

Appendix 1 – Names of B.C. Conifers

Pinaceae family

Amabilis fir	Ba	<i>Abies amabilis</i> (Dougl.) Forbes
Grand fir	Bg	<i>Abies grandis</i> (Dougl.) Lindl.
Subalpine fir	Bl	<i>Abies lasiocarpa</i> (Hook) Nutt.
Noble fir	Bn	<i>Abies procera</i> Rehd.
Coastal Douglas-fir	Fdc	<i>Pseudotsuga menziesii</i> (Mirb.) Franco
Interior Douglas-fir	Fdi	<i>Pseudotsuga menziesii</i> var. <i>glauca</i> (Beissn.) Franco
Mountain hemlock	Hm	<i>Tsuga mertensiana</i> (Bong.) Carr.
Western hemlock	Hw	<i>Tsuga heterophylla</i> (Raf.) Sarg.
Western larch	Lw	<i>Larix occidentalis</i> Nutt.
Whitebark pine	Pa	<i>Pinus albicaulis</i> Engelm.
Limber pine	Pf	<i>Pinus flexilis</i> James
Coastal lodgepole pine	Plc	<i>Pinus contorta</i> Dougl.
Interior lodgepole pine	Pli	<i>Pinus contorta</i> var. <i>latifolia</i> Dougl. ex Loud.
Western white pine	Pw	<i>Pinus monticola</i> Dougl. ex D. Don
Ponderosa pine	Py	<i>Pinus ponderosa</i> Laws
Black spruce	Sb	<i>Picea mariana</i> (Mill.) B.S.P.
Sitka spruce	SS	<i>Picea sitchensis</i> (Bong.) Carr.
Interior spruce	Sx	<i>Picea glauca</i> (Moench) Voss, <i>Picea engelmannii</i> Parry ex Engelm and hybrids
Sitka × interior spruce hybrid	SxS	<i>Picea x lutzii</i> Little

Cupressaceae family

Yellow-cedar	Yc	<i>Chamaecyparis nootkatensis</i> (D. Don) Spach
Western redcedar	Cw	<i>Thuja plicata</i> Donn ex D. Don

Appendix 2 – Glossary[◇]

Abaxial: Referring to the upper seed surface.

Abscisic acid (ABA): A naturally occurring plant growth substance that promotes leaf fall and dormancy in seeds and buds.

Adaxial: Referring to the lower seed surface.

Anatomy: The study of the structure of living organisms, especially of their internal parts by means of dissection and microscopic examination. (compare *Morphology*)

Angiosperms: The flowering plants, which are the plants with the most advanced structural organization in the plant kingdom. Monocots with one cotyledon, dicots with two cotyledons.

Anthocyanin: One of a group of flavanoid (naturally occurring phenolic compounds) pigments. Occur in the cell vacuoles* of various plant parts.

Cambium: A plant tissue consisting of actively dividing cells that is responsible for increasing the girth of the plant (i.e., it causes secondary growth). The two most important cambia are the vascular cambium and the cork* cambium. The vascular cambium occurs in the stem and root; it divides to produce secondary xylem* and secondary phloem*. In mature stems the vascular cambium is extended laterally to form a complete ring.

Chalazal: The part of a plant ovule* where the nucellus* and integuments* merge. Associated with the cotyledon end of the seed.

Chloroplasts: Chlorophyll containing organelles of plant cells involved in photosynthesis.* Generally lens shaped and bounded by a double membrane.

Chromosomes: A threadlike structure found in the nucleus of plant cells. They carry the genes (DNA*) that determine an organisms individual characteristics.

Conifers: Seed-bearing plants comprising the conifers, including the pines, firs, and spruces. Gametes are carried in male and female cones, fertilization usually being achieved by wind-borne pollen. The ovules* and the seed into which they develop are borne unprotected (rather than enclosed in an ovary, as in the Angiosperms*). Internal tissue and cell structure of these species is not as advanced as in the angiosperms. Typically evergreen trees inhabiting cool temperate regions and have leaves reduced to needles or scales. (see also *Gymnosperm*)

Cortex: The tissue exterior to the vascular system in plant stems and roots. It is composed of parenchyma* and shows little structural differentiation.

Corrosion cavity: The cavity in the central portion of the megagametophyte that forms through cell breakdown. The embryo will grow into this cavity.

Cupressaceae: A family of gymnosperms* characterized by persistent scale-like leaves and cones in which the bracts and scale is wholly fused. Genera present in B.C. include *Thuja*, *Chamaecyparis* and *Juniperus*.

