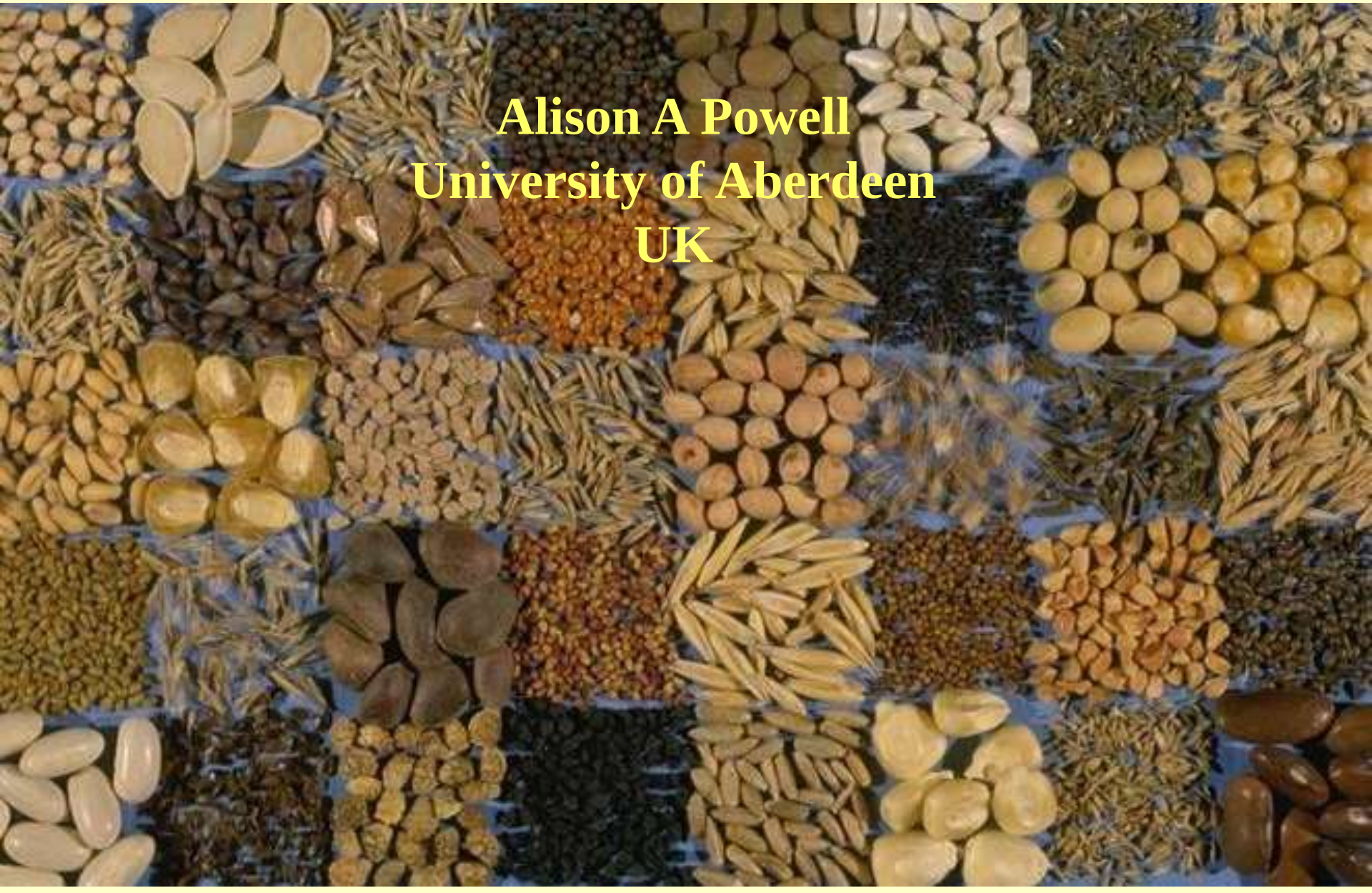
Physiology of germination and dormancy



Alison A Powell
University of Aberdeen
UK

Dry seed

Physiological germination (radicle protrusion)

Normal seedling
(ISTA germination)



