Wiarton Willy:
*did not see shadow*

Punxsutawney Phil:
*did not see shadow*

Shubenacadie Sam:
*did not see shadow*

# Who you gonna trust?



http://www.groundhogsday.com/

Mr. Prozac

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# Wiarton Willie suspected in double murder

*Last Updated Tue, 23 Sep 2003 20:35:26*

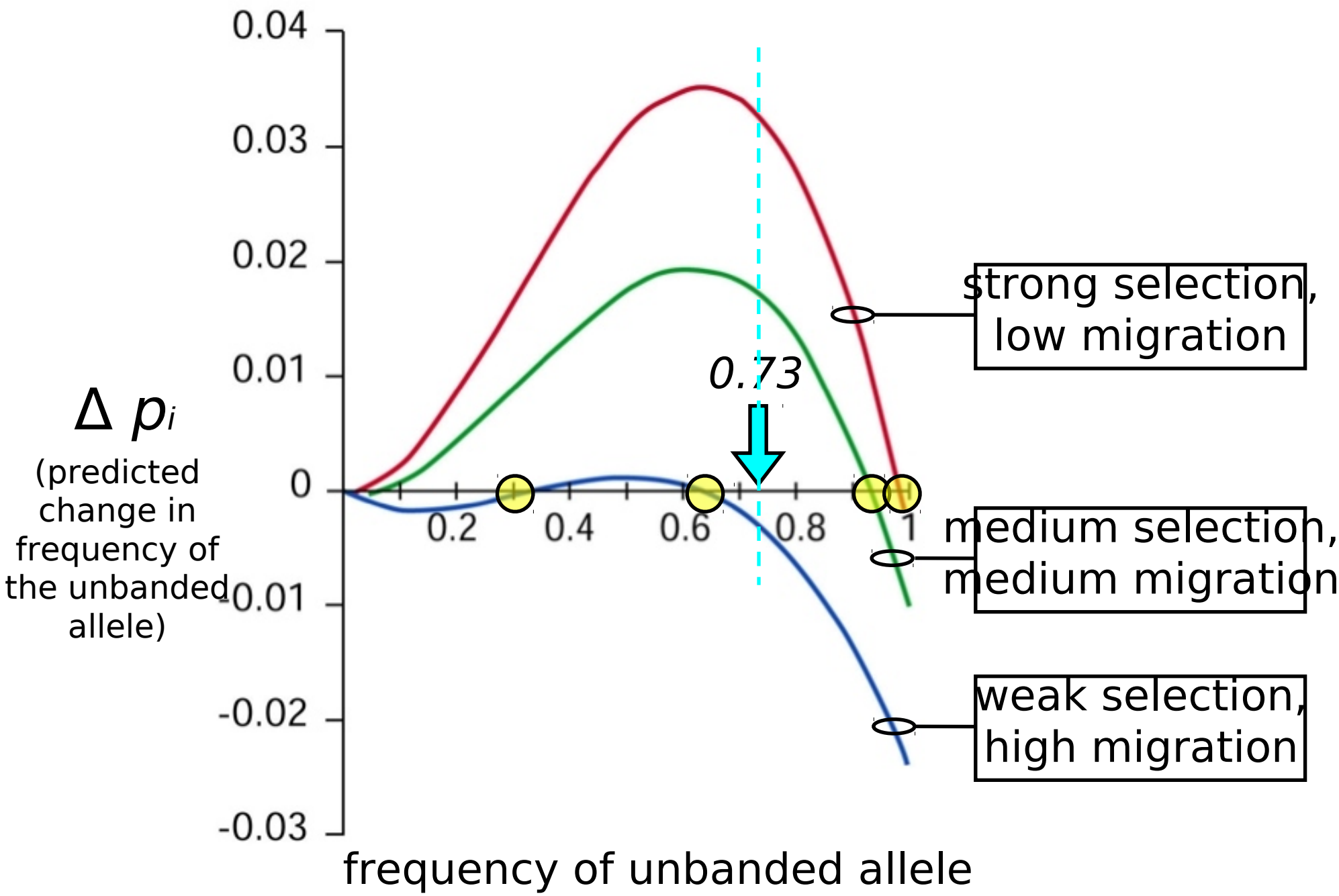
WIARTON, ONT. - An official in small-town Ontario is being accused of covering up a murder, but she says she was protecting the town from bad publicity.

