Tree Seed Biology

Tree Seed Workshop – 2007

Dave Kolotelo

Dave's Top 7 Take Home Messages

1) Collection timing, method and subsequent handling of cones (interim storage) can have a large impact on seed quality.
2) Cone and seed processing activities are aimed at optimizing tradeoffs between seed quality and quantity (yield). They can also greatly impact seed quality.
3) Conifers possess *orthodox* seeds which can be stored at low moisture contents at sub-freezing temperatures. Good Storability.

4) Seed needs to be imbibed (hydrated) before dormancy removal or germination will occur.

5) Most conifers possess some type of dormancy mechanism that needs to be overcome before germination will occur.

6) Cold stratification is probably the closest we get to a panaceae in Forestry

7) Cone and seed handling practices have improved greatly, but we are often left with the legacy of our ignorance.

Panaceae = a remedy for all ills or difficulties

Basic Concepts

- **Seed is a living biological end-product of genetic and environmental interaction and its behaviour cannot be predicted with certainty**
- Forest tree seeds (+shrubs, ground vegetation) are in a relatively wild state compared to agricultural crops
- **genetic diversity ⇑**
- 'complicates' direct adoption of agricultural seed hanling techniquesand methods

Gymnosperms - 400 million years old

- 70 genera - 700 species
- naked seeds - not contained in ovules
- storage reserves from female parent (1n)

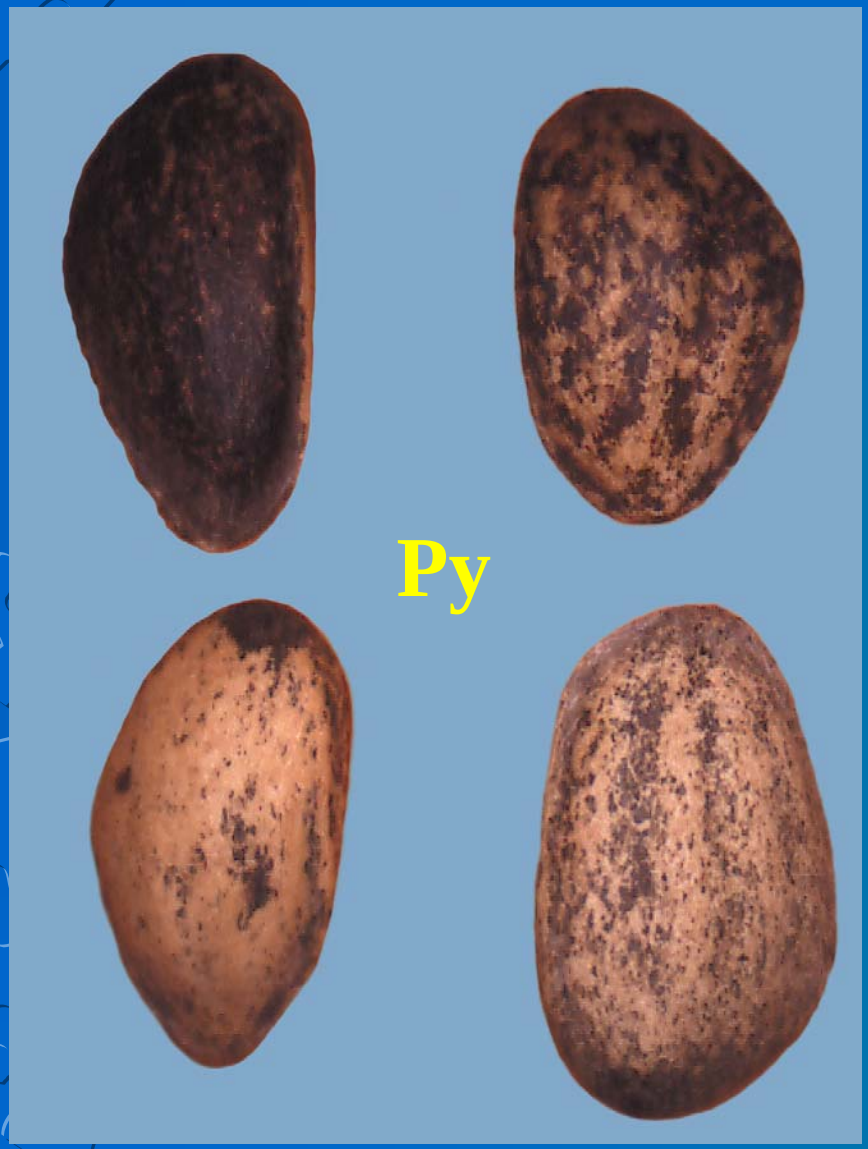
Angiosperms - 160 million years old

- about 250 000 species
- an ovary covers the seed
- storage reserves from both (3n)
- dicots and monocots

Morphology

- The study of external form and structure of organisms
  - seed size
  - seed shape
  - presence of structures (wing, resin vesicles)
  - seed condition (moisture level , health)

Within-Seedlot Variability



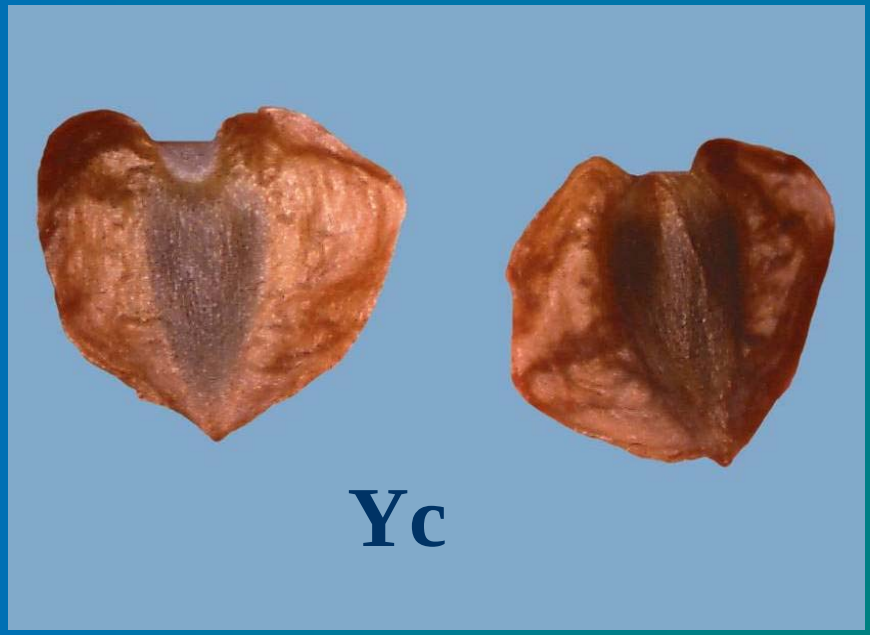
Pli *vs.* Sx Morphology

- Pli generally darker, larger (size & weight) and with ridges on the seed coat
- there will be an overlap at the extremes of both species

- Seeds are similar, but time from pollination drastically different (1 year later in Pli)


Py
Pli
Pw


Lw
Fd_


Yc

Wet *vs.* Dry

Resin Vesicles

Present in Hw, Hm, Cw and all *Abies* spp.

Function not known ??

- protection against excessiove drying
- may inhibit germination (dormancy)