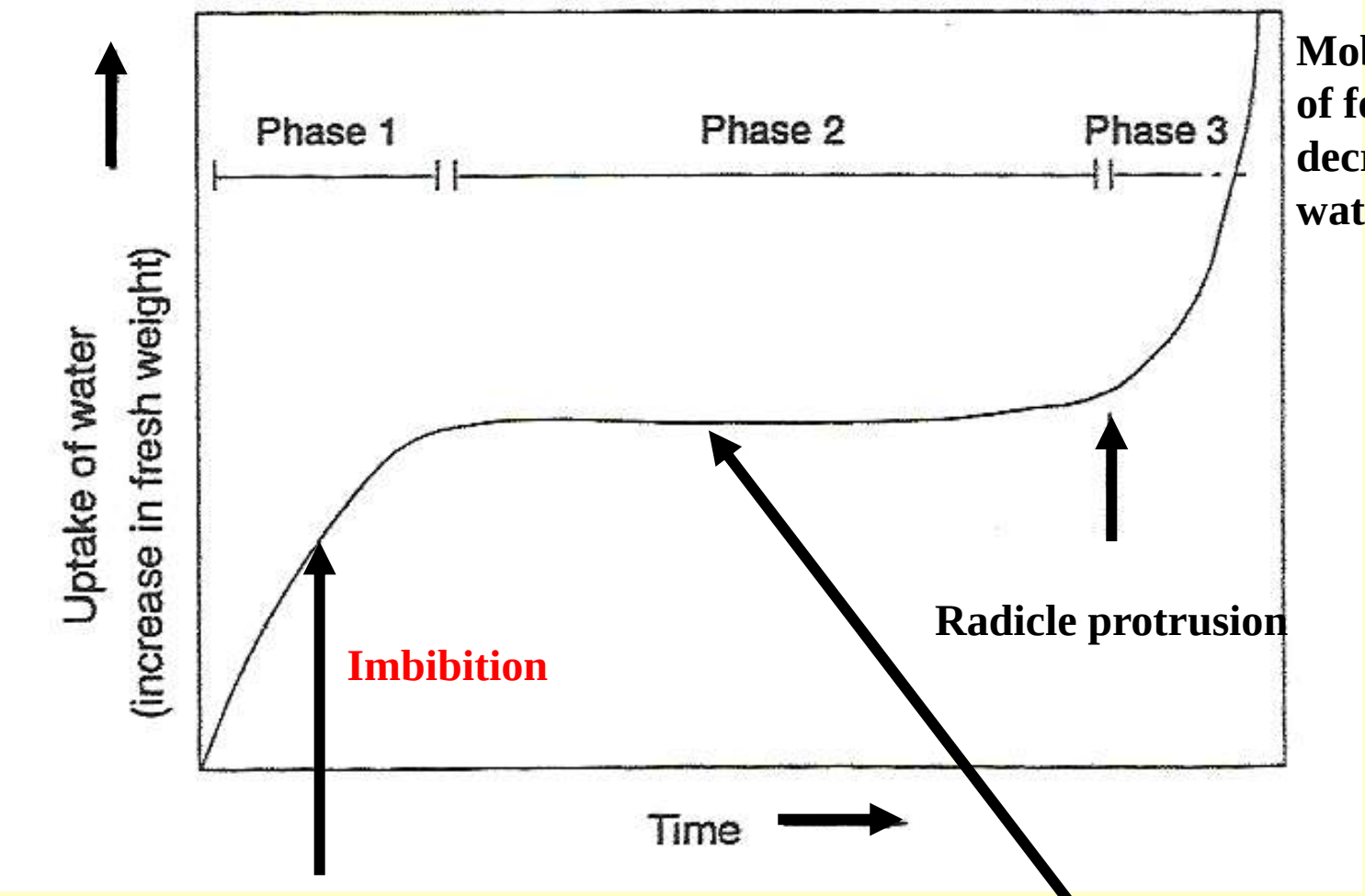



Dry seeds

- **Low moisture content**
- **High matric potential (-350 to -50MPa)**

Low water potential

Water uptake



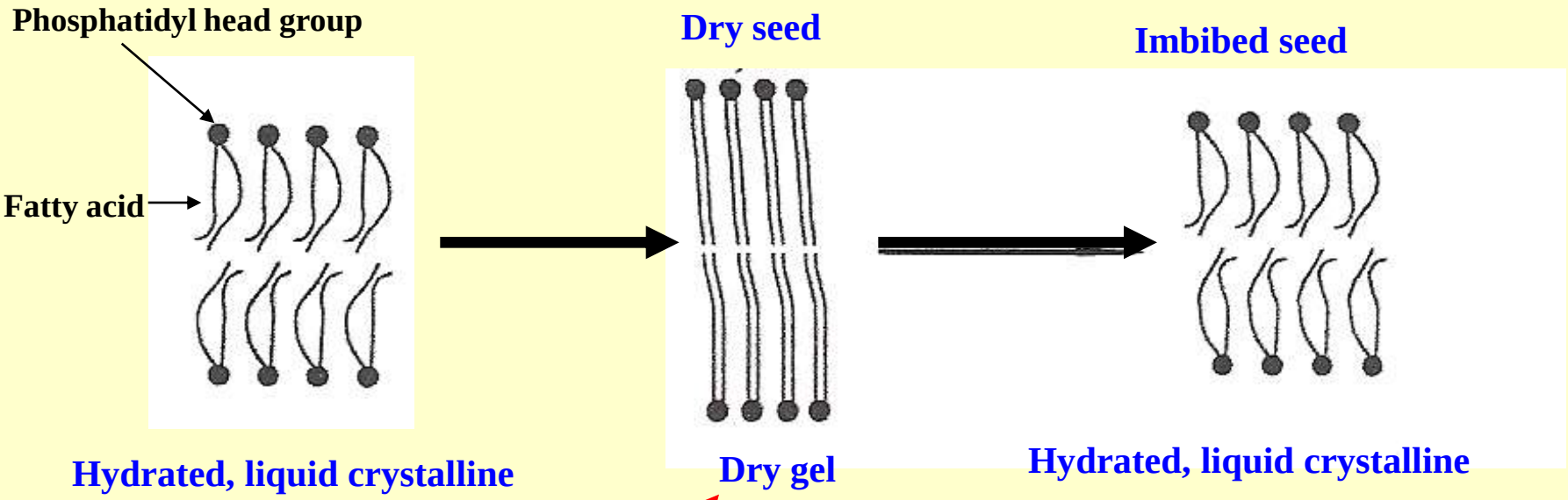
Mobilisation of food reserves, decreased water potential

Water potential gradient (seed vs environment) results in rapid water uptake (physical process)