Francesca Dobbyn told Wiarton town council on Monday that she knew Wiarton Willie might have killed his two understudies, but hid the facts so the town's summer tourist season wouldn't be hurt.

Wiarton Willie is an albino groundhog that is brought out every Groundhog Day to predict the coming end of winter. He is also the town's mascot and main tourist attraction.

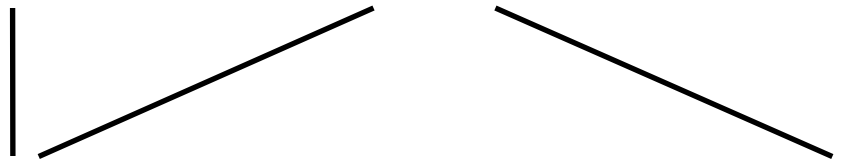
*Wiarton Willie*

The Wiarton Willie Festival held every February generates about $750,000 for the town. That makes Willie a powerful rodent.


0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
0.2
0.4
0.6
0.8
1
0.73
Δ $p_i$
(predicted change in frequency of the unbanded allele)
strong selection, low migration
medium selection, medium migration
weak selection, high migration
frequency of unbanded allele

# Population Subdivision

| | ***AA*** | ***Aa*** | ***aa*** |
|---|---|---|---|
| subpop. 1 | $(0.3)^2 = 0.09$ | 0.42 | $(0.7)^2 = 0.49$ |
| subpop. 2 | $(0.7)^2 = 0.49$ | 0.42 | $(0.3)^2 = 0.09$ |
| **Mean** | **0.29** | **0.42** | **0.29** |



frequ. A = 0.5 frequ. a = 0.5

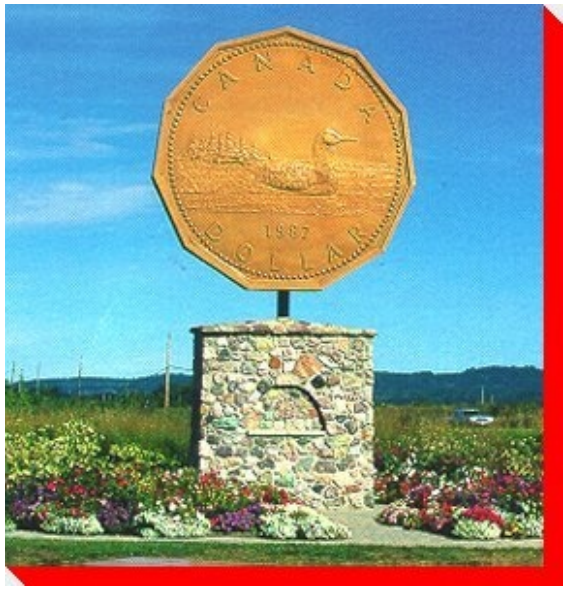
# *The Wahlund Effect*

| | ***AA*** | ***Aa*** | ***aa*** |
|---|---|---|---|
| Mean Observed | 0.29 | 0.42 | 0.29 |
| H-W Frequencies | **0.25** | **0.50** | **0.25** |

- a population with subdivision always displays a deficit of heterozygotes in the equilibrium calculation.
- occurs even though the two populations are themselves at equilibrium.

# Wahlund Effect Cont'd

- one needs to know the population structure before believing equilibrium frequencies.
  - *or, a deficit of heterozygotes may signal subdivision.*
- when two distinct populations fuse, the proportion of homozygotes declines.
  - fitness loss due to deleterious homozygous recessive variation (e.g., many genetic diseases) will decline.




# Genetic Drift

- toss a coin 10 times
- odds of a head = 0.5 / toss
- odds of 10 heads = $0.5^{10} = 1/1000$
- odds of 6 heads ≈ 1/5
- toss a coin 1000 times, the chance of flipping 600 heads is a very much smaller number.

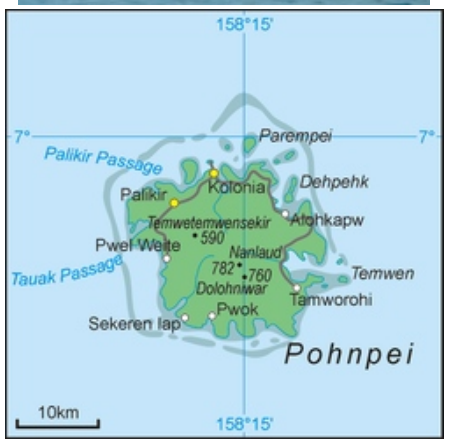
# The Founder Effect

- part one: a new population is established from a small number of colonizers or survivors.
- part two: their gene frequencies are unrepresentative of those in their predecessor population.
  - what is the chance a subsample of the originating population will *lose* an allele?

