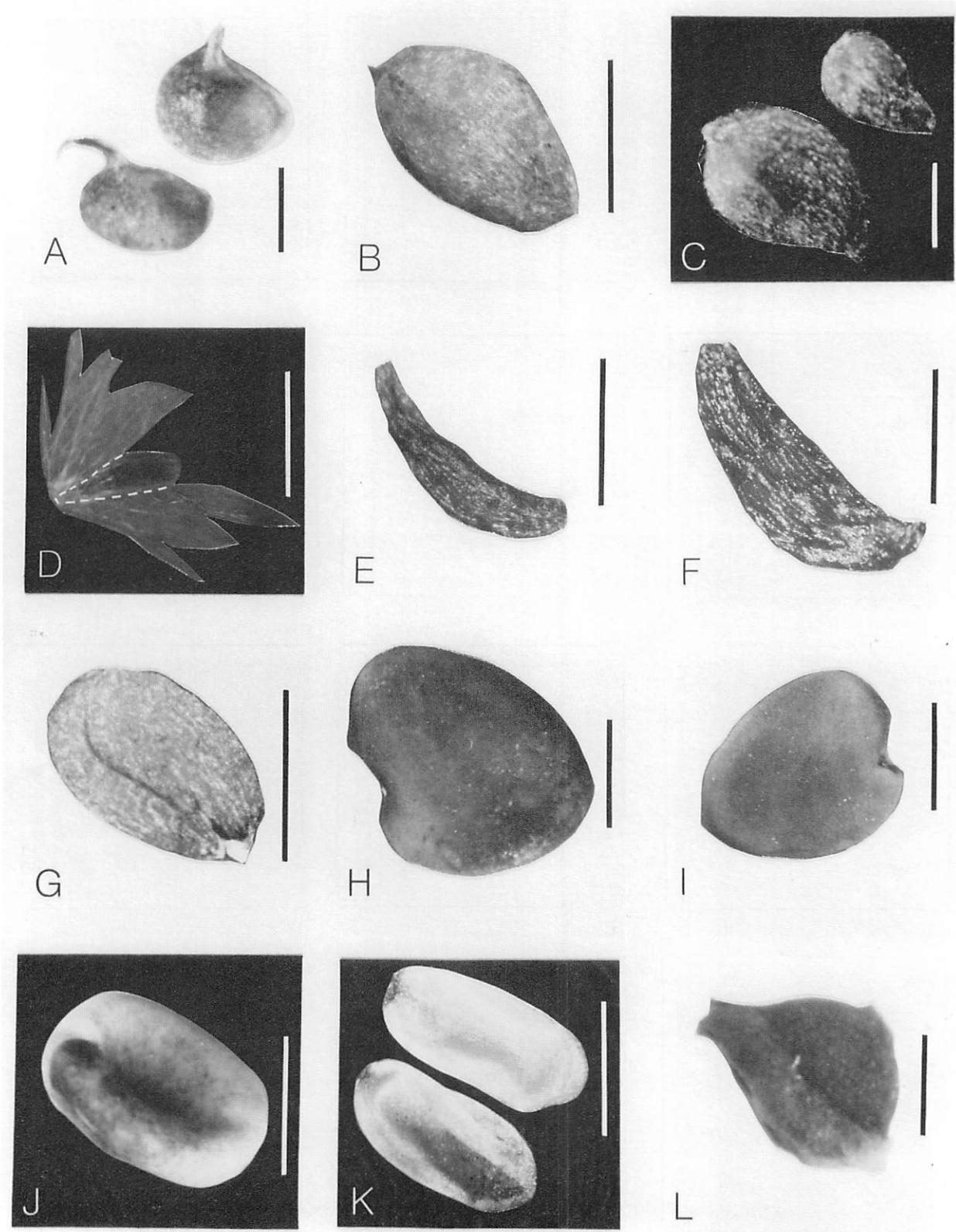


Figure 5

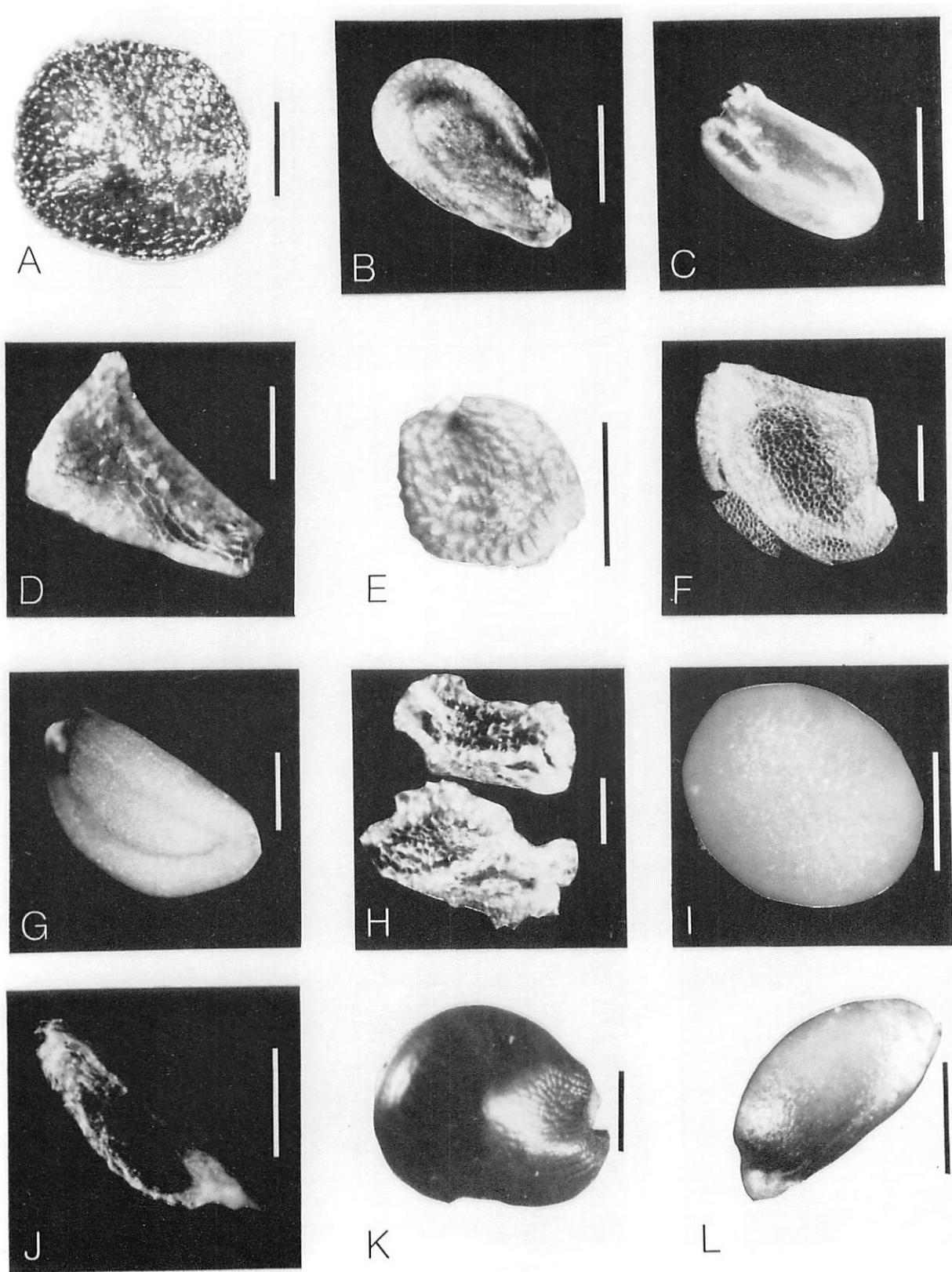