Damaged Ba resin vesicles

Damage to resin vesicles will reduce germination

Surface ‘moist’ *vs.* ‘dry’ seed

Practical Morphology

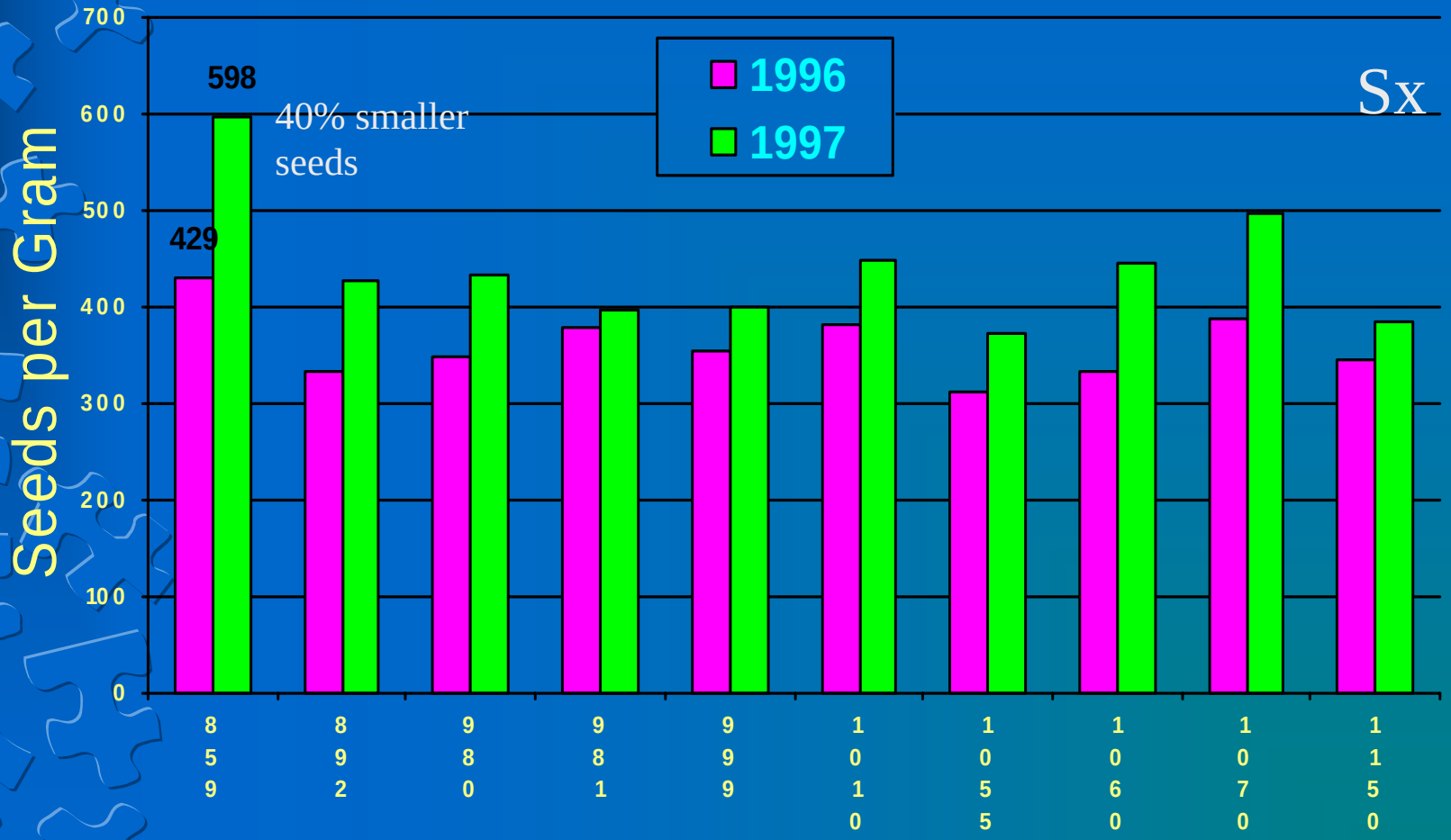
- Seedcoat cracking
  - germination
  - mechanical damage
- Resin vesicle damage
  - Broken vesicles, resin, odour
- Mycelium
  - indication of fungi, possibly a disease
- Insect damage - unlikely

‘A’ vs. ‘B’ Differences

Seed Size

- orchard-produced seed larger in Pinaceae
- fairly low heritability (E > G)
- larger seeds increase sowing efficiency
- no strong relationship between seed and seedling size - variable results ?
- gains from sowing sized seed fractions not obvious/practical at current request sizes
- family sowing ?? advocated by some, but request sizes still an issue ?
  - Related more to seedling growth (recoverables) vs. sowing efficiency

Temporal Variation (yr -to- yr)



You buy seed by weight don't you?

‘A’ vs. ‘B’ Differences

Germination parameters

- fairly high heritability (G >E)
- no large differences between A and B seed
  - except Yc (Environment) - pollen effects?

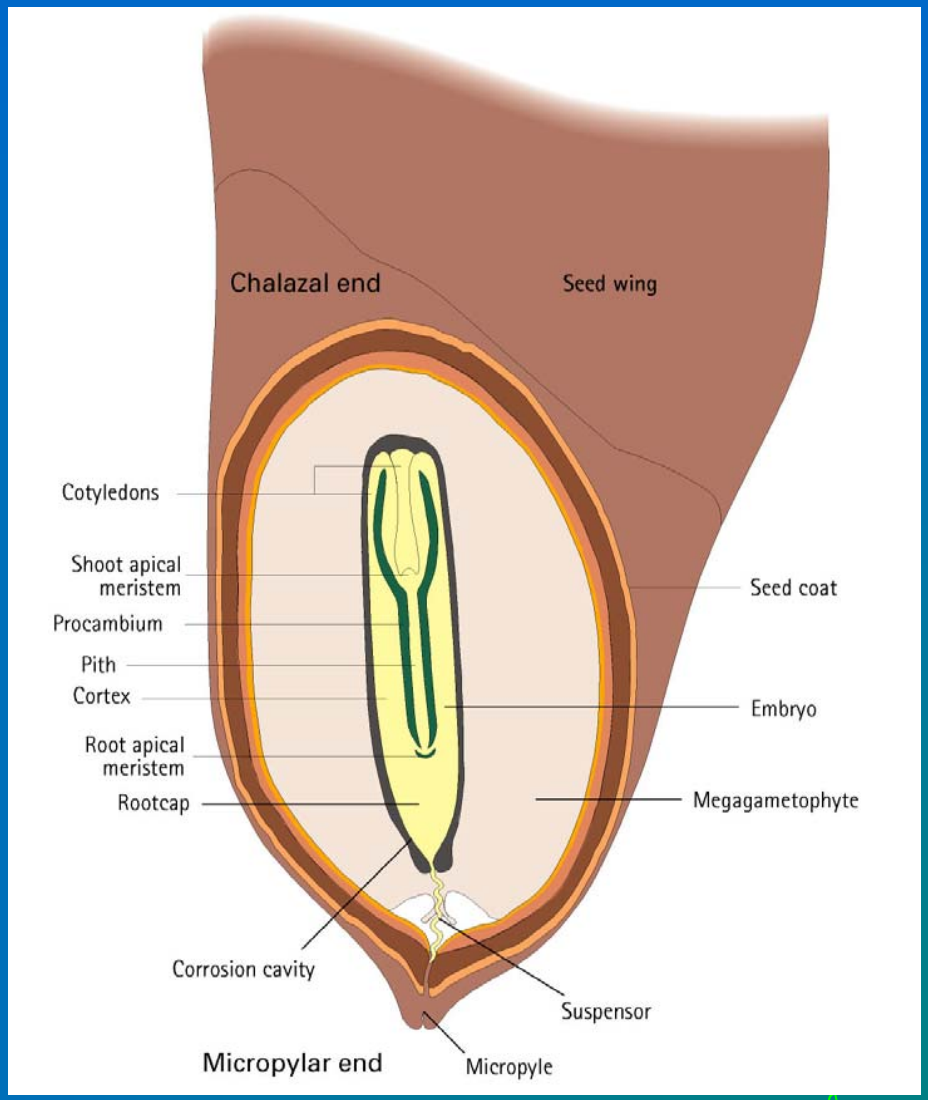
Dormancy

- can be influenced by environment – year-to-year variability
- no heritability estimates available
- Method of quantifying dormancy coming!!

Anatomy

- The study of the structure of internal parts of an organism by dissection and magnification
  - cutting tests
  - x-rays
  - prepared slides