Water potential of seed and environment at equilibrium

Priming

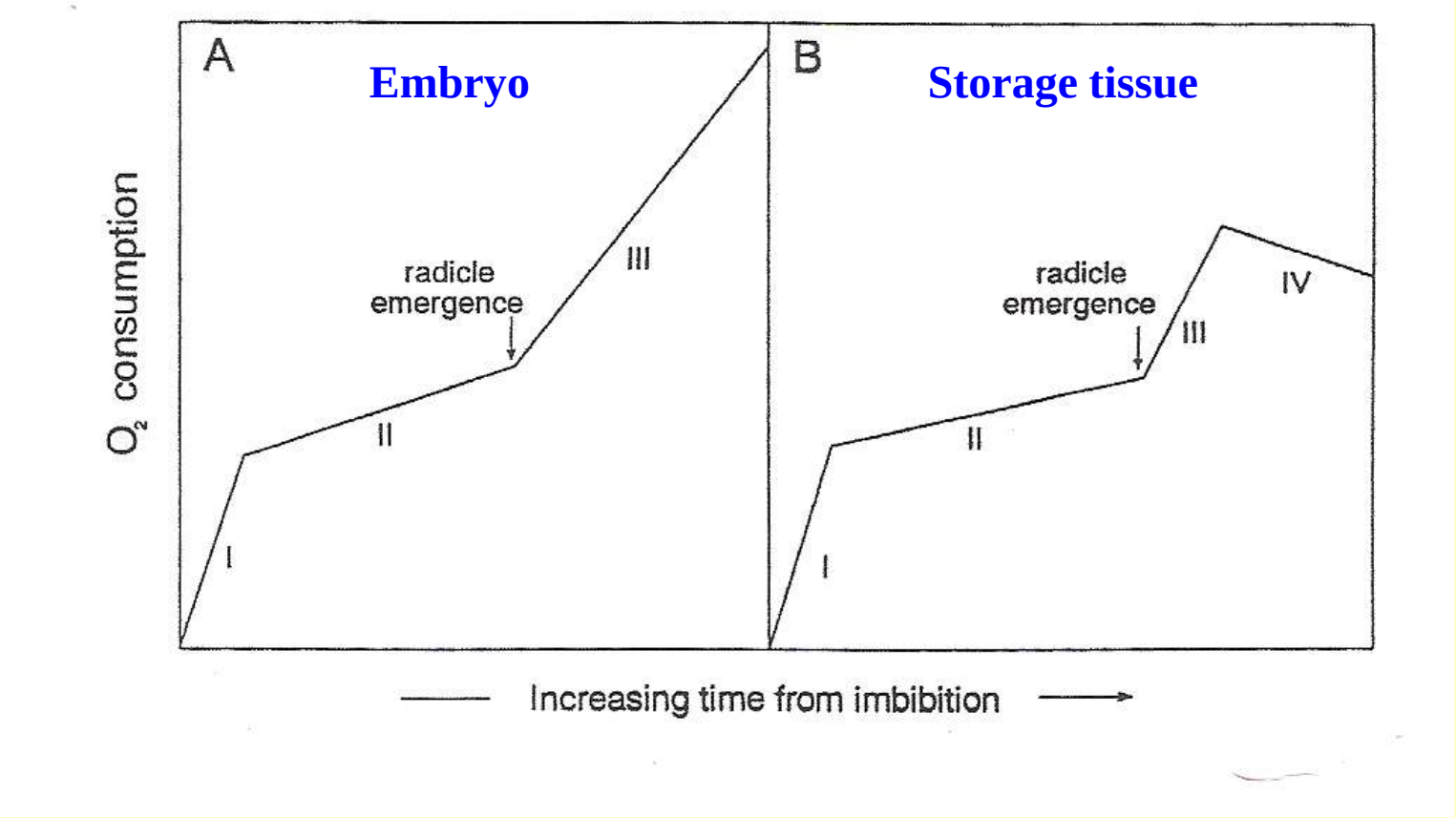
Membrane changes during imbibition?



Rapid water uptake

Imbibition damage → **Reduced germination**

Respiration during imbibition and germination



I: Activation of enzymes

Active mitochondria

II: Synthesis of enzymes / mitochondria

Temporary anaerobiosis (CO_2/ O_2)
Ethanol / lactate produced

Taken from Bewley and Black, 1994

Seeds: Physiology of development and germination

Protein and RNA synthesis

- **Resume minutes after hydration**
- **rRNA, tRNA, some mRNAs: retained in dry seed**
- **Initial synthesis:**

Translation of mRNAs (mRNA turnover)