Figure 6

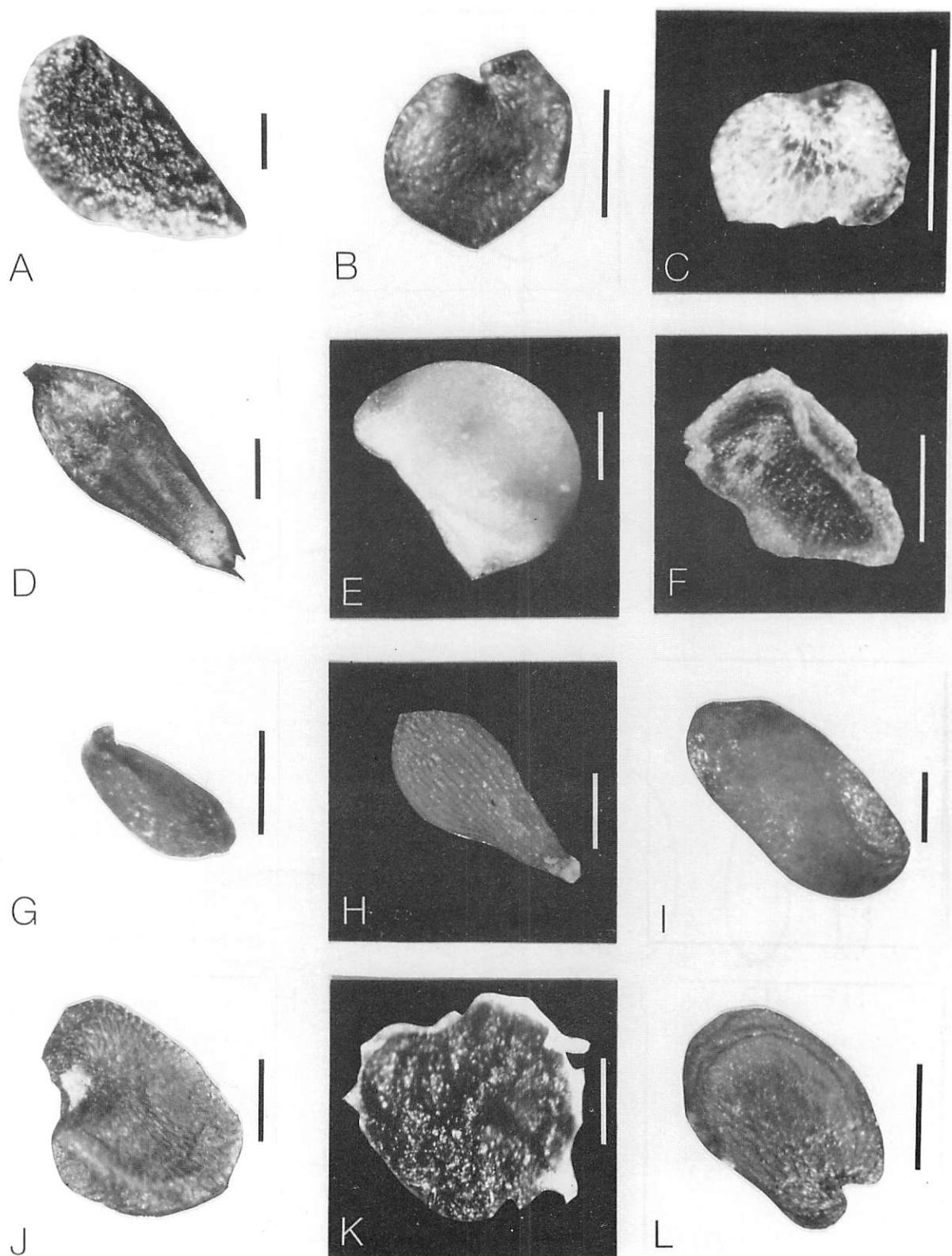


Figure 7

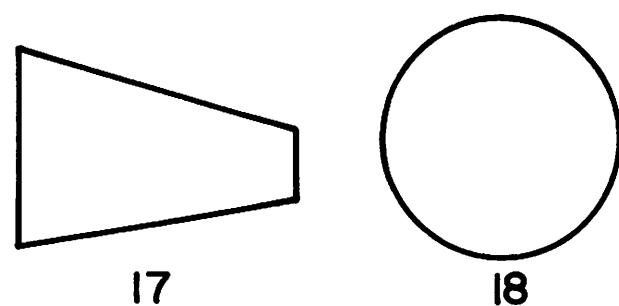