Cytoplasm: The jelly-like matrix of a cell in which the organelles are suspended.

Diploid: (2n) Twice the haploid number of chromosomes* characteristic of the species. The diploid number is designated as 2n. Two sets of chromosomes are present, one set being derived from the female parent and the other from the male.

Embryo: The structure in plants that develops from the zygote prior to germination.

Embryogeny: The process of embryo formation and associated changes occurring within an ovule.

[◇] Definitions have been obtained primarily from the Oxford Dictionary of Biology, but other references have been used, including Esau and Fahn, if no definition was found.

* Indicates those words found elsewhere in the glossary.

Endosperm: A nutritive tissue, characteristic of flowering plants, that surrounds the developing embryo* in a seed. Its cells are triploid and many plants, such as cereals and oil crops, are cultivated for the rich food reserves in the endosperm.

Epicotyl: The region of a seedling stem above the stalks of the seed leaves (cotyledons) of an embryo plant. It grows rapidly in seed showing hypogeal germination and lifts the stem above the soil surface. (compare *Hypocotyl*)

Epidermis: The outermost layer of cells covering a plant. It functions to protect the plant from injury and to reduce water loss. Some epidermal cells are modified to form guard cells or hairs of various types.

Epigeal: Describing seed germination in which the cotyledons emerge from the seed and function as leaves. Typical of the gymnosperms.

Epithelial cells: A compact layer of cells, often secretory, covering a free surface or lining a cavity or duct.

Family: A category used in the classification of organisms that consists of similar or closely related genera.*

Genus: (pl. Genera) A category used in the classification of organisms that consists of similar or closely related species.

Guard cell: Specialized semicircular epidermal cells, whose movements (due to changes in water content) control the size of the opening of the stomate.

Gymnosperm: Any plant whose ovules,* and the seed into which they develop, are borne unprotected, rather than enclosed in ovaries. (The term gymnosperm means naked seed.)

Haploid: (1n) Describing a nucleus, cell, or tissue with a single set of unpaired chromosomes.* The haploid number is designated as *n*.

Hypocotyl: The region of the stem beneath the cotyledons and directly above the root of an embryo. It grows rapidly in seedlings showing epigeal germination and lifts the cotyledons above the soil surface. (compare *Epicotyl*)

Hypogeal: Describing seed germination in which the cotyledons remain contained within the seed coat.

Imbibition: The movement of water into substances that do not dissolve resulting in swelling. Full imbibition of seed is characterized by all seed contents becoming filled with water or 'imbibed'. It is critical in imbibition that water reaches the embryo.

Integument: The outer protective covering of a plant ovule.* It is perforated by a small pore, the micropyle. Usually two integument(s) are present in angiosperms* and one in gymnosperms.* After fertilization the integuments form the seed coat.

Lignin: A complex organic polymer that is deposited within the plant cell walls during secondary thickening. Lignification makes the walls woody and rigid. (see *Sclerenchyma*)

Lipid: Any of a diverse group of chemical compounds, occurring in living organisms and having a variety of functions, that are insoluble in water, but soluble in organic solvents such as chloroform, benzene, etc. They have many carbon-hydrogen bonds and release a larger amount of energy than other organic compounds.

Longitudinal section: Of or pertaining to length; placed or running lengthwise.

Megagametophyte: Female gametophyte.

Megaspore cell wall: The lipid-rich cell wall of the megagametophyte. Synonymous to the pollen wall in the male gametophyte.

Micropyle: A minute opening in the integument of an ovule through which the pollen tube normally passes to reach the embryo sac, usually closed at maturity to form a superficial scar and usually the point of radicle emergence.

* Indicates those words found elsewhere in the glossary.

Microtome: A machine used to cut thin sections (3–5 mm thick) of plant or animal tissues for microscopic observation.

Moisture content: A derivation of the proportion of moisture within an object. For seed, moisture content is based on the proportion of moisture relative to the initial (fresh) weight and is usually presented as a percentage. The calculation is: $\text{moisture content} = (\text{fresh weight} - \text{oven-dry weight}) / \text{fresh weight}$ and multiplied by 100. For other materials (i.e., wood) moisture content is calculated on a dry weight basis and it is this term which appears in the denominator.

Morphology: The study of the form and structure of organisms, especially their external form. (compare *Anatomy*)

Nucellus: The tissue that makes up the greater part of the ovule* of seed plants. It contains the embryo* sac and nutritive tissue. It is enclosed by the integuments* except for a small gap, the micropyle.

Opacity: The inability of an object or substance to allow light to pass through. The term for the opposite condition is translucency.