# The Founder Effect

- high frequencies of otherwise rare diseases in populations founded by small number of colonists.
  - achromatopsia (total colour blindness / rod monochromy)

    - recessive, occurs at frequency <0.0001 (carriers ≈ 1/200) -- a cone defect found on cVIII.




    - 5-10% occurence; carriers found > 30% in Pingelapese.
      - 3000 Pingelaps founded from 20 survivors of Typhoon Lengkieki in 1775.

- chance an individual founder is $AA = p^2$
- chance two individuals are $AA = (p^2)^2$
- chance $n$ individuals are $AA = (p^2)^n$
- chance of total homozygosity in founder population: $\mathbf{(p^2)^n+(q^2)^n}$

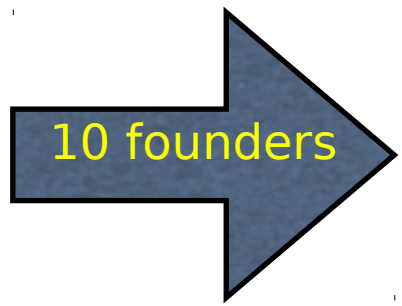
e.g., chance of losing an allele that has frequency of 10%:

- in founder population of 2: $(0.81)^2 = 0.64$
- in population of 10: $(0.81)^{10} = 0.122$
- in population of 20: $(0.81)^{20} = 0.015$

# Many alleles

- The odds of fixing any single allele by drift are simply its $(\text{frequency}^2)^N$
- The probability of losing any allele will be the sum of the other individual fixation probabilities.

| Alleles |
| --- |
| 1 @ 0.6 |
| 2 @ 0.3 |
| 3 @ 0.1 |




probability of losing allele 1 is $(0.4^2$

$= 1 \times 10^{-8}$

probability of losing allele 3 is $(0.9^2$

$= 0.122$

# General Consequences

- chance of losing a common allele very small, even with a strong bottleneck.
- drift is adirectional.
- chance of changing gene frequencies very large.
  - Dutch Afrikaaners arrived in S. Africa in 1652 on one ship.
  - 50% of current 2.5 million population have 20 names traceable to that ship. 1/3 white South Africans descended from 40 founders.
  - Huntington's Disease, Porphyria variegata at extremely high frequencies.

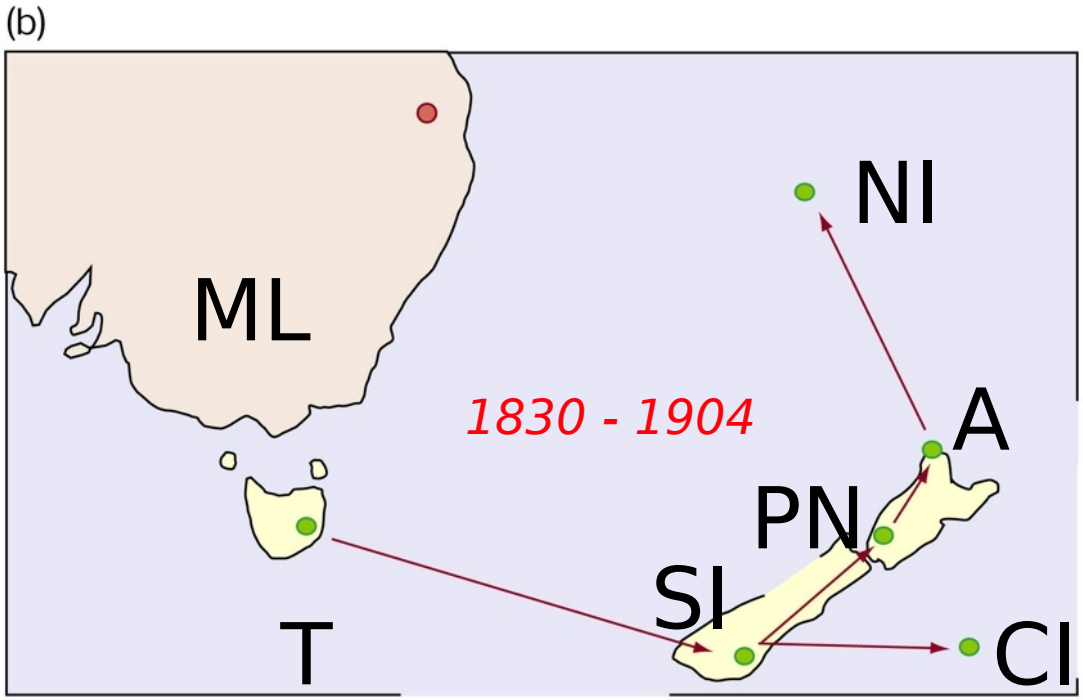
*>8000 cases alone traceable to Gerrit Jansz (settler) or Ariaantje Jacobs (wife)*