↓

Polysomes

↓

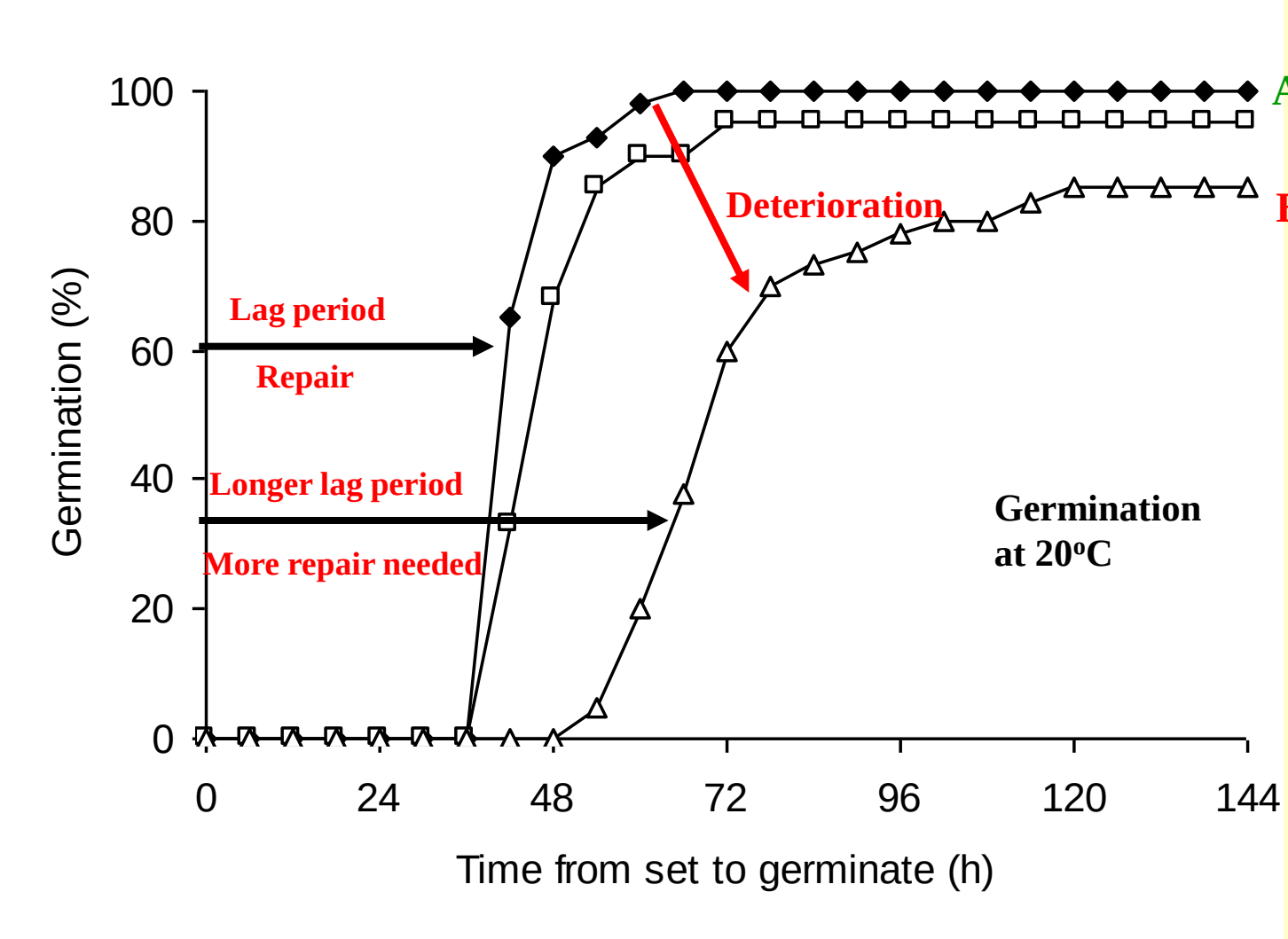
Proteins synthesised

DNA synthesis

- **DNA repair**
- **DNA replication**

- **DNA repair**
  - **DNA damage**
    - **drying/ rehydration; storage**
  - **Single and double strand breaks**
    - **endonuclease activity, free radicals, base loss**
  - **Repair by DNA polymerases and ligases**