Ovules: The part of the female reproductive organs of seed plants that consists of the nucellus,* embryo* sac, and integuments.* The ovules of gymnosperms* are situated on ovuliferous scales of the female cones while those of angiosperms* are enclosed in the ovary. After fertilization, the ovule becomes the seed.

Parenchyma: Roughly spherical relatively undifferentiated cells, frequently with air spaces between them. The cortex and pith are composed of parenchyma cells.

Phloem: A tissue that conducts photosynthate* in vascular plants from regions where they are produced (notably the leaves) to regions where they are needed (meristems).

Photosynthate: The product of photosynthesis.* It passes from the leaves or stem to areas of need through the phloem.

Photosynthesis: The chemical process by which green plants synthesize organic compounds. Chloroplasts absorb the energy of sunlight to initiate a complex set of reactions to produce sugars used in the production of plant material.

Pinaceae: A family of gymnosperms* characterized by persistent or deciduous spirally arranged leaves, distinct bracts, and scales in a woody cone. Genera present in B.C. include *Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, and *Tsuga*.

Pit: A depression or cavity in the secondary wall of a plant cell that facilitates the movement of substances between adjacent cells.

Pith: (syn Medulla) The cylinder of parenchyma* tissue found in the centre of plant stems interior to the vascular system.

Polyembryony: The formation of more than one embryo in a plant seed.

Procambium (provascular tissue): A plant tissue formed by the apical meristems of shoots and roots. It consists of cells elongated parallel to the long axis of the plant. The procambium subsequently gives rise to the primary vascular tissue.

Purity: A seedlot characteristic describing the weight of pure seed in relation to the weight of seed and debris. Purity standards are currently 97%. The purity is used to derive the seeds per gram variable from the average weight of 100 seeds.

Sclerenchyma: Plant cells whose cell walls have become impregnated with lignin.* Due to the added strength that this confers, sclerenchyma plays an important role in support. The cell walls contain pits, enabling the exchange of substances between adjacent cells. Mature sclerenchyma cells are dead, since the lignin makes the cell wall impermeable to water and gases. (compare *Parenchyma*)

* Indicates those words found elsewhere in the glossary.

Seed coat: The lignified * or fibrous protective covering of a seed that develops from the integuments* of the ovule* after fertilization.

Seedlot: A quantity of cones or seeds having uniformity of species, source, quality, and year of collection. To register a seedlot the moisture content must be between 4.9 to 9.9 % and the purity above 97%.

Species: A category used in the classification of organisms that consists of a group of similar individuals that can breed among themselves and produce fertile offspring.

Specific gravity: The ratio of the density a substance to the density of water at 4°C. The density of water is 1.00 g/cm³ and specific gravity is unitless.

Stomata: (pl.; sing. stoma) Pores that function in the exchange of gases between the plant and atmosphere. Large numbers are aggregated on the epidermis and usually more numerous on the lower surface. Each stoma is bordered by two guard cells.*

Stratification: A technique used to overcome embryo dormancy in seed. Stratification is synonymous with moist-chilling. Seed are imbibed and then put into cool conditions (2–5°C) for the duration required to overcome embryo dormancy.

Tannin: One of a group of complex organic chemicals commonly found in leaves, unripe fruits, seed coats, and the bark of trees. Their function is uncertain though the unpleasant taste may discourage grazing animals. Some tannins have commercial uses, notably in the production of leather and ink.

Vacuoles: A space within the cytoplasm* of a living cell that is filled with air, water, or other liquid. In plants there is usually one vacuole bonded by a single-layered membrane.

Variety: Variety designation is used when organisms from different geographic areas have anatomical and morphological differences not considered large enough for designation as different species.

Vascularized: Possessing organized vascular tissues (see *Xylem** and *Phloem**).

Xylem: A tissue that transports water and dissolved mineral nutrients in vascular plants. In flowering plants it consists of hollow vessels that are formed from cells (vessel elements) joined end to end. The end walls of the vessel elements are perforated to allow the passage of water. In less advanced vascular plants, such as conifers* and ferns, the constituent cells of the xylem are called tracheids. The walls of the xylem cells are thickened with lignin,* the extent of this thickening being greatest in secondary xylem. Xylem contributes greatly to the mechanical strength of the plant: wood is mostly made up of secondary xylem. (see *Fibre*; compare *Phloem*)

Zygote: A fertilized female gamete. The product of fusion of the nucleus of an ovule with the nucleus of a pollen grain.

* Indicates those words found elsewhere in the glossary.

