GENETIC VARIATION, ADAPTATION AND SEED GERMINATION

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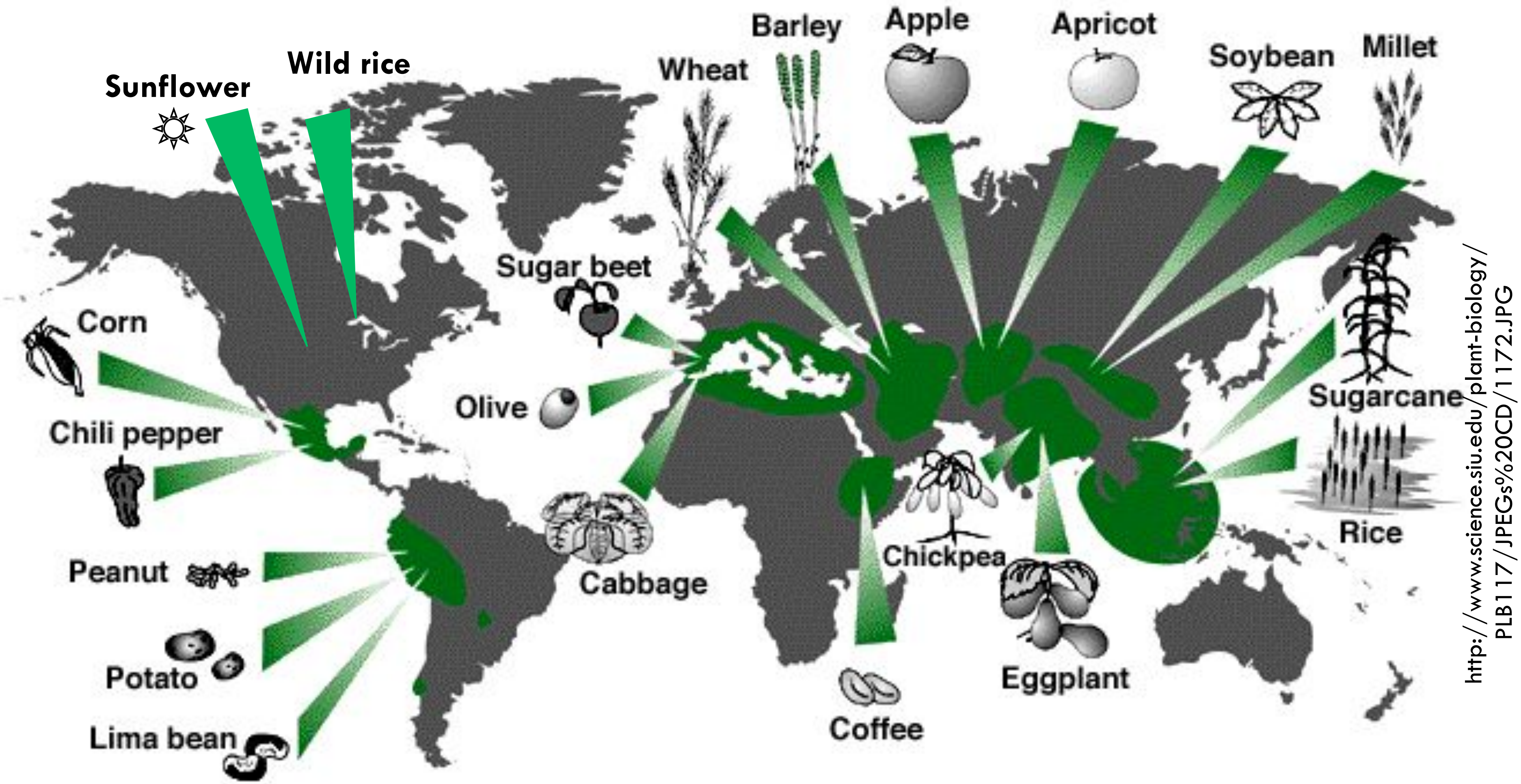
Centers of Origins



Areas of crop diversity where landraces grown

This only covers a small slice of global agrobiodiversity

Importance of landraces/heirlooms

- Cultural significance
- Unique characteristics, local use
- Can be more productive than improved varieties
- Allows for evolution with novel challenges
- Genetic resources for global and local agriculture