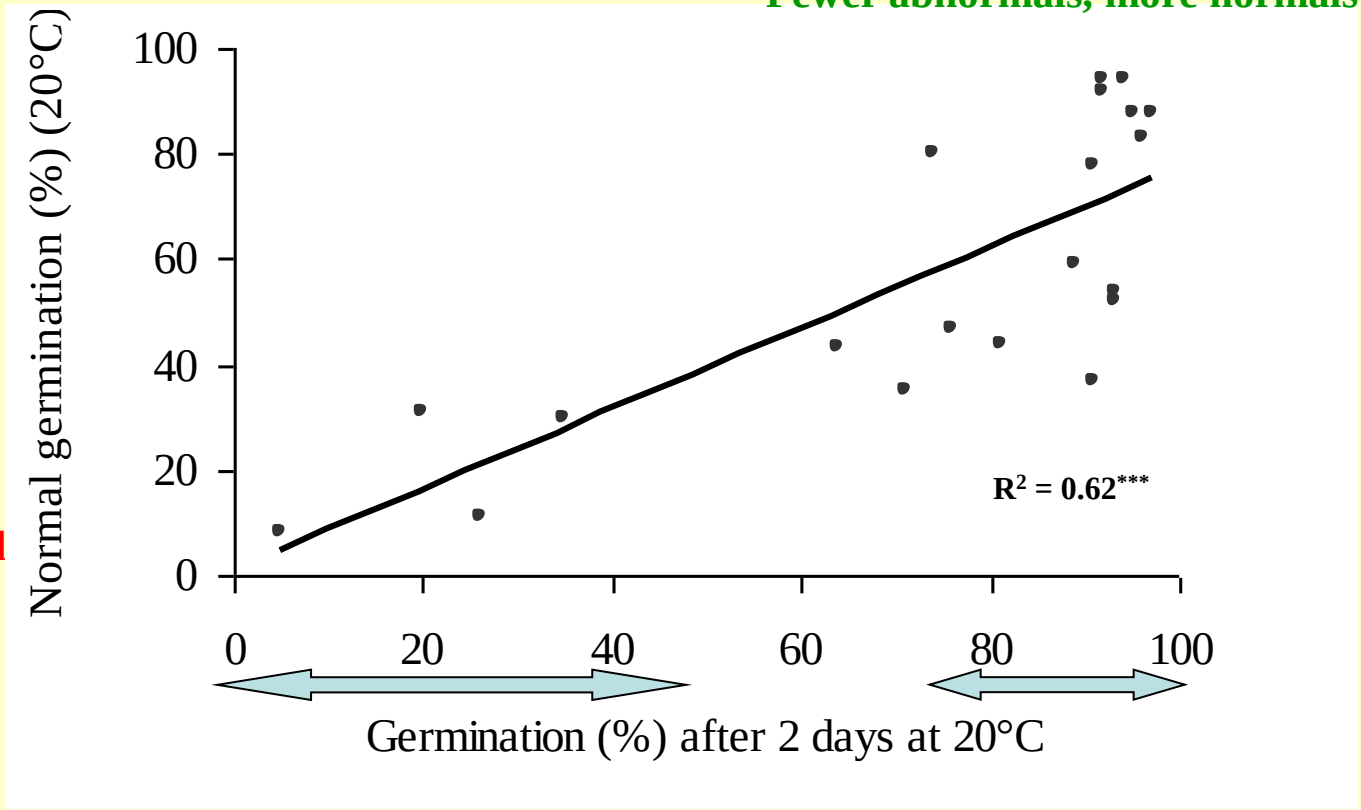
Time course of germination



Repair also during priming

Lag period, repair and normal vs abnormal seedlings (oil seed rape)

A: less deteriorated
Less repair needed
Fewer abnormals, more normals



B: deteriorated lot
More repair needed
Repair incomplete
Few normals

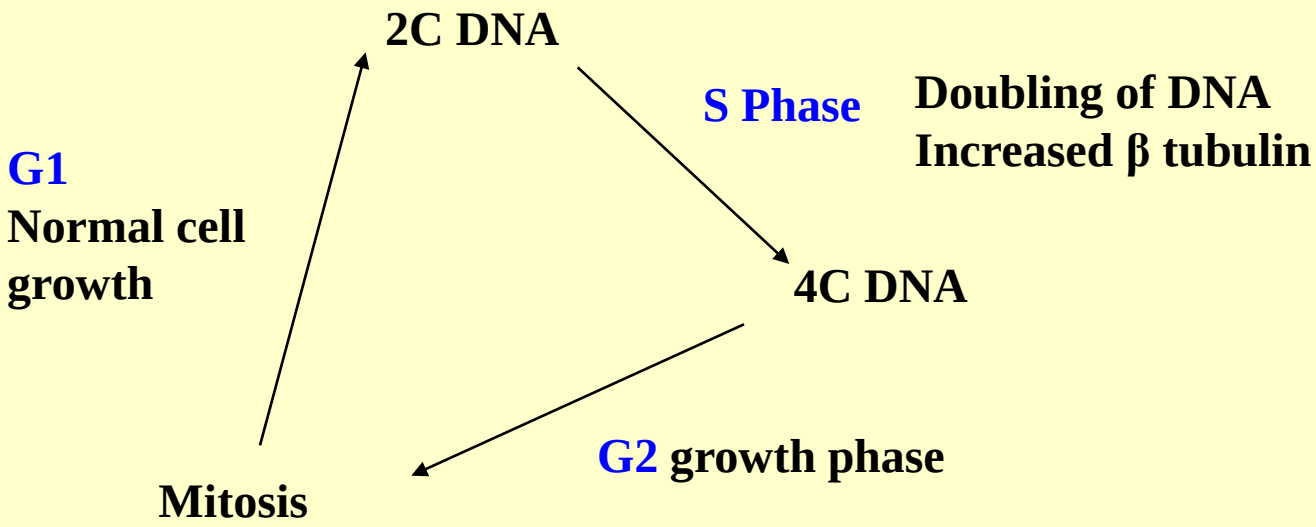
B
Slow germination
Low germination at 5d
Long lag period

A
Faster germination
High germination at 5d
Short lag period

From Khajeh Hosseini, Nasehzadeh and Matthews,2010
Seed Science and Technology,38, 602-611