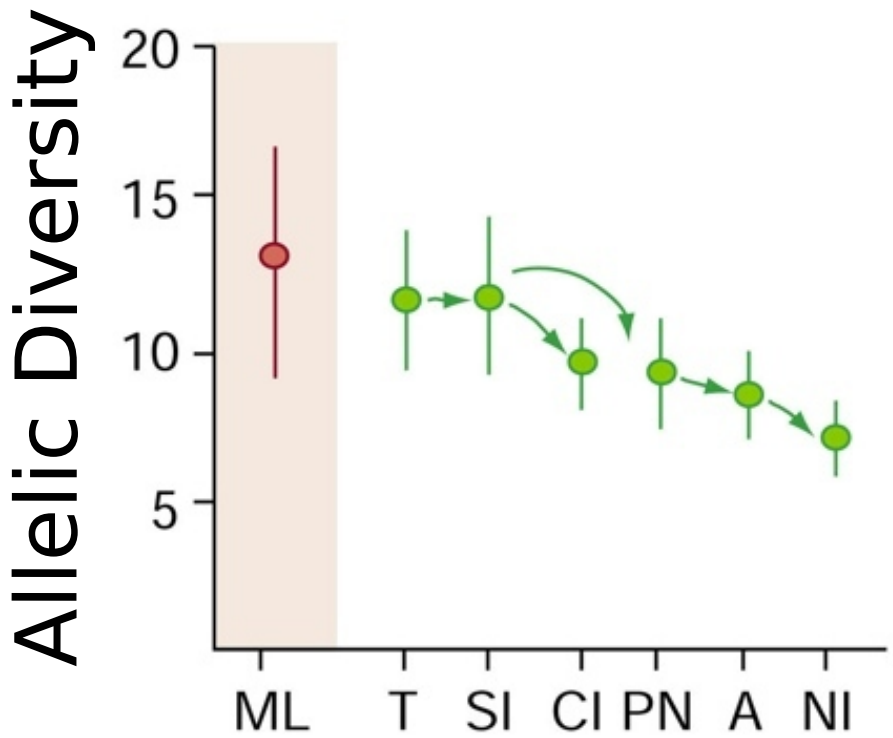
# Measures of Diversity

## Components of Heterozygosity

1. Allele Richness: the average number of alleles per locus in the genome.
2. Genetic Polymorphism: the fraction of loci in the genome with 2+ alleles at frequency of >0.01.