Seed Anatomy



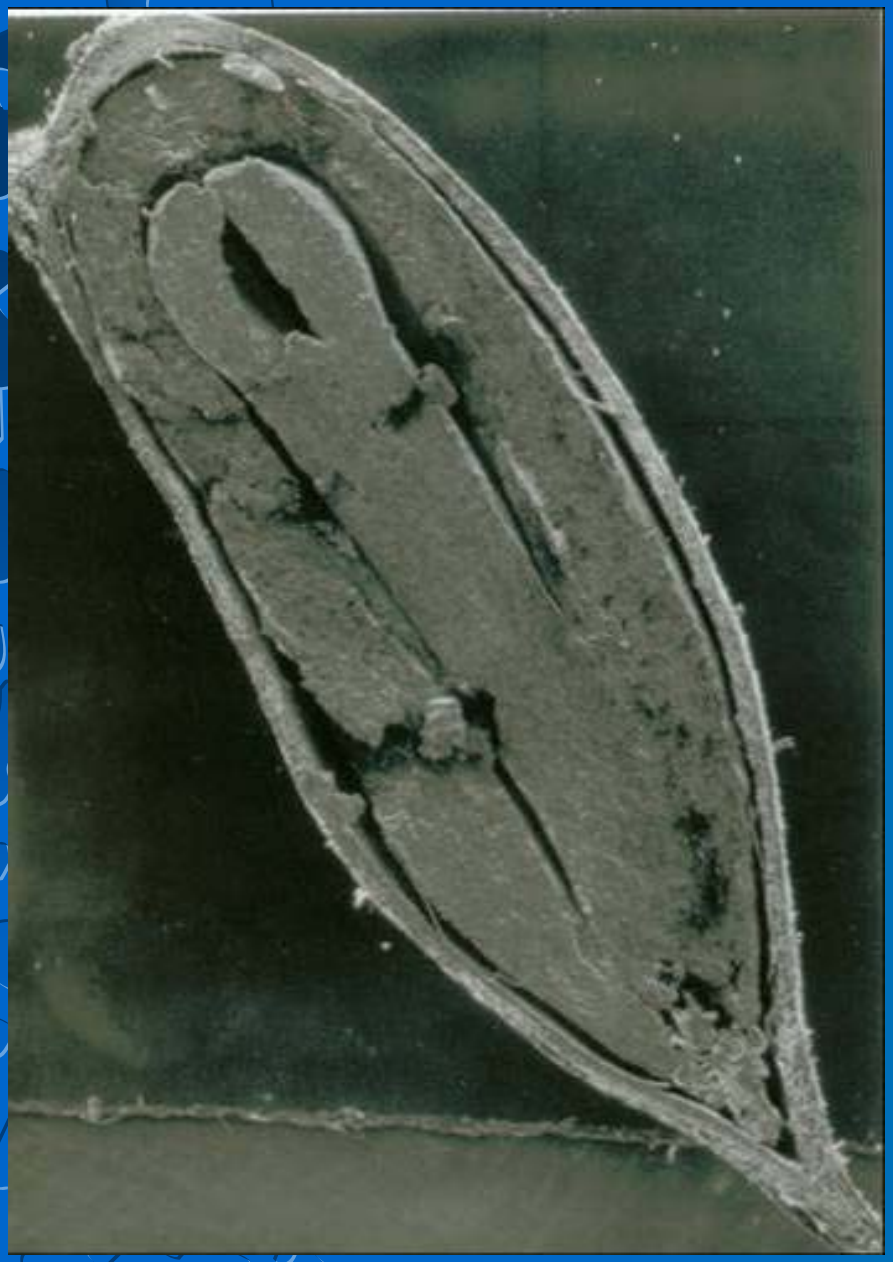
Moisture Uptake Comparison

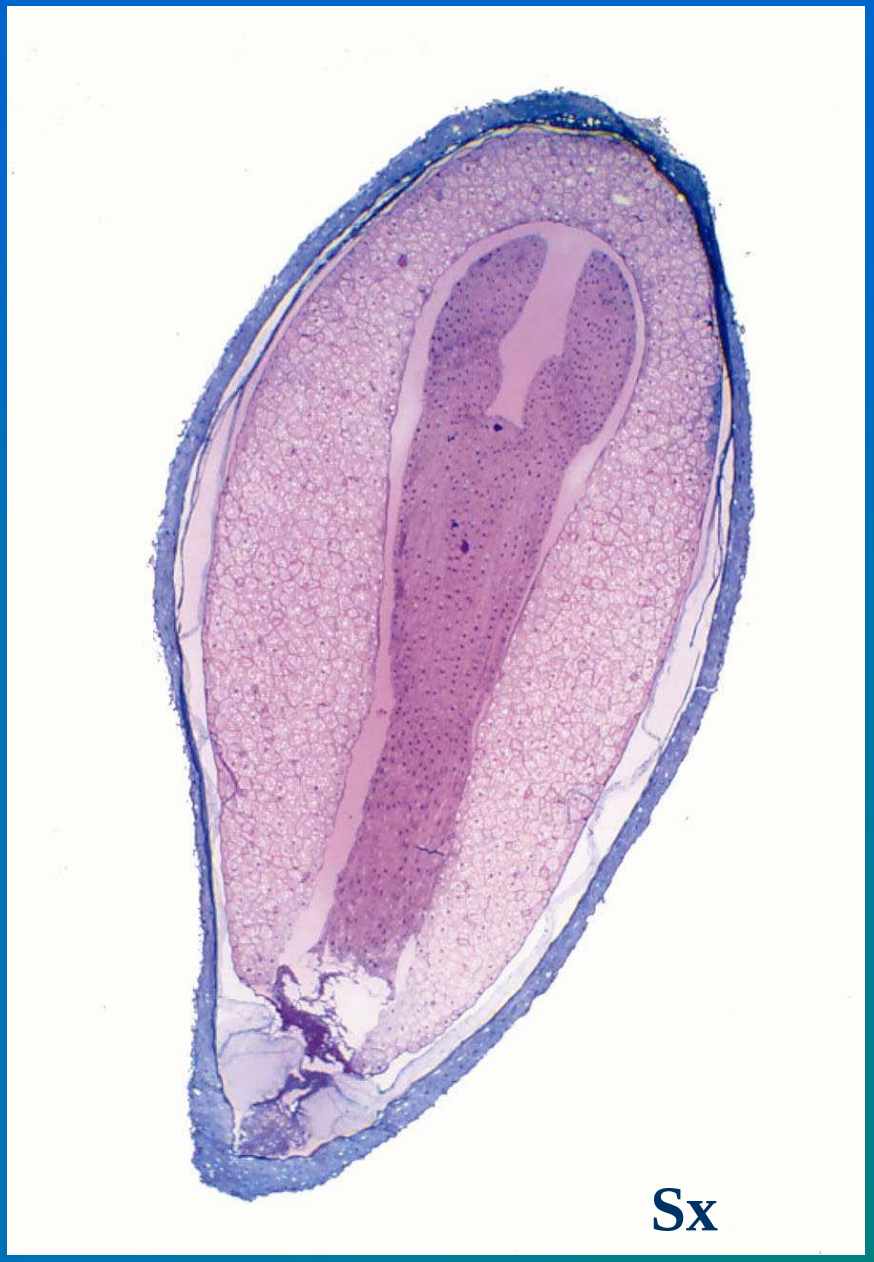
Non-Viable seeds

Seeds can be classified based on anatomy , but it is not always possible to determine what happened to the seed

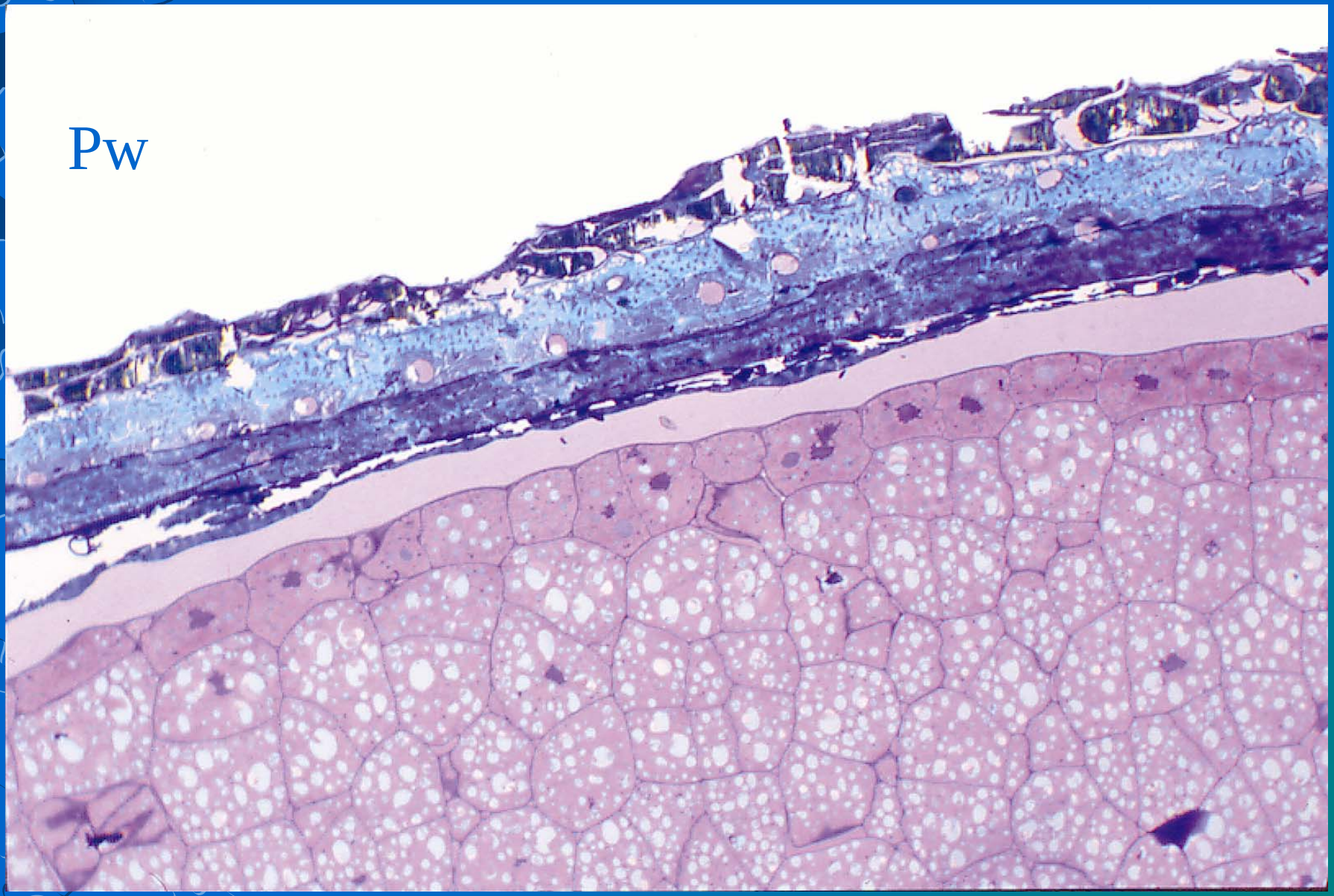
classification isn’t always black and white