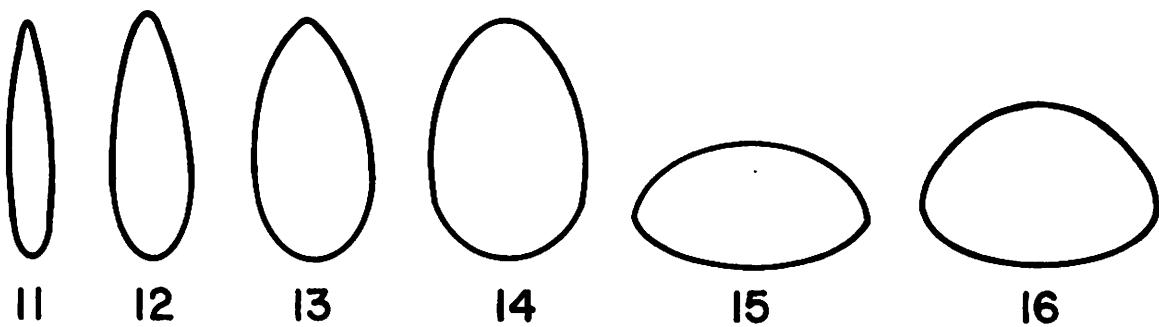
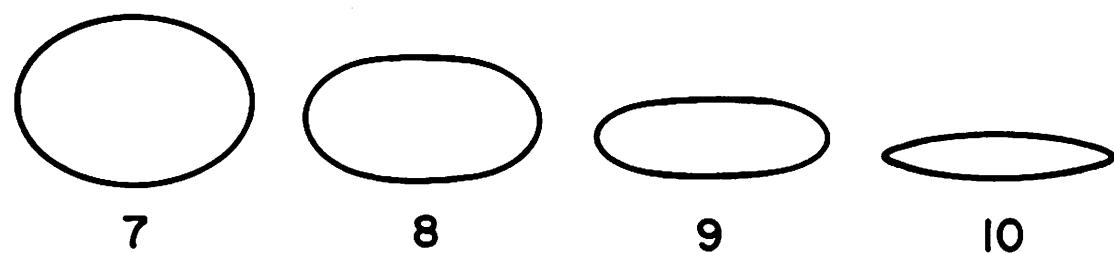
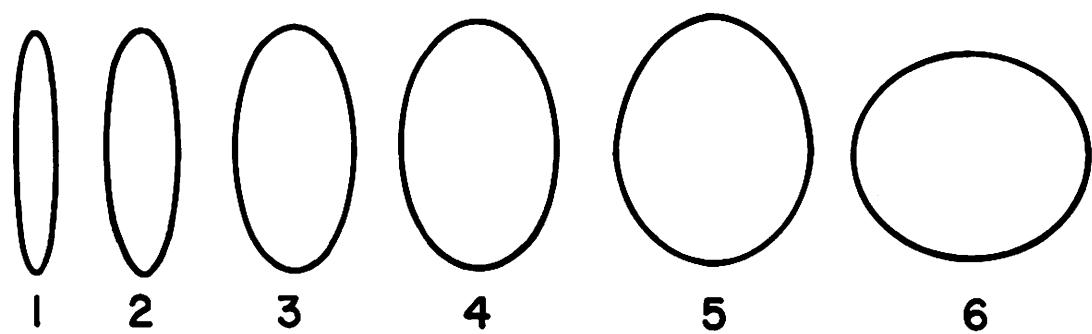


Figure 8

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