- chance of losing some rare alleles is high



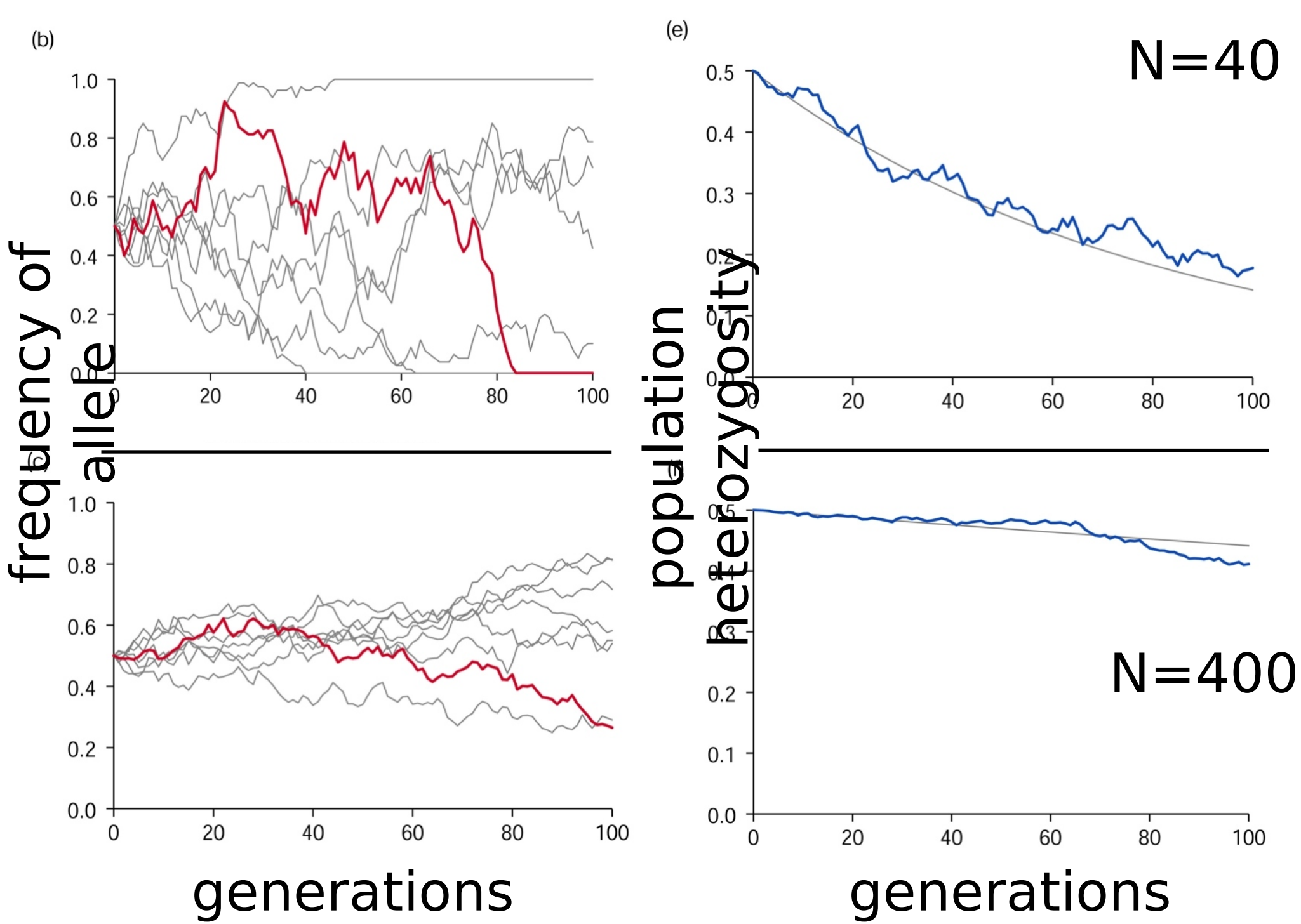



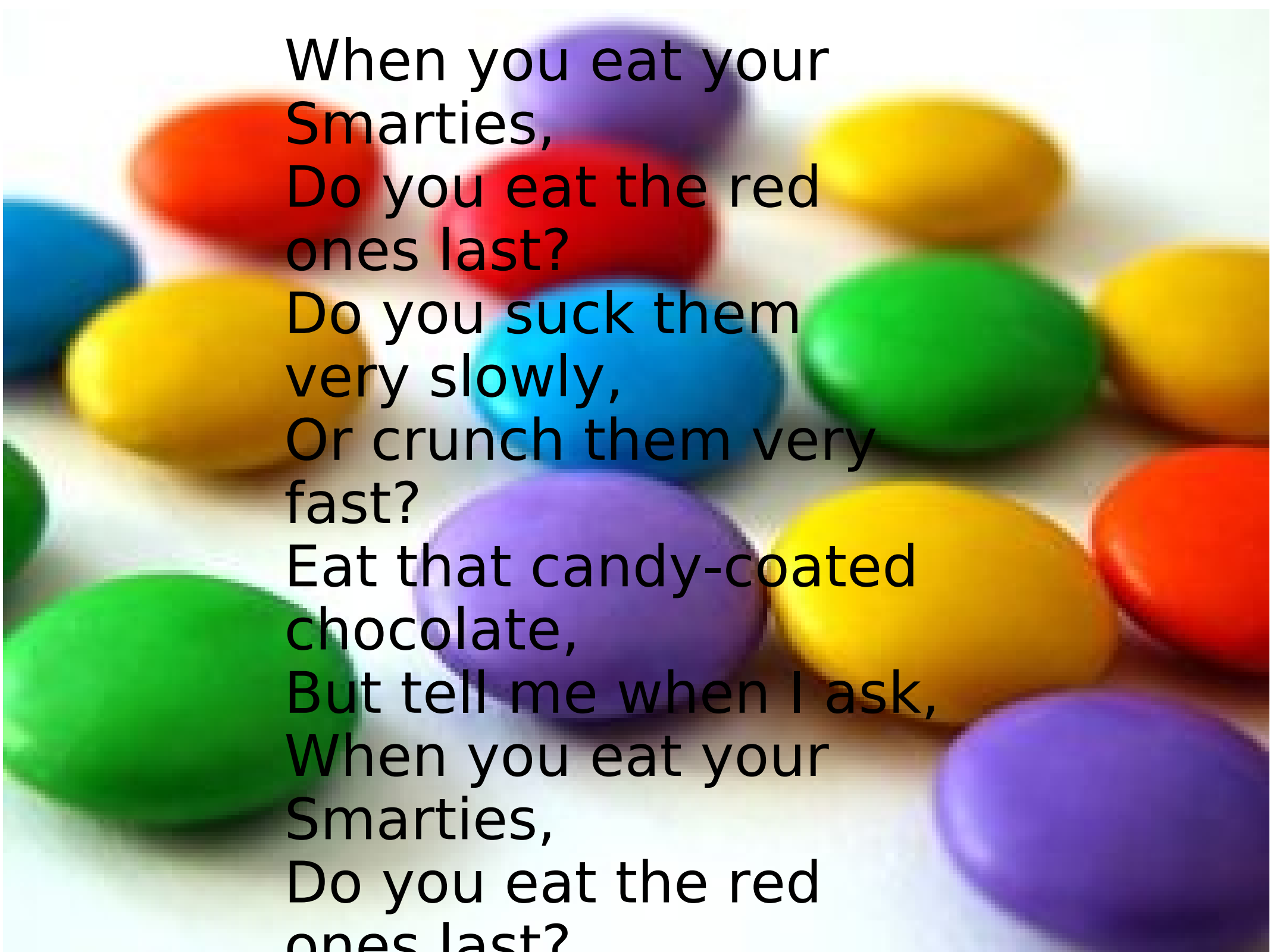
# Fixation by Drift

- drift is integrally related to population size.
- due to drift alone, the chance of an individual copy of a gene fixing is **1/2N** (if population is diploid).
- assuming there are multiple copies of the same gene (allele) then the probability of an allele fixing is: **its copy number / 2N.**

# It follows that...

- sooner or later one allele will fix due to selection or drift.
- heterozygosity -- the frequency of heterozygotes -- will decline with time.
- by drift, the number of heterozygotes in the next generation will be **H* {1-1/2N}**


(b)
(e)
N=40
N=400
frequency of allele
population heterozygosity
generations
generations


When you eat your
Smarties,
Do you eat the red
ones last?
Do you suck them
very slowly,
Or crunch them very
fast?
Eat that candy-coated
chocolate,
But tell me when I ask,
When you eat your
Smarties,
Do you eat the red
ones last?