Micropylar ‘plug’ in Pw

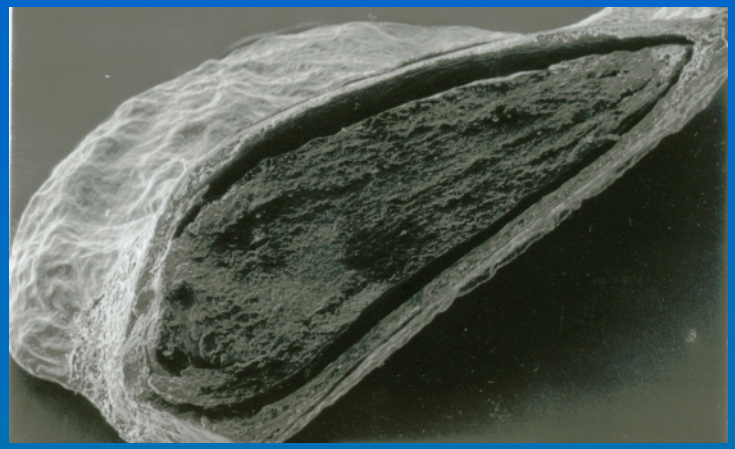



Sx

Pw



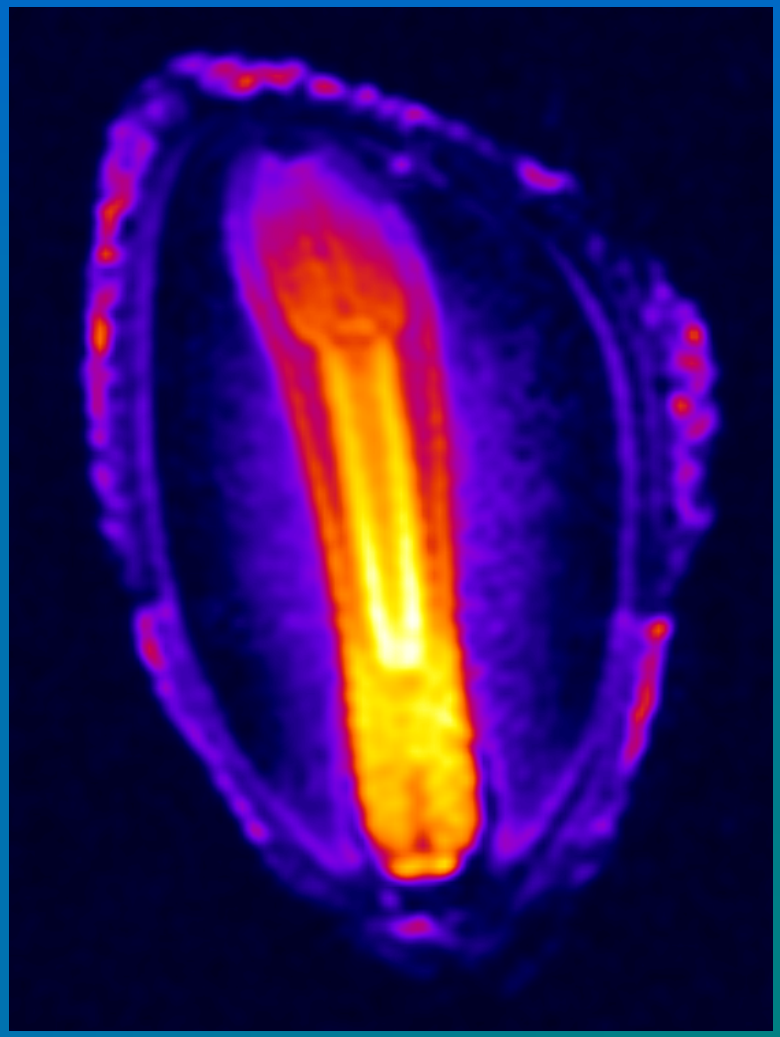
Yellow cedar



Physiology

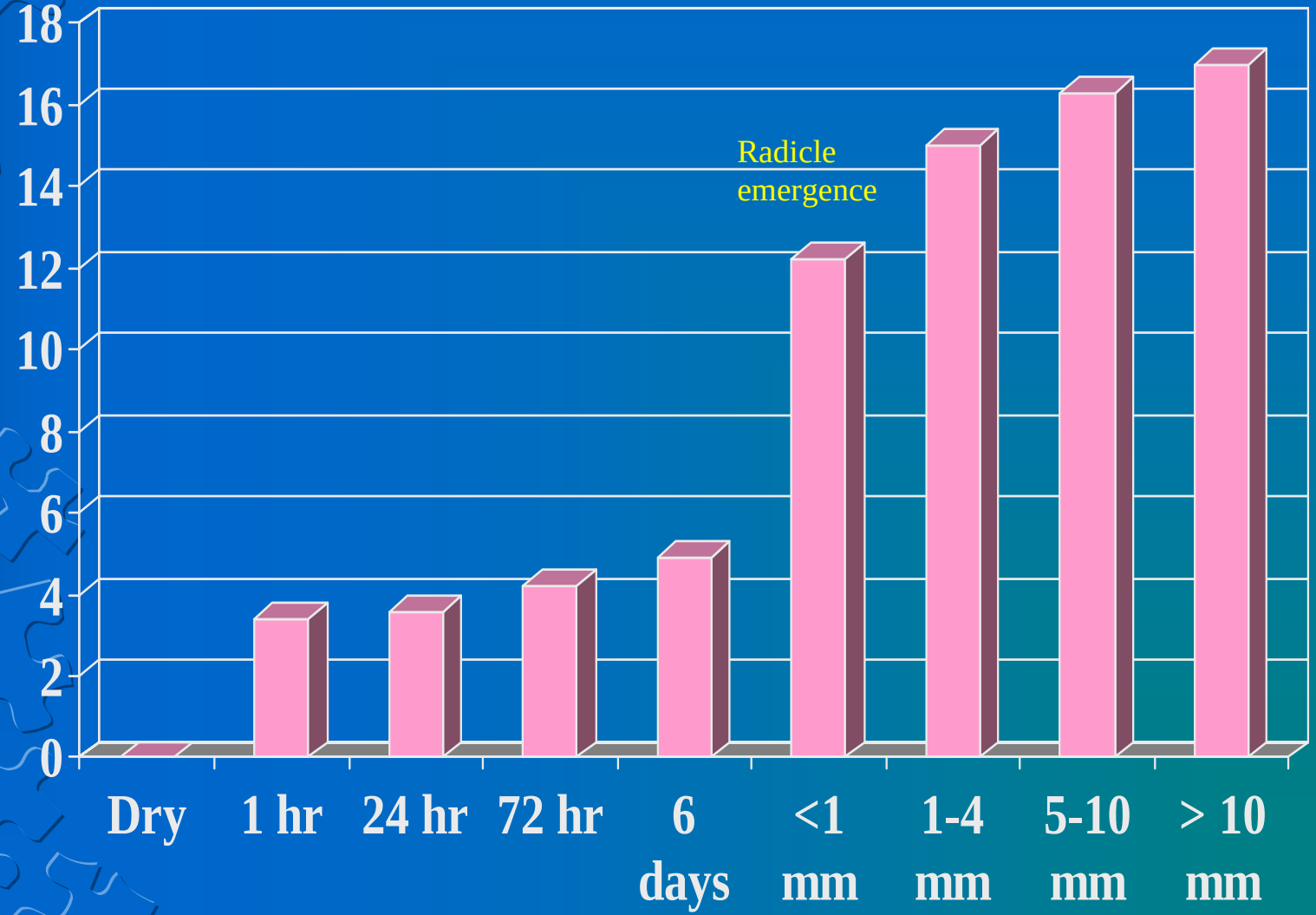
- the study of the functions and functioning of organisms and their parts

- respiration
- moisture uptake
- dormancy
- germination



Respiration in Douglas-fir

(Leadem 1993)



What does a seed need to germinate?