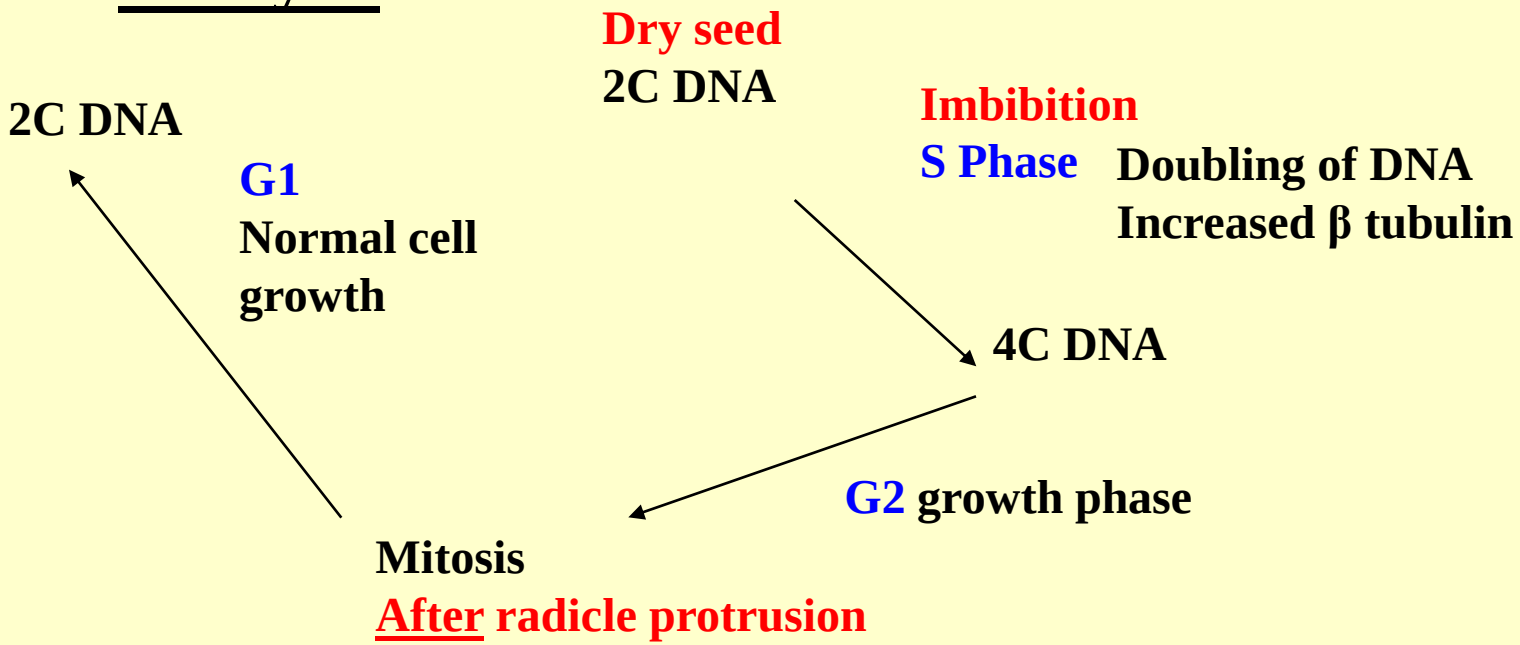
- **DNA synthesis**

Cell cycle



- **DNA synthesis**

Cell cycle



Priming: 4C DNA produced when germination is advanced following repair

Implications for seed storage (Powell et al, 2000 Journal of Experimental Botany, 51,2031-2043)

High germination, high vigour (little deterioration).

Advancement, 4C DNA synthesis, reduced longevity

High germination, low vigour (deteriorated seed)

Repair, little advancement, improved longevity

Final stages of ‘germination’

- **Radicle extension and protrusion:**
  - **cells expand**
  - **increased turgor; cell walls yield**
  - **causes unknown**
  - **possible role for expansins**
    - **proteins involved in cell wall relaxation in vegetative growth; loosen H bonds?**

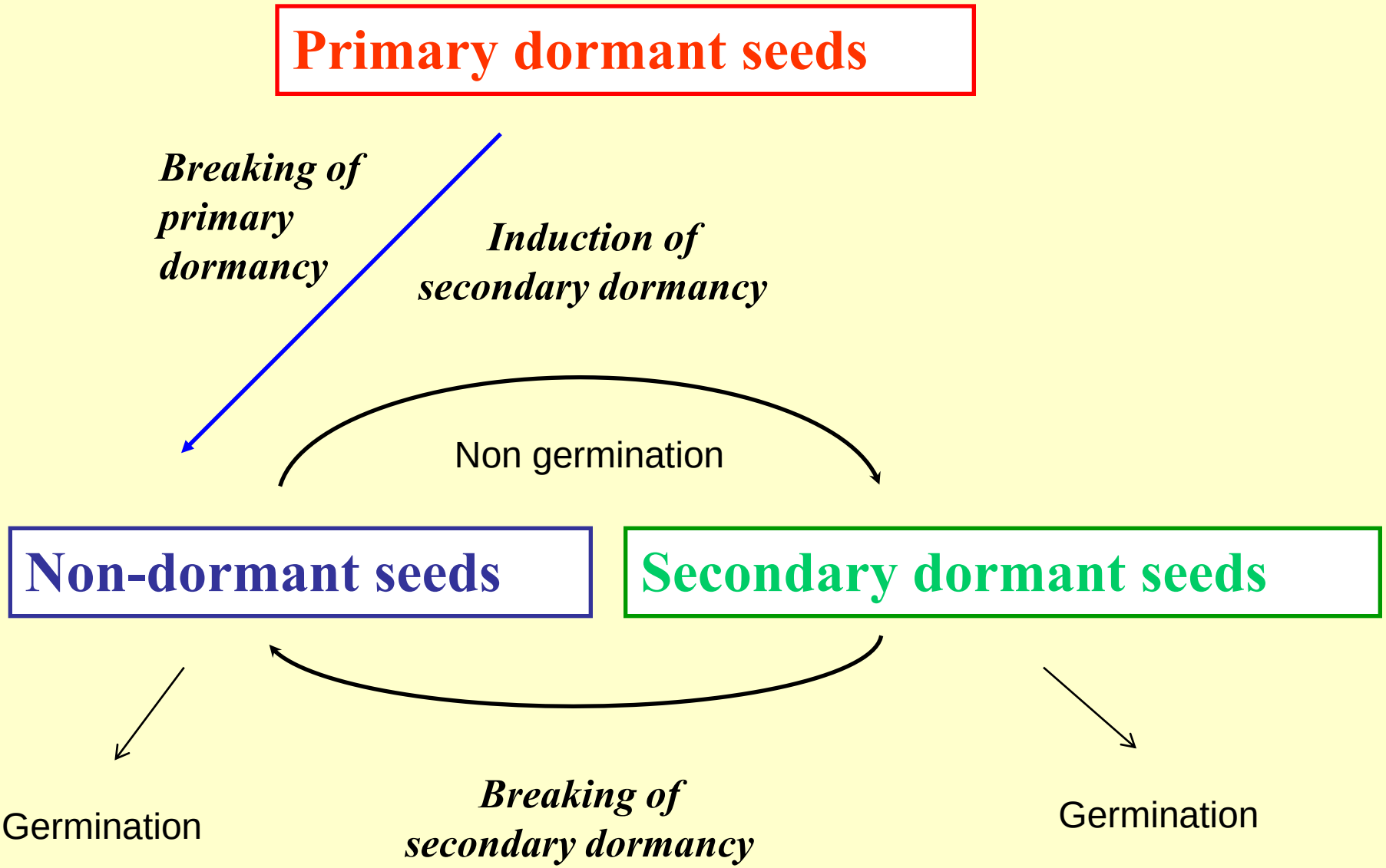
- **Production of normal seedling**
  - **Mobilisation of storage reserves**
  - **Seedling growth**