Appendix 3 – Germination Test Codes

Code	Species	Soak (hours)	Surface dry	Strat.◊ days	Temp. (°C)	Strat. redry	Strat. days	Redry temp. (°C)	Test days	Germinator temp. (°C)*
G10	Fd, S, Lw	24	y	21	2	n	0	–	21	30 – 20
G20	Pl, Py	24	y	28	2	n	0	–	21	30 – 20
G31	Hw, Hm	24	y	28	2	n	0	–	28	20 – 20
G32	Bg	48	y	28	2	n	0	–	28	30 – 20
G44	Ba, Bl, Bn	48	n	56	2	n	0	–	28	25 – 15
G52	Yc	48	n	28	20	n	56	2	28	30 – 20
G55	Pw	336	n	98	2	n	0	–	28	30 – 20
G64	Ba, Bl, Bn	48	n	28	2	y	56	2	28	25 – 15
D1	Cw	0	–	–	–	n	–	–	21	30 – 20
W1	Pl, S	24	–	0	–	n	–	–	21	30 – 20

◊ Strat. is the abbreviation for stratification.

* 8 hrs at higher temperature, 16 hrs at lower temperature.

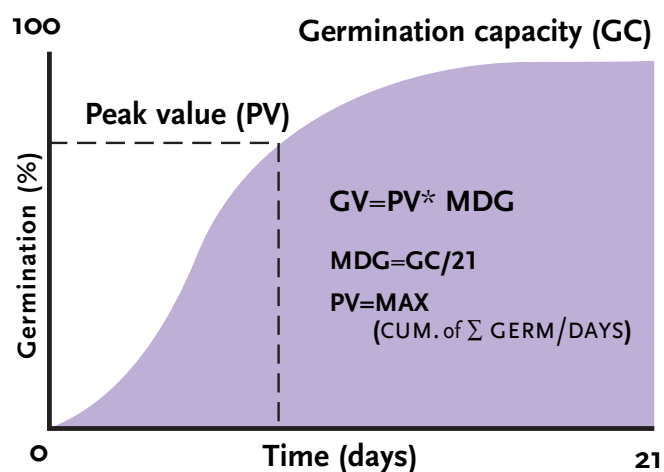
Appendix 4 – Germination Variables

The germination capacity (**GC**) is the main criteria used to define seedlot quality. The **GC** is the percentage of seeds that have germinated during a germination test (21 or 28 days depending on species – see Appendix 3). Germination tests consist of four replicates of 100 seed samples. Germinants are counted and removed from dishes on Monday, Wednesday, and Friday once the radicle is four times the length of the seed coat. Seeds which germinate abnormally are not included in the **GC**. The **GC** is used in determining sowing and oversow factors and in calculating the grams of seed required to meet a request. It is a very useful variable, but it should be supplemented with a variable describing the germination rate (faster germination usually equates to a more uniform crop).

The Germination Value (**GV**) has historically been used to define ‘vigour’ and is the other variable in addition to **GC** that is available on SPAR.¹ The **GV** is a product of two additional variables: mean daily germination (**MDG**) and peak value (**PV**). $GV=MDG * PV$.

The **MDG** is simply the germination capacity divided by the number of days in test [$MDG=GC/\#days\ in\ test$]. For example, a Sx seedlot which is tested for 21 days, with a **GC** of 91% would have a **MDG** of 4.3. **MDG** is a linear description of germination, but germination is not linear and this parameter alone is not very useful.

The **PV** is the point at which the cumulative germination percent divided by the number of days is maximum. The **PV** describes germination rate and is best understood with an example from a germination test sheet as illustrated below. The first step is to obtain the mean germination for each test date [i.e., for day 7: $(52+57+55+60)/4 = 56$]. For each test date we will then calculate the average cumulative germination [i.e., for day 7: $20.75+56=76.8$]. The cumulative germination is then divided by the test days and the maximum value for the cumulative germination divided by test days is the peak value [i.e., for day 7: $76.8/7 = 11.0$]. In this example, the peak value is 11.0 and it occurs on day 7. The **PV** is more informative if presented as cumulative germination and days to arrive at this level [77%/7 days] rather than simply a single number [11]. The **GC** is equal to 91% and the **MDG** is equal to 4.3. The **GV** is then the product of $MDG*PV = 11.0*4.3 = 47.3$ or 47 as **GC** and **GV** are usually presented as whole numbers.