- **Moisture**
- **Overcome Dormancy**
- **Temperature Sums**

properly stratified conifer seed does not have a light requirement

- some angiosperms have more specific requirements - light, alternating temperature and/or moisture,gases, nutrients, smoke

Conifers are relatively simple to germinate

Efficiency is the isssue –large energy input !

Moisture

- Storage at 4.0-9.9% (minimize metabolism)
- Seed needs a minimum of about 20% to overcome dormancy
- 30% appears optimal for most species and this generally is ‘surface-dry’ seed following adequate imbibition (see Operational Table 👍)

- **We want to maximize internal moisture without having moisture on the seed coat**

A Tricky Balance

Three Phases of Water Uptake

- **Imbibition** - (Reactivation)
  - rapid exponential mc gain
  - initiate cellular metabolism
  - build up of energy for future activities
- **Mobilization** - (Breakdown)
  - mc remains stable
  - complex molecules are broken down
  - dormancy is overcome in this phase
- **Emergence** - (Buildup)
  - exponential increase in mc
  - buildup of complex molecules - seedling structure

Moisture Uptake Comparison

Seed Dormancy

- failure of an intact viable seed to complete germination under favourable conditions
- in conifers we are usually dealing with physiological dormancy that is overcome by stratification (moist-chilling)
- cold stratification alters the hormonal balance [ABA +] within the seed to allow germination to proceed
- in some conifers the outer tissues (seed coat, membranes) can also be involved

“Dormancy may be perceived as a strategy for optimizing the distribution of germination through space and time in order to maximize survival, but this seldom coincides with the nursery workers objectives”

Seed Dormancy

Physiological or ‘embryo’ dormancy

No Dormancy	- **Cw**
Low Dormancy	- Hw, Sx, SS, Lw, Fd
Mid Dormancy	- Pli, Hm, Bg, Py
Deep Dormancy	-**Yc, Pw, Ba, Bl**

Physical seed coat or ‘membrane’ dormancy is associated with Pw, Yc, and Py

Lots of Variability within a species

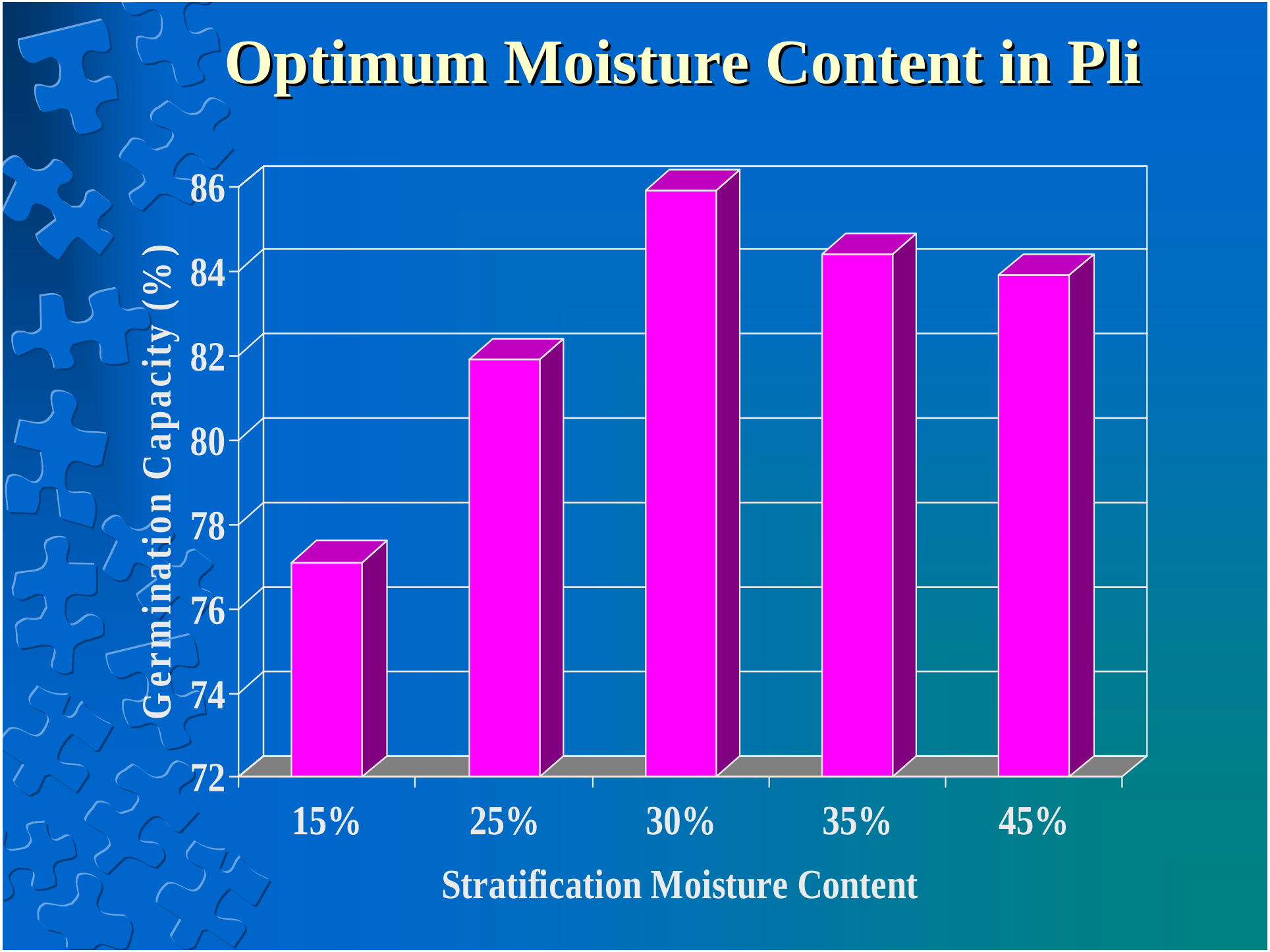
Stratification

- Originally used to describe the ‘layering’ of seeds between moistened material (i.e. cloth, peat, sand, paper)
- current procedures called ‘naked stratification’ as no media is used
- moistened seed placed into polyethylene bags
- 4 mil (.1 mm) polyethylene allows some oxygen and other gas exchange
- top should be open to maximize gaseous exchange (availability of oxygen)