Dormancy

- **Prevents germination even in conditions adequate for germination**
  - **Evolutionary adaptation**
  - **Bet-hedging**

- **Two types of dormancy**
  - **Primary dormancy**
    - **part of genetic programme of seed development and maturation**
  - **Secondary dormancy**
    - **Mature imbibed seed**
    - **Induced by environment**
    - **Occurs in non-dormant seeds + initially with primary dormancy**

Dormancy : inability to germinate in apparently favorable conditions



Courtesy of Françoise Corbineau

Factors that maintain dormancy

- **Maternal**
  - **Testa / pericarp/ endosperm/ megagametophyte (gymnosperms)**
    - **Mechanical**
    - **Natural chemical inhibitors**
    - **Permeability (water, gases)**
- **Embryo**
  - **Endosperm:**
    - **Restraint of radicle growth**
  - **Hormones:**
    - **ABA/GA_3 antagonism;**
    - **embryo sensitivity to ABA and GA_3**
  - **Genetics**
    - **Interaction of dormancy promoting + germination repressing loci vs germination promoting loci**

Dormancy classification: Baskin and Baskin

Dormancy breaking

- **2 processes**
  - **Dormancy breaking**
    - **Dormancy breaking agent**
    - **Threshold value; single event or incremental events**
    - **>1 factor may be effective**
    - **Increased range of conditions in which germination will occur**
  - **Germination**
    - **Requires right conditions even after dormancy broken**

e.g. Summer annuals: Dormancy broken by low temperature;
Germination requires a higher temperature

Dormancy cycling

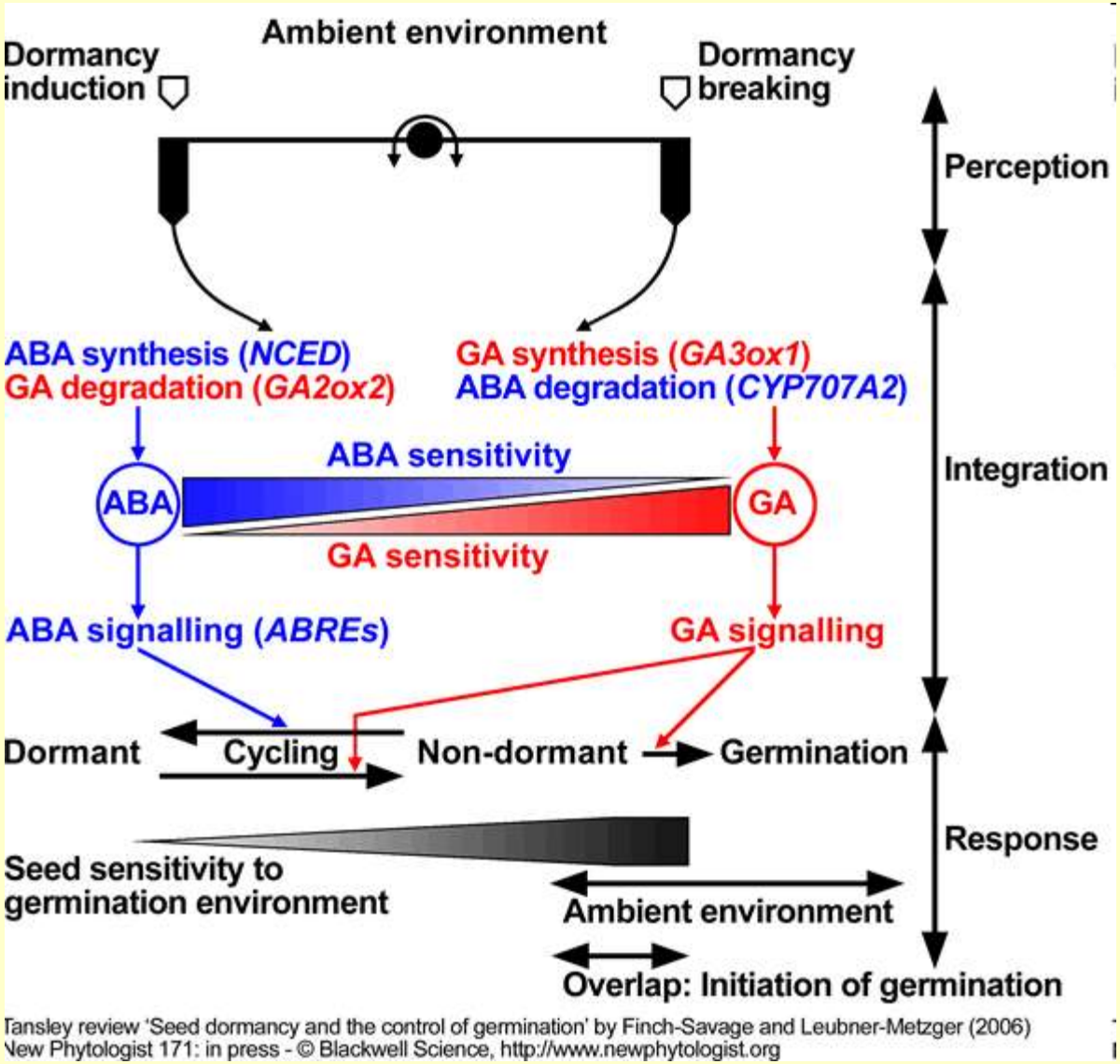
- **Primary dormancy decays**
- **Increased range of conditions in which germination will occur, until non-dormant**
- **But if germination not triggered, dormancy re-established**