Test Day	3	5	7	10	12	14	17	19	21
Rep	NUMBER OF NORMAL GERMINANTS COUNTED								
1	0	20	52	10	8	0	0	0	0
2	0	21	57	10	4	2	0	0	0
3	0	23	55	8	5	1	0	0	0
4	0	19	60	7	3	1	2	0	0
Mean	0	20.8	56.0	8.8	4.0	1.0	0.5	0.0	0.0
Cumulative	0	20.8	76.8	85.5	89.5	90.5	91.0	91.0	91.0
Cum./Day	0	4.2	11.0	8.6	7.5	6.5	5.4	4.8	4.3

¹ SPAR – Seed Planning and Registry System – a MoF mainframe system for registering new seedlots and for securing seed for reforestation.

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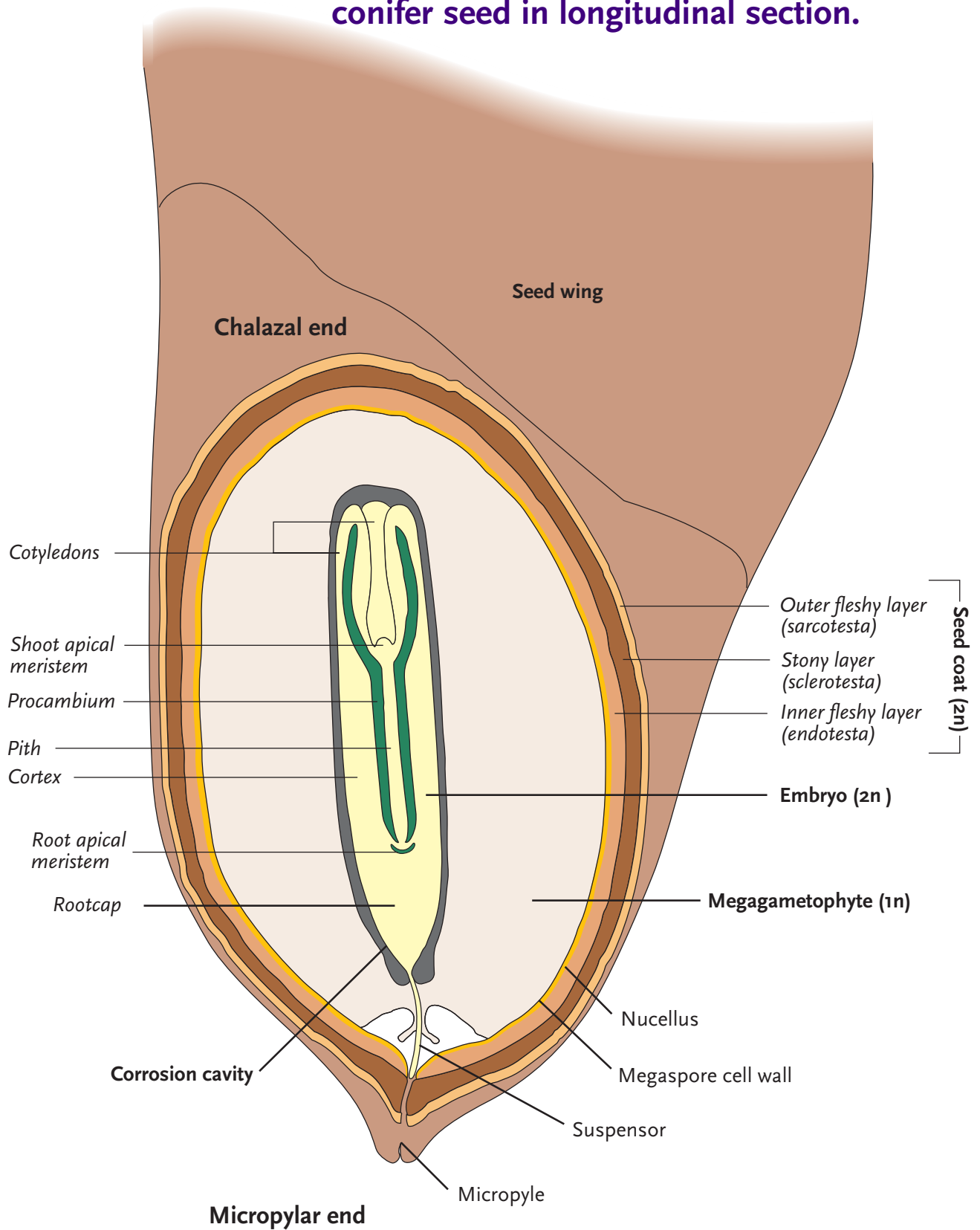
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Anatomical details of a generalized conifer seed in longitudinal section.



Chromosome complements for tree seed components indicated by 2n=diploid and 1n=haploid.