Stratification Benefits

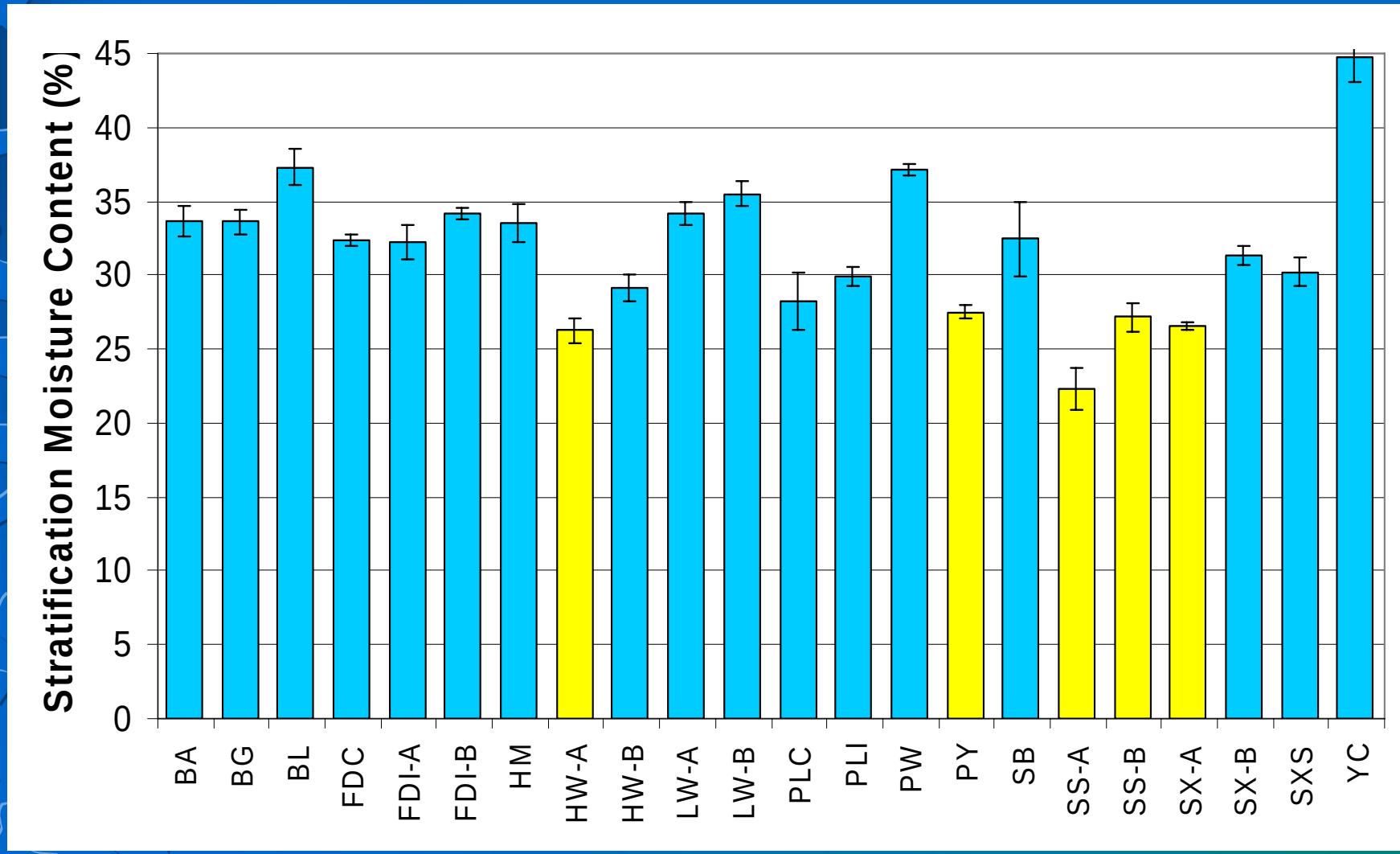
- Overcome embryo dormancy to allow germination to proceed
- Increased speed and uniformity of germination
- Increased vigour (*i.e.* increased ability to germinate over sub-optimal conditions)
- Decreased window of opportunity for pests
- Activation of natural cellular repair mechanisms

Optimum Moisture Content in Pli

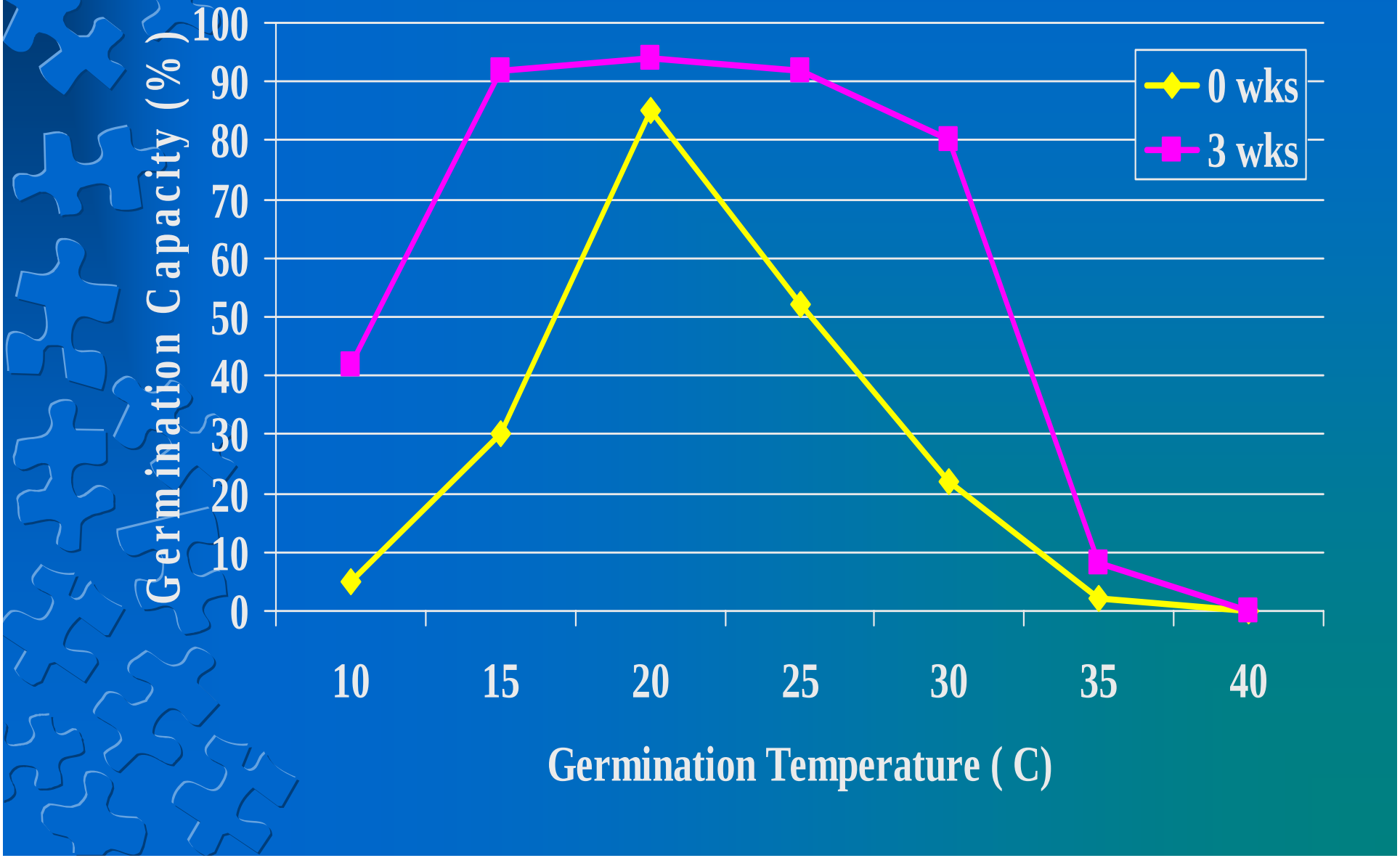


Stratification Moisture Content Variability

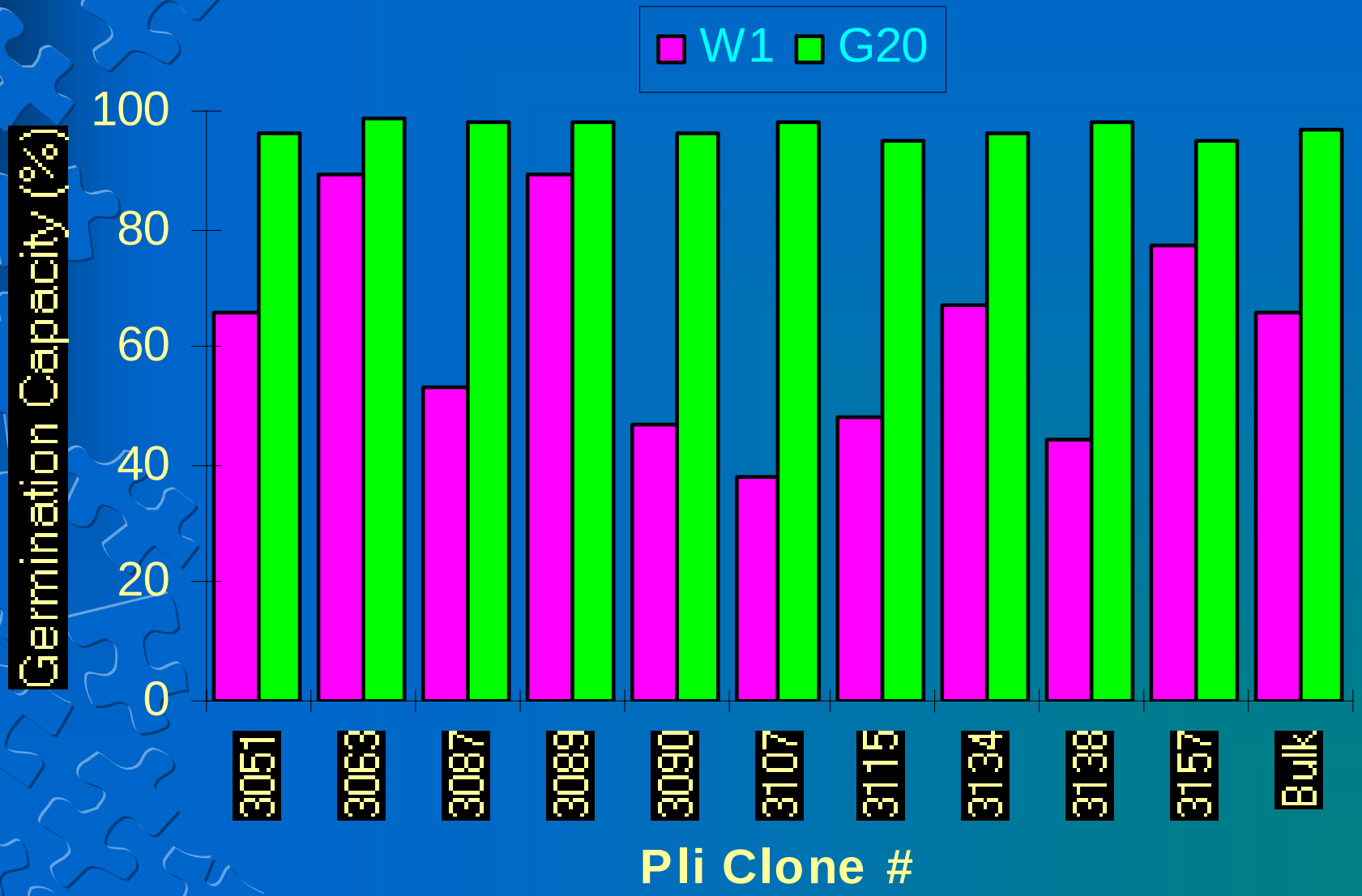
5-year average (2003-2007)