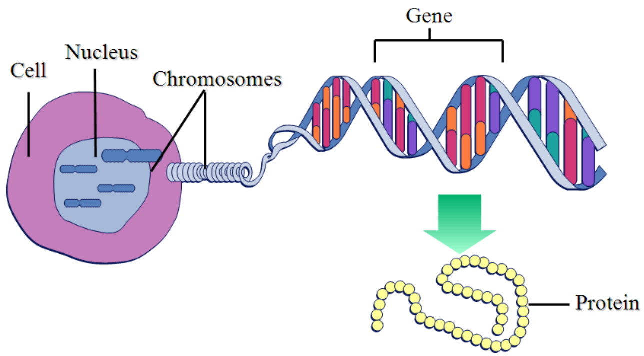
Photo: David Spooner

Multiple measures of genetic diversity:

variation within or among seed lots

Molecular genetic variation

- Many methods for quantifying, many metrics
- Variation in genetic sequences of DNA throughout the genome
  - may or may not underlie specific traits



https://socratic.org/questions/

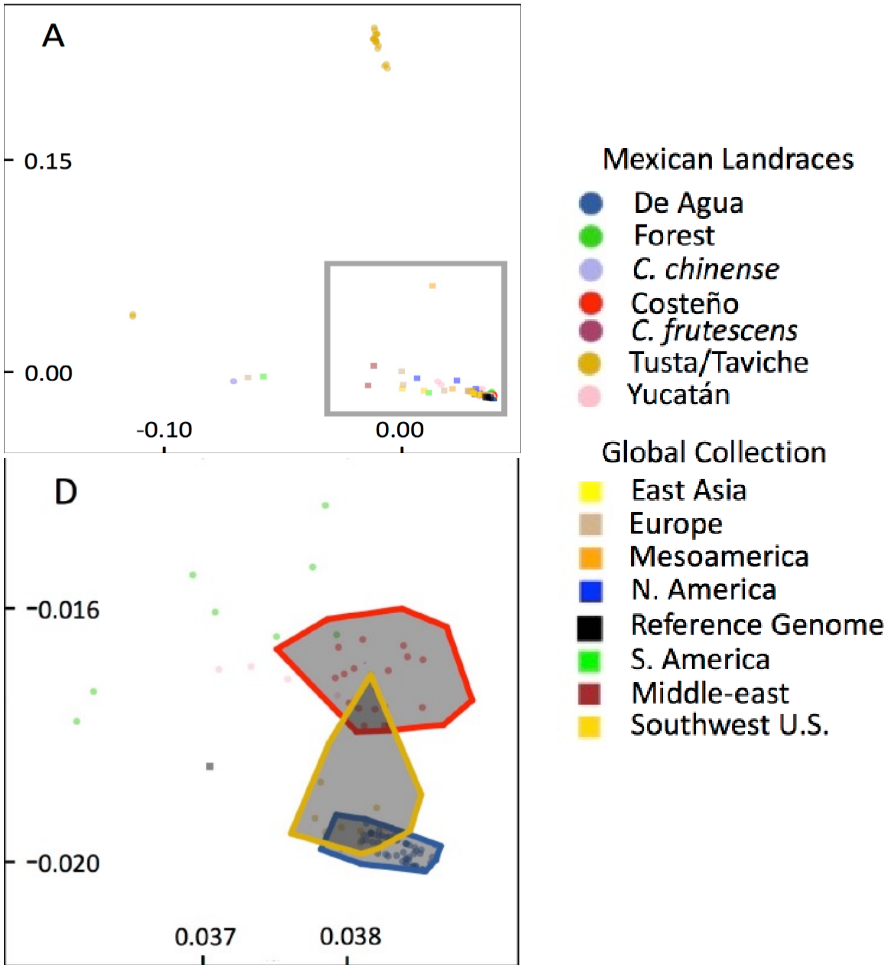
Quantitative genetic variation

- Variation in traits that are controlled by genes
  - Morphology, physiology, developmental timing
- Best estimated when grown and measured in uniform environment

Kristin Mercer, Seeds to Sustainability Workshop

Example: Molecular genetic variation

- Chile peppers from all over the world and from Oaxaca, Mexico
- Variation among Oaxacan peppers appears to be greater than the global collection
  - Tusta very divergent
- Less variation among some Oaxacan landraces