# Smarties Trivia

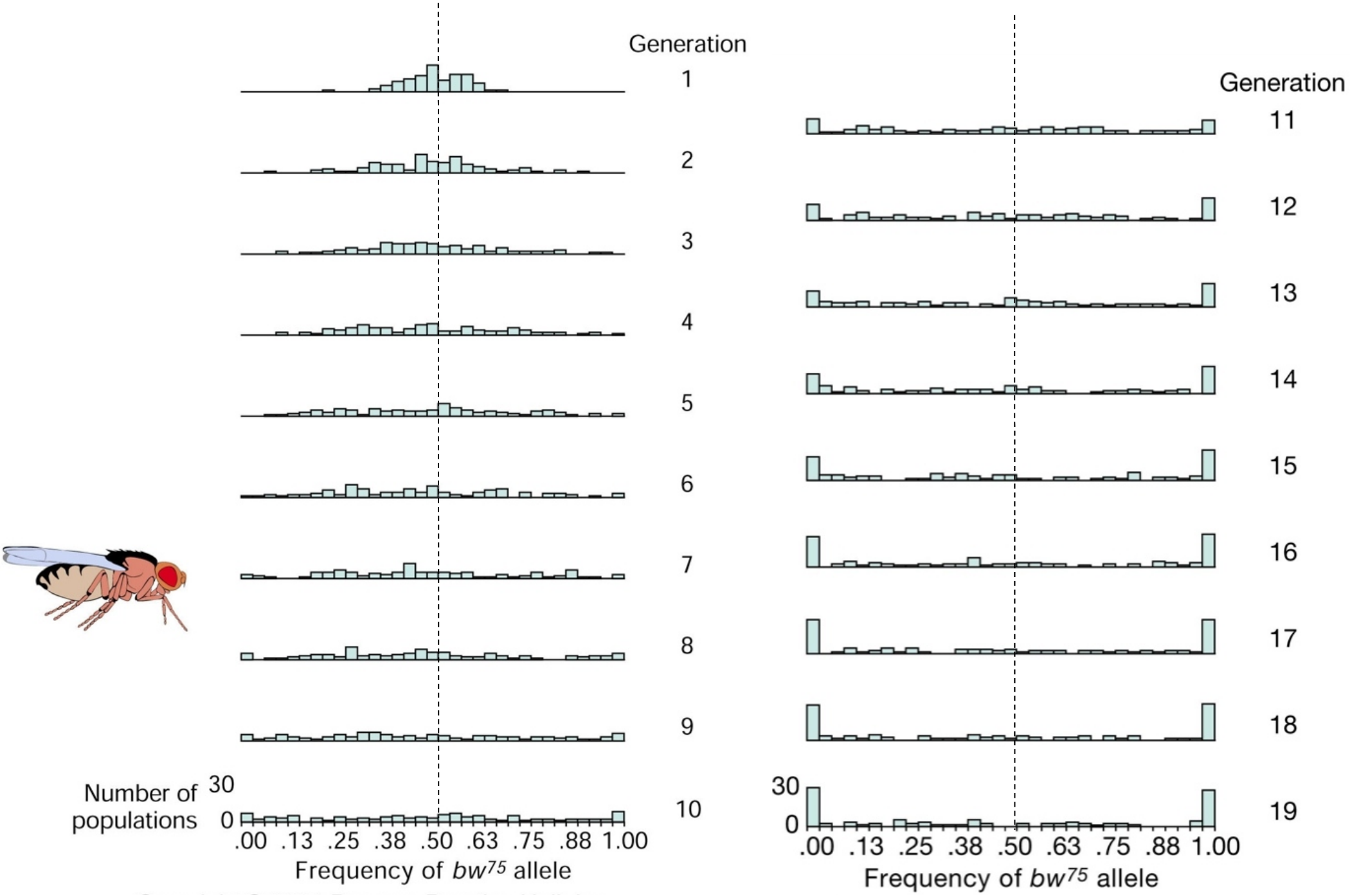
- 1937 “Chocolate Niblet Beans” Rowntree of York introduced.
- Light brown replaced by blue in 1989.
- Both orange and light brown Smarties’ chocolate flavoured in UK (never in Canada).
- 570,000 tubes  / day (48/box; UK)
- over 300 tubes consumed every minute in UK.
- Nestlé claims that Canadians eat enough Smarties each year to circle Earth 350x.
- On 25 October, 2003, Kathryn Ratcliffe set a Guinness World Record by eating 138 Smarties in three minutes using chopsticks.