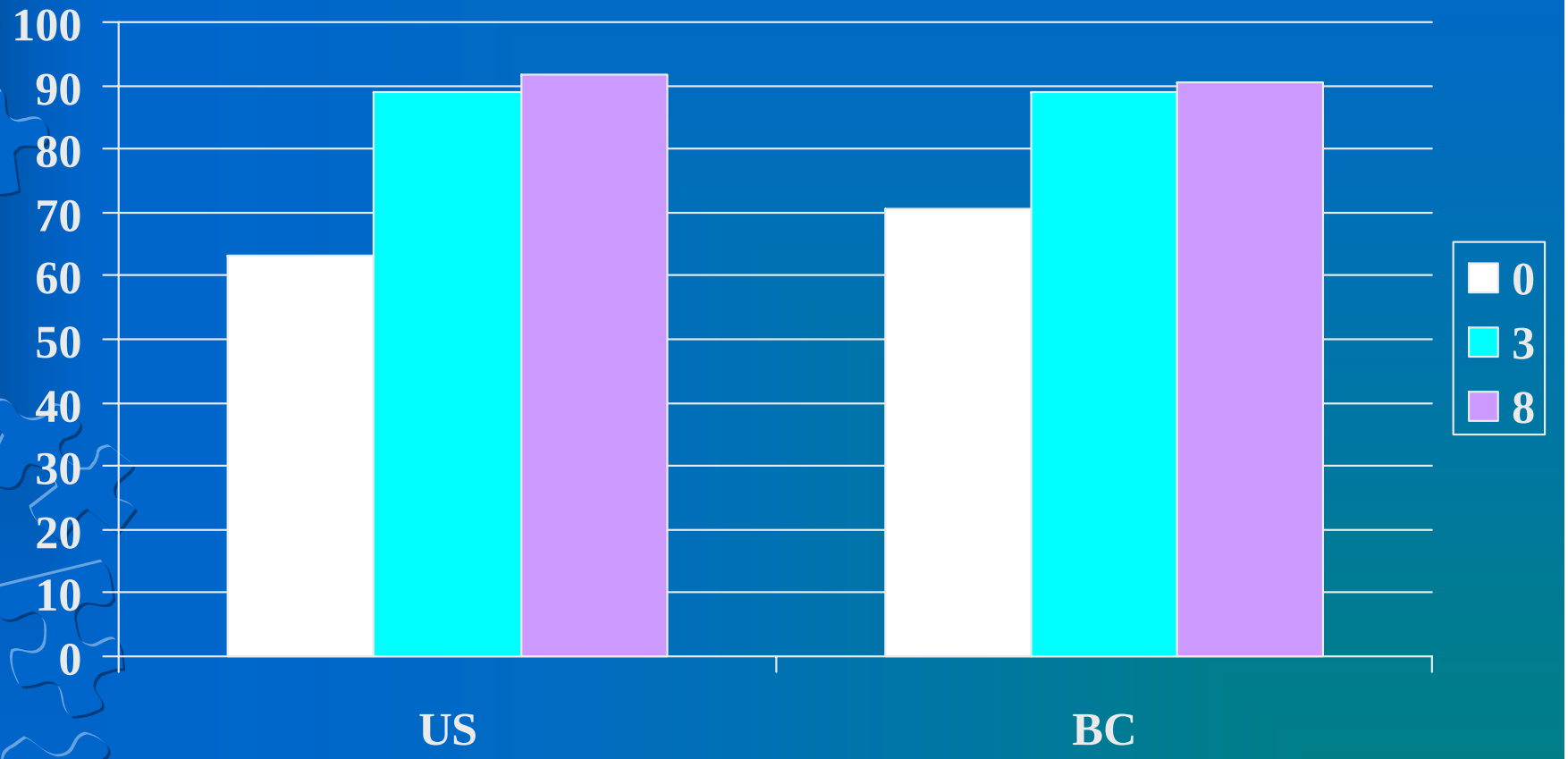
Stratification increases Vigour



Family Variability



A- class Fdc - 0, 3, 8 weeks Stratification



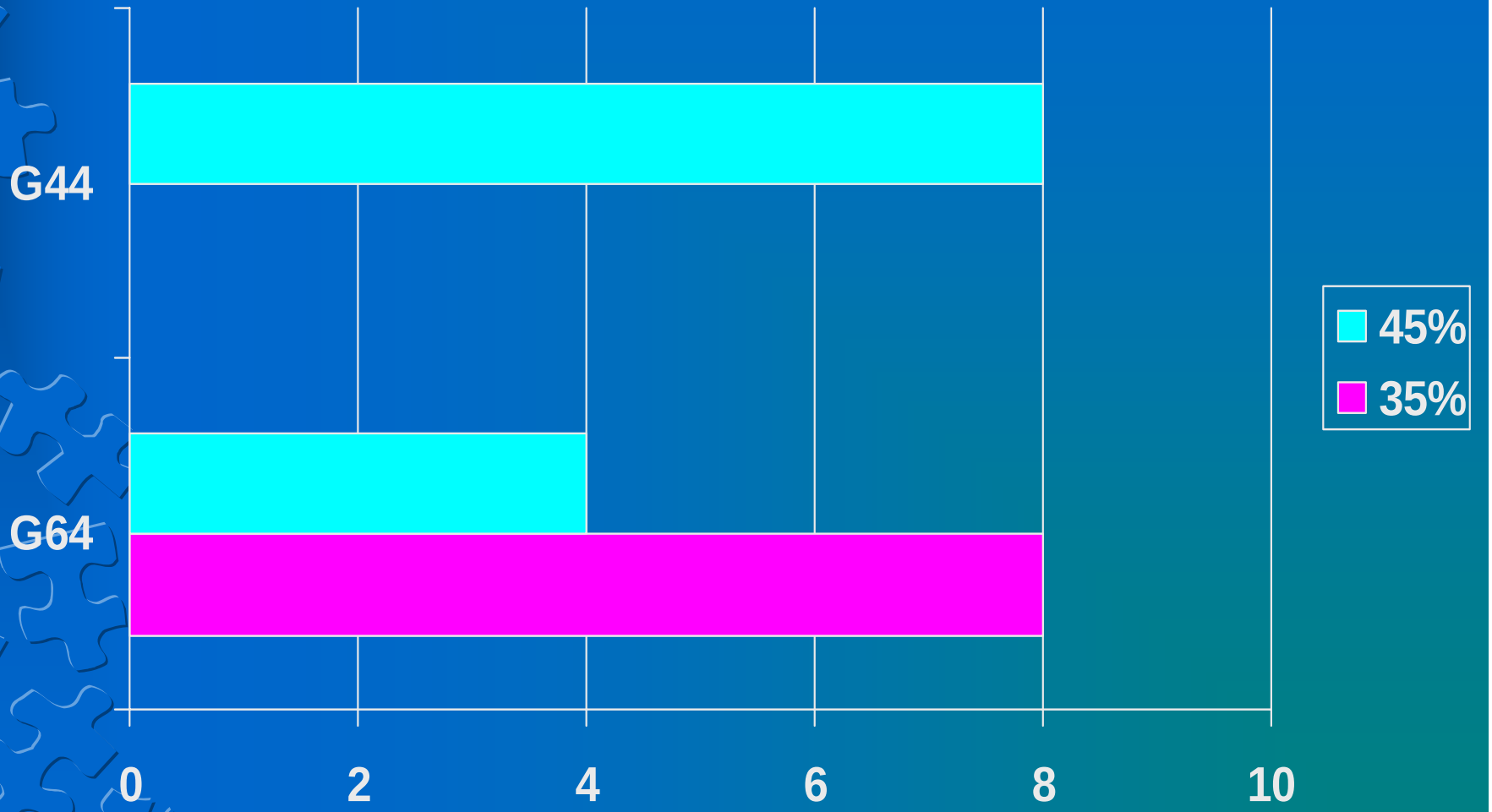
5 seedlots from each origin used

Dry-back and Strat.-Redry

In 1986 three research papers were published illustrating the benefits of ‘split’ stratification