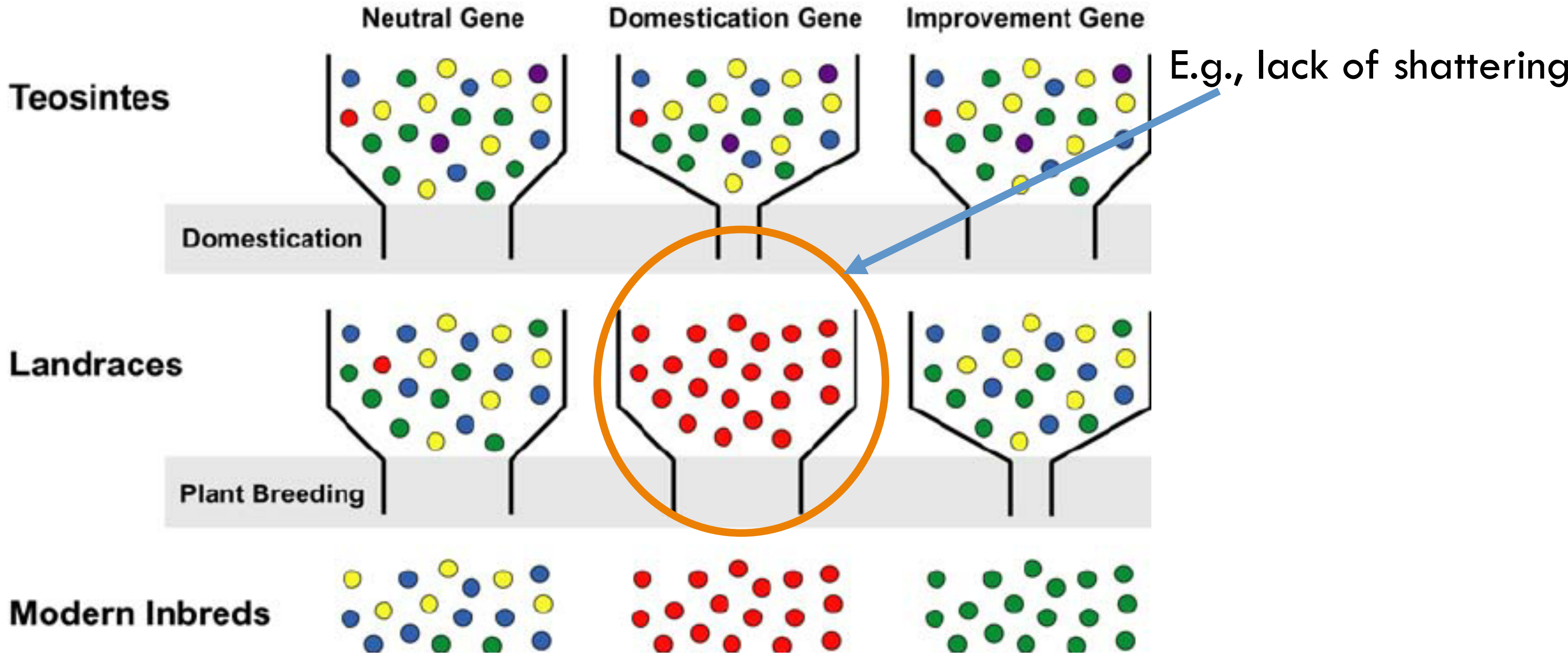


Example: Quantitative genetic variation

- Chile pepper fruit shape varies among seed lots
- How much variation in fruit shape within a seed lot?
- Why tell you about this?
  - Important for breeding or adaptation – any kind of change you want to make on a seed lot

What determines how much variation a seed lot has?

- Overall process of domestication often reduces genetic variation



Not true for tomato!

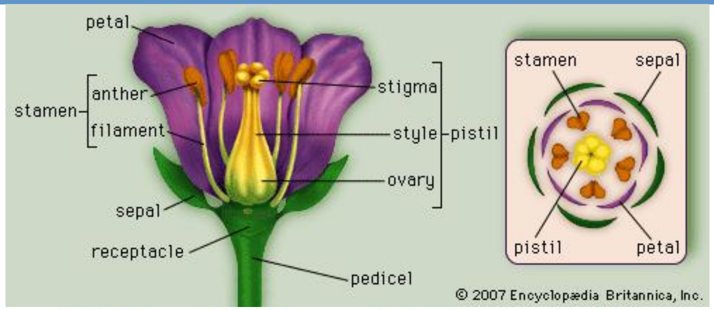
(Yamasaki et al. 2005. The Plant Cell)