.

Factors breaking dormancy

- **Environmental**
  - **Temperature**
    - **Dry after-ripening; alternating temperature; stratification**
  - **Light**
    - **Light / dark; single doses**
- **Chemical**
  - **Inorganic**
    - **CO_2, nitrate, nitrite**
  - **Organic**
    - **Varied; butenolides (KAR1)**
- **Hormonal**
  - **ABA / GA balance**

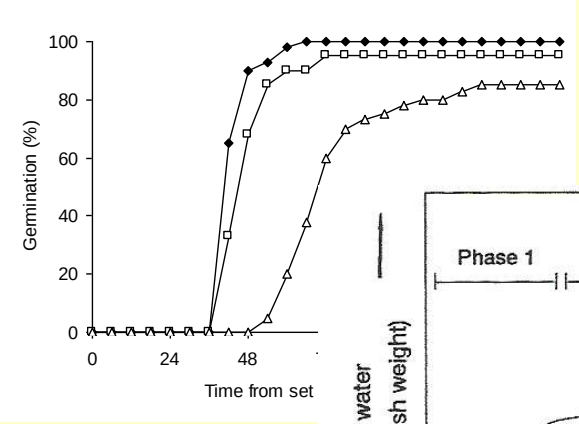
Role of hormones in breaking dormancy

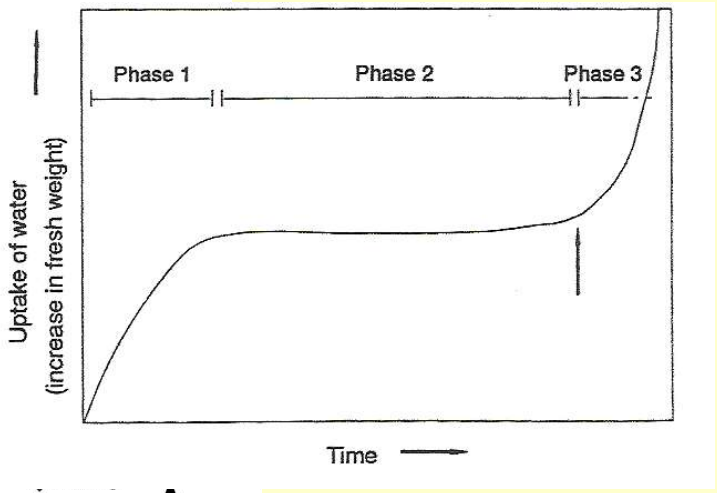


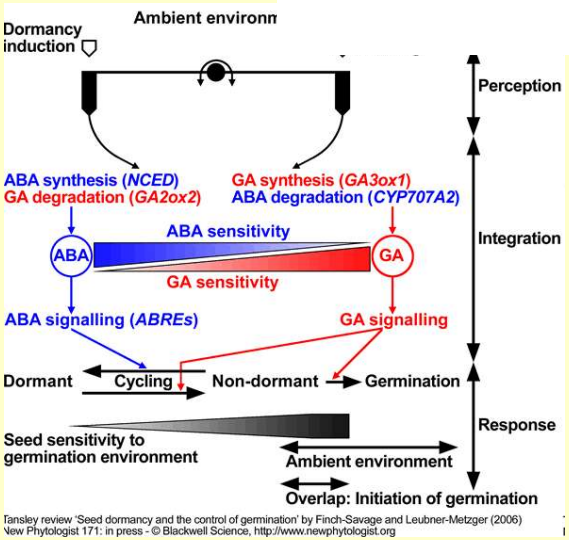
Tansley review 'Seed dormancy and the control of germination' by Finch-Savage and Leubner-Metzger (2006)
New Phytologist 171: in press - © Blackwell Science, http://www.newphytologist.org

Seed physiology

Seed testing







Thank you!