- Edwards, D.G.W. 1986. Special prechilling techniques for tree seeds. J. Seed Tech. 10:151-171.
- Leadem, C.L. 1986. Stratification of *Abies amabilis* seeds. Can. J. For. Res. 4:755-760
- Tanaka, Y and D.G. W. Edwards. 1986. an improved and more versatile method for prechiling *Abies procera* Rehd. seeds. Seed Sci. Technology 14: 457-464

G44 *vs.* G64

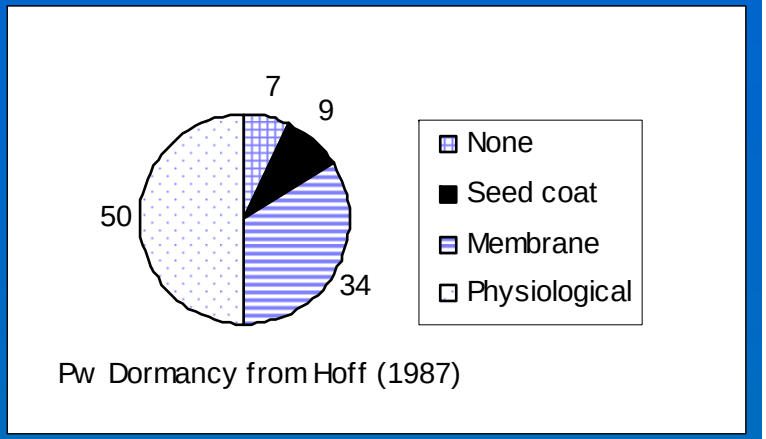


Abies moisture content

- stratification -redry or dryback requires moisture content control
- former procedures utilize visible clues and timings to obtain proper moisture content
  - 45%++ - drain excess moisture
  - 30-35% - dryback
- currently we use target moisture content calculations (use of seed weight to estimate seed moisture content)

Western White Pine

Complex dormancy in Pw



Pw Dormancy from Hoff (1987)

1996 – new test type for Pw (G55)

- 20% gain in germination
- **Lab gains not duplicated in operations ???**
- Lots of trial work

Now

- Target stratification m.c. to 37% (34-40% OK)
- Recommend 3-week stratification extension
- Limit bag size to 750 g (other sp. 3000 g)
- Use larger bag (improve aeration)
- Monitor and “mix each unit” – M, W, F
- QA on all Pw seedlots

Temperature

- If adequate moisture is available and dormancy is overcome then temperature is the rate limiting factor
- biological limits exist (30-35° C) that depends on moisture content and species
- increased germination temperatures result in faster, more uniform germination that also reduces window of opportunity for pests
- soil or grit temperature more useful
- more in the Germination Environment talk

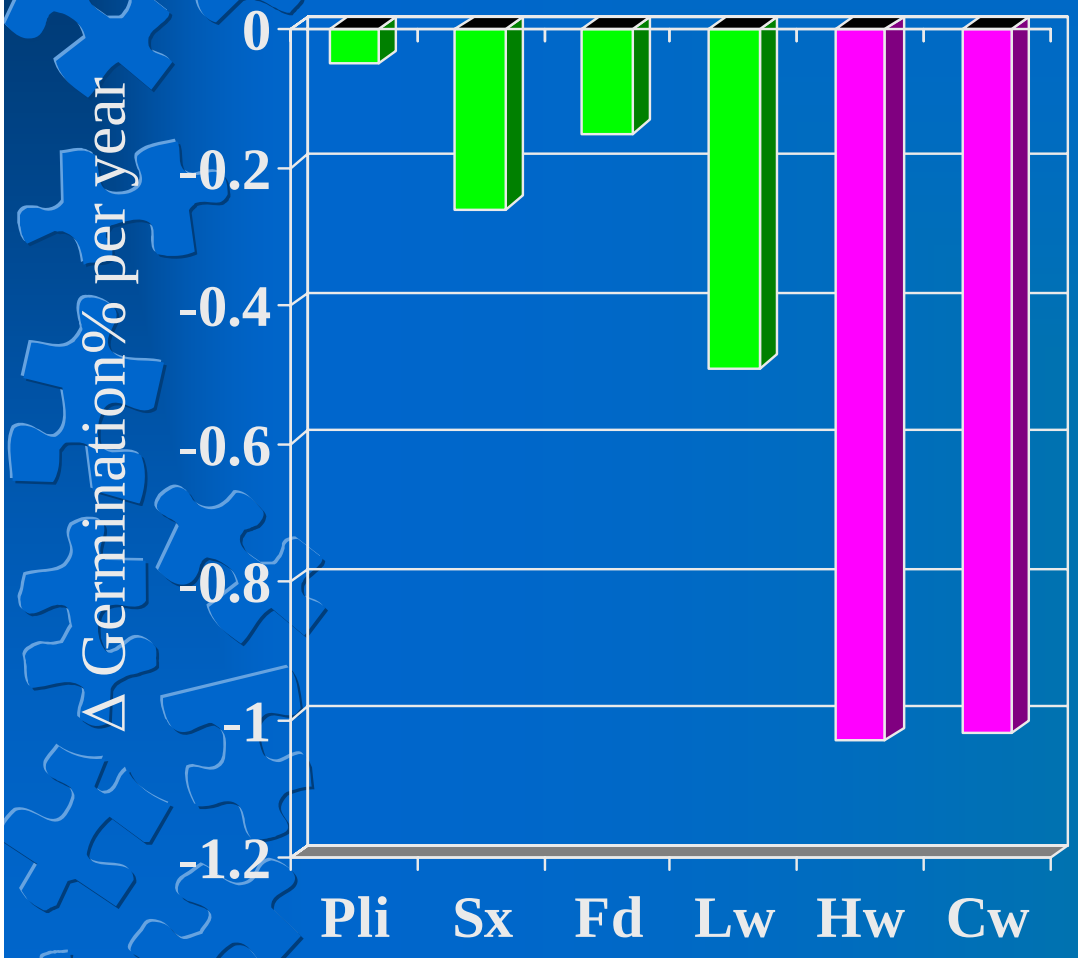
Seed Deterioration

1) Seed will first lose vigour (ability to germinate under sub-optimal conditions)
2) then loose ability to germinate normally
3) then die (no germination)

Theories

- depletion of food reserves
- alteration of chemical composition
- membrane alteration
- enzyme alteration
- genetic damage

Seed Deterioration



- minimize metabolic activity (mc, temp)
- quantified as

  Δ GC / year
- large variation between species
- used to specify species retest frequencies
- variation also exists within species

Additional Seed Biology Information

Seed Handling Guidebook Kolotelo, Van steenis, Peterson, Bennet, Trotter and Dennis

Tree Seed Working Group Newsbulletin - free electronic newsletter

New Tree Seed Centre web page

- http://www.for.gov.bc.ca/hti/treeseedcentre/index.htm

Tic Talk - Tree Improvement + Newsletter - periodically

Journals

Seed Science and Technology
Seed Science Research
Seed Technology
Canadian Journal of Botany
Canadian Journal of Forest Research
Tree Planters Notes
Forest Nursery Notes

Books

Bewley and Black,Seeds - Physiology of Development and Germination

Farmer, Seed Ecophysiology of Temperate and Boreal Zone Forest Trees

Dave Kolotelo

Cone and Seed Improvement Officer

BCMOFR Tree Seed Centre

Tree Improvement Branch

(604) 541-1683 ext. 228

Dave.Kolotelo@.gov.bc.ca

http://www.for.gov.bc.ca/hti/treeseedcentre/index.htm