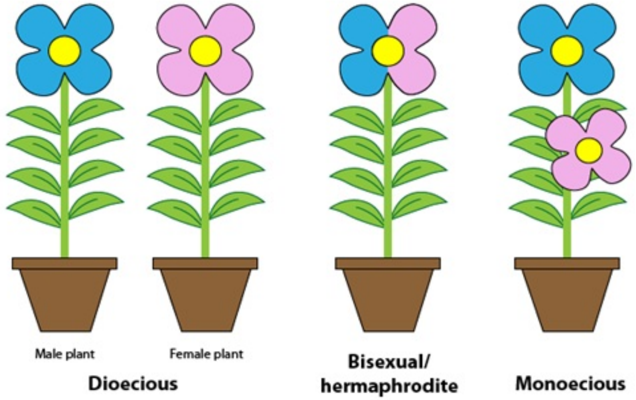
Underlying variation in a species determined largely by mating system

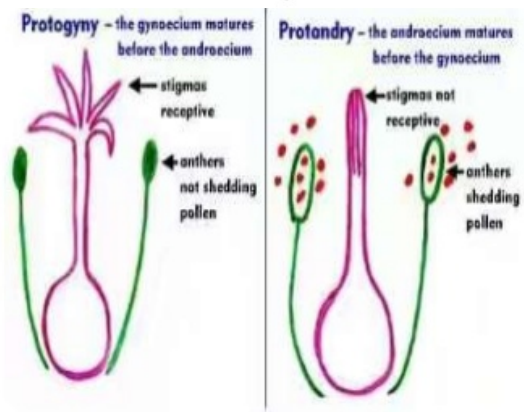
- Mating system: how the species reproduces
  - Asexually reproducing: clones
  - Flowers outcrossing or self-pollinating or both
  - If outcrossing, insect or wind pollinated
  - A sexually reproducing, outcrossing species would have greatest variation within seed lots
  - An asexually reproducing species would have little variation within seed lots

Flower types and mating system

- Flowers
  - Perfect vs. imperfect
- If imperfect, pollen has to move to female flower, often outcrossing
  - Monoecious ex. Corn, squash
  - Dioecious ex. asparaus
- If perfect, could be selfing or outcrossing
  - Selfing if flowers never open
  - Outcrossing if pollen and stigma mature at different times: dichogamous
    - Or if self incompatability system at work







http://plantbreeding.coe.uga.edu/index.php?title=4._Plant_Reproductive_Systems

https://www.slideshare.net/VenkatasubramanianP3/sexual-incompatibility

Mating system

- Important determinant of genetic variation
- Can help you know whether a commercial or heirloom you are working with has much variation

http://www.asiaseeds.com/wp-content/uploads/2015/01/Cayenne-Chile-Pepper2.jpg

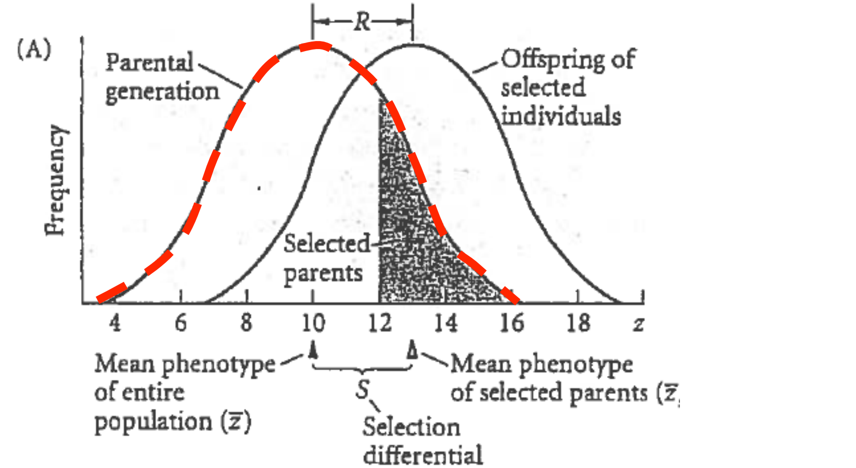
Ex. Predominantly selfing chile has little variation within variety

https://s-media-cache-ak0.pinimg.com/originals/fd/f9/c0/fdf9c07d402568f2c8cbaff92c2598ec.jpg

Ex. Outcrossing maize may have a lot of variation within variety

Genetic variation and selection

- Genetic variation necessary for selection
  - Trait must be heritable (controlled to some degree by genes)
  - Select plants with phenotype of interest
- Genetic variation is also the result of selection
  - Human selection: variation across chile landraces for pungency
  - Natural selection: variation for traits that provide adaptation

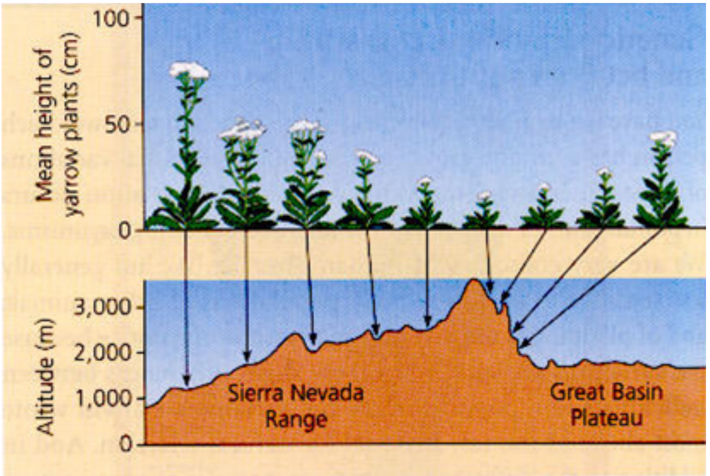


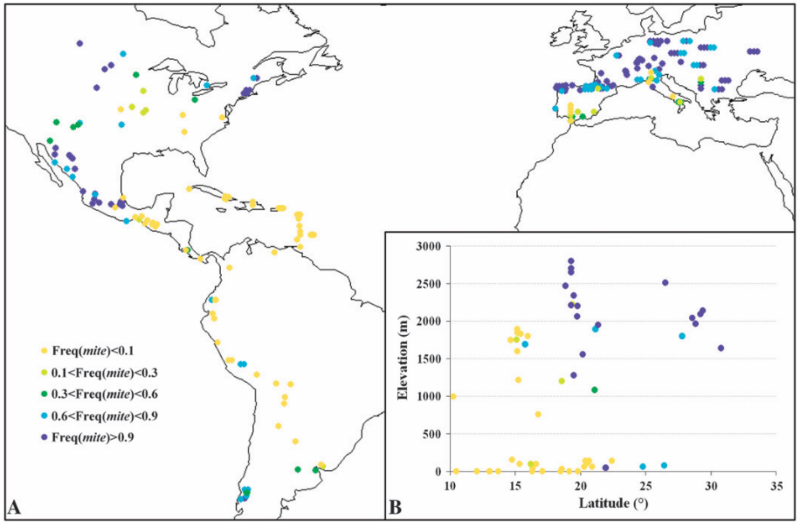
What is adaptation?

- Genetic variation that makes crop able to survive or reproduce better under local conditions
  - Often results from selection operating to change the population's genetic make-up
  - Over generations
  - May take many years or centuries to occur
  - Ex. Domestication often required adaptation to farming context

Selection by the environment

- Traits that increase productivity under certain environmental conditions can result in genetic variation
  - E.g., height, developmental time, physiology
- Variation in adaptation across the species range
  - Maize from higher elevation and latitudes have higher frequencies of a particular genetic variant





(Ducroq et al., 2008)

How to have useful adaptations?

- Varieties selected by farmers or breeders in similar conditions to yours
  - Locally or elsewhere
- Choice of crops based on environmental tolerances
  - Some may require lots of irrigation, etc. if not well adapted
- Select your own!
- Need to consider adaptations that might be relevant in the future (although the future seems to be now)
  - Climate change bringing warmer temperatures, more variable rainfall

Adaptation: can be rapid

- Evidence for rapid evolution to climate in landraces of pearl millet in the Sahel

Evolution of earlier flowering time in response to recent drought

Artificial selection may also help natural selection along

(Vigoroux et al. 2011)

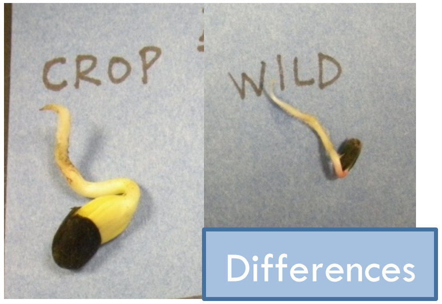
Seed germination

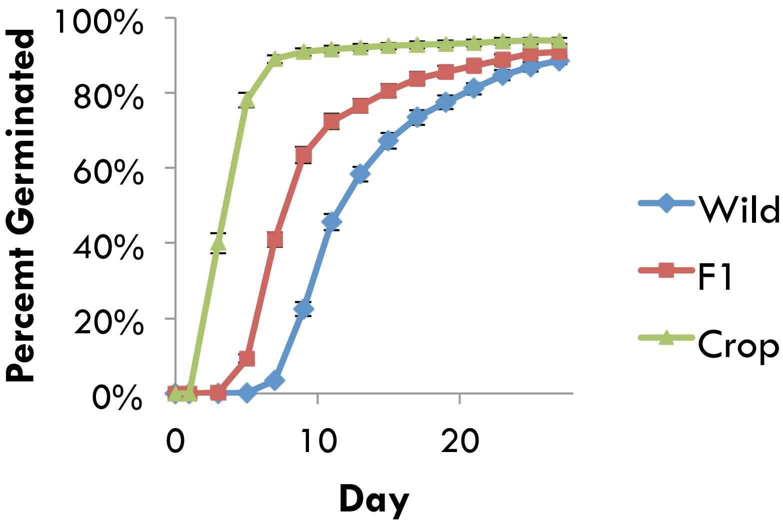
- Trait on which selected acted during domestication
  - Some crops retain dormancy e.g., canola, more recent domesticates
- Low germination can indicate some lack of adaptation

Domestication alters seeds

- With domestication:
  - Increased seed size
    - Better yield
    - Larger seedlings
  - Reduced seed dormancy (increased germination)
  - Altered responses to certain environmental cues

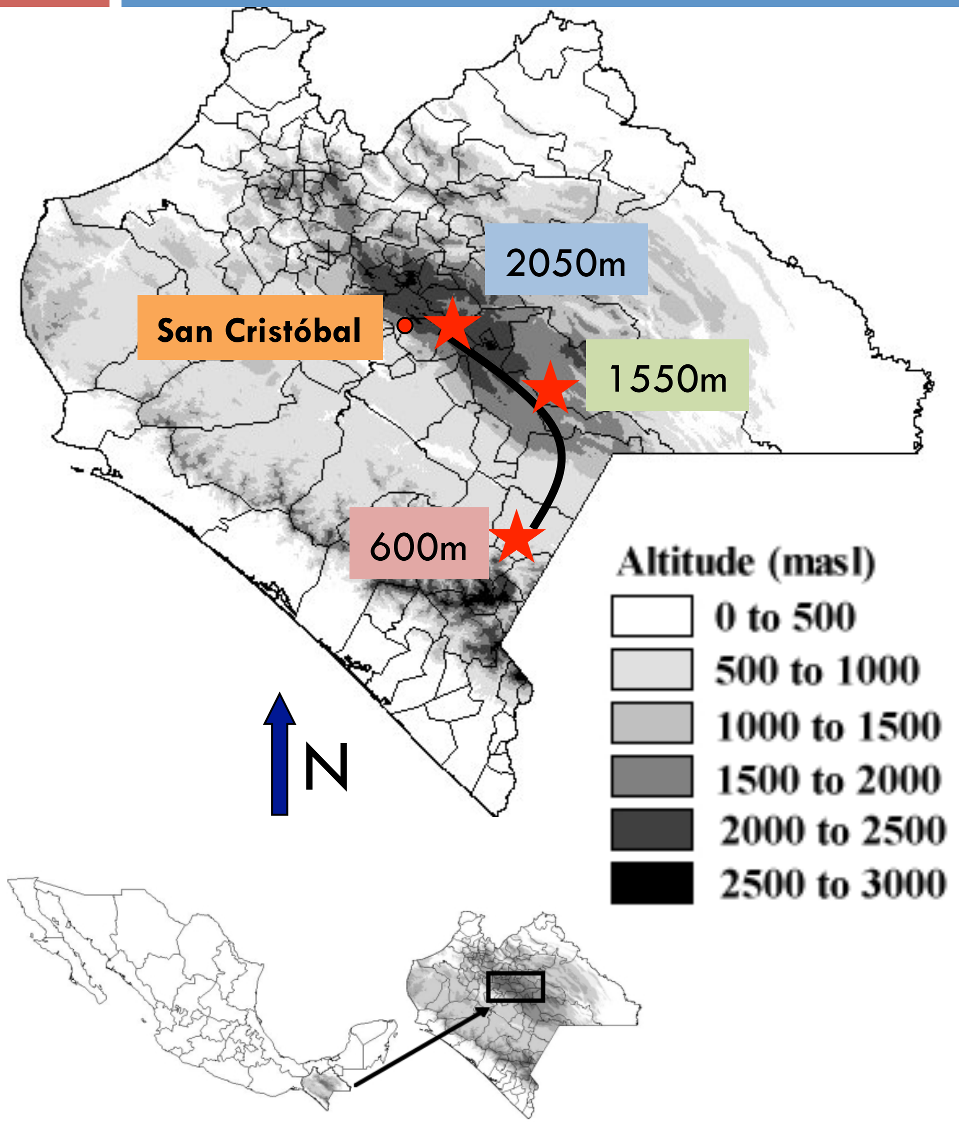
Sunflowers





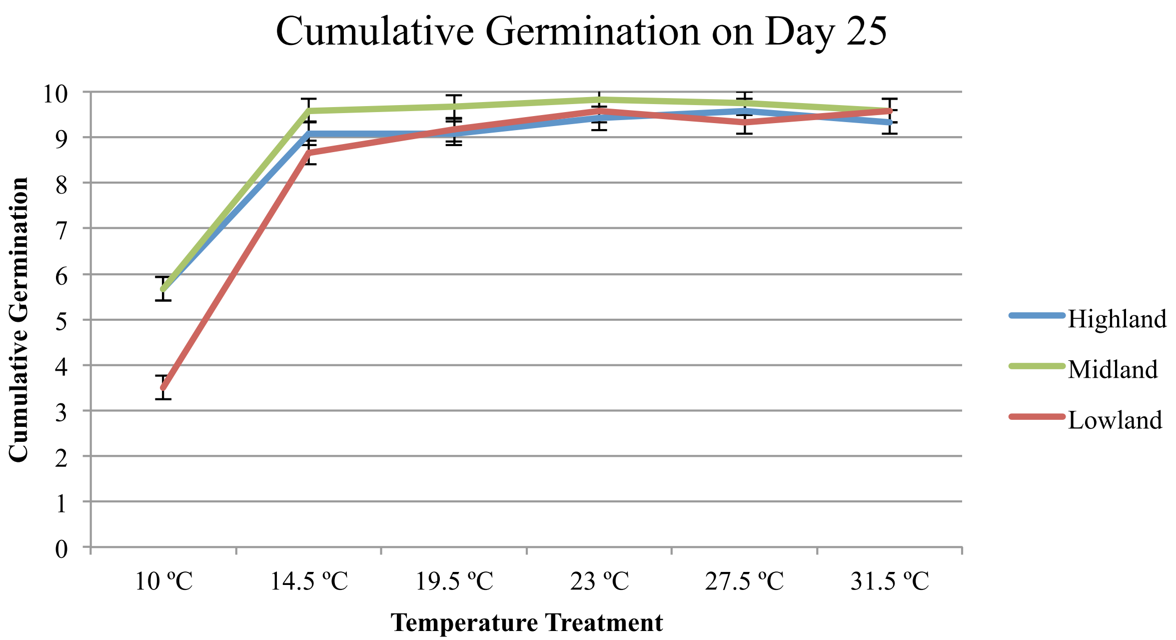
(Weiss et al. 2013. Seed Science Research)

Collections of landrace maize along transect



- Germinated seeds at a range of temperatures to see if seeds were adapted to particular conditions

Adaptation to germination temperature



- Landraces from hotter climes (lower elevation) were slower to germinate than those from cooler regions
- Likely adaptation to early season conditions

Lewis, 2013. Undergrad thesis

What do seeds need to germinate well?

- Harvest when ripe
  - Later than when we harvest fruit for eating (overripe – ex. Eggplant shriveled and hard)
- Dry well
  - Air movement, sun/shade
  - Heat – careful if saving seed
  - Increases germination, tolerance to dessication, vigor, longevity
- Store in cool, dry conditions with oxygen
  - Cool = not too hot, not too cold
  - Dry = <25% relative humidity best
    - use some kind of dessicant; dry-rite, dry beads
- Clean well
  - To reduce insect attack and pathogen load
  - Can infest during production or storage
- Some require seed treatment – scarification, soaking
- Germinate under suitable conditions

Questions