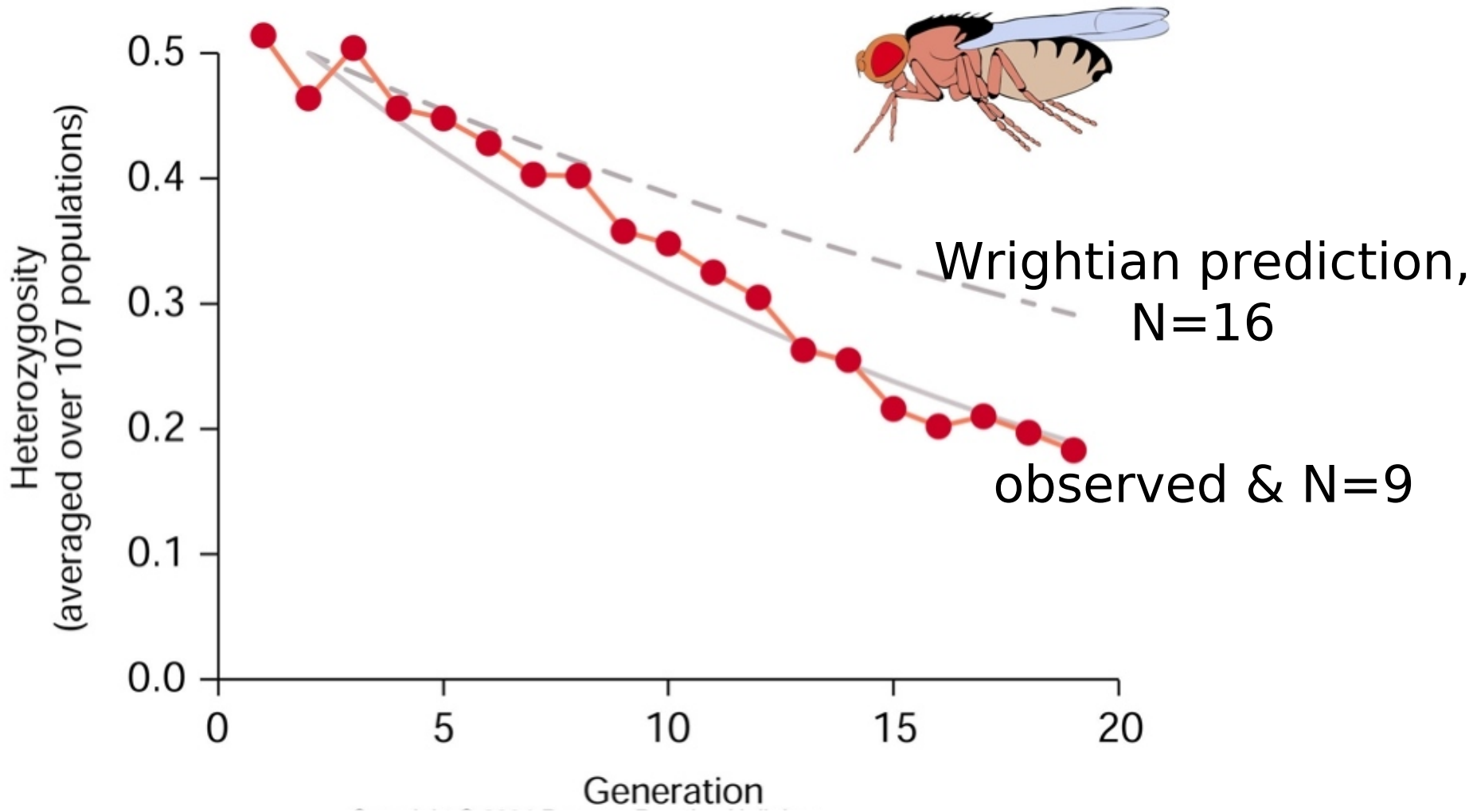
# Assignment

- Collect genotype frequency data for a population of Smarties
  - count each of seven morphs (red, yellow, orange, brown, green, purple, blue)
  - count any mutant Smarties with unusual phenotypes and note with email
  - email genotype frequency to me for computation of estimated global genotype frequencies.
  - eat Smarties (red ones last)

# Buri's Drift Exp't

- founded 107 populations of *D. melanogaster* with 8 pairs each.
- all founders heterozygous for $bw^{+}/bw^{75}$
- no known (or measured) fitness effect of alleles.
- ran experiment for 19 generations.


Generation
1
2
3
4
5
6
7
8
9
10
Generation
11
12
13
14
15
16
17
18
19
Number of populations
30
0
.00 .13 .25 .38 .50 .63 .75 .88 1.00
Frequency of bw75 allele
30
0
.00 .13 .25 .38 .50 .63 .75 .88 1.00
Frequency of bw75 allele




A population's EFFECTIVE SIZE is never as large as its census size.

# Effective Population Size

- The number of individuals in an idealised population that shows the same magnitude of drift as the real population.
- populations are genetically never as large as their census size.
- differences in survival and repro success lead to unequal contributions of gametes to next generation.
  - variance in male mating success may be particularly high.
- skewed sex ratios strongly affect $N_e$

# Calculating $N_e$

a crude* approximation of effective size is given by:

$$N_e = (4N_m * N_f) / (N_m + N_f)$$

*this is approximate because relative fitness is not estimated.

# Sexual Selection & $N_e$

- a population with 100 breeding males and 900 females has an effective size of 360.
- in lekking species or those with extreme dominance heirarchies, whole social groups of females may mate with the same male.

$$N_e = (4N_m * N_f) / (N_m + N_f) \approx 4$$

note: this calculation assumes only one round of breeding and no migration between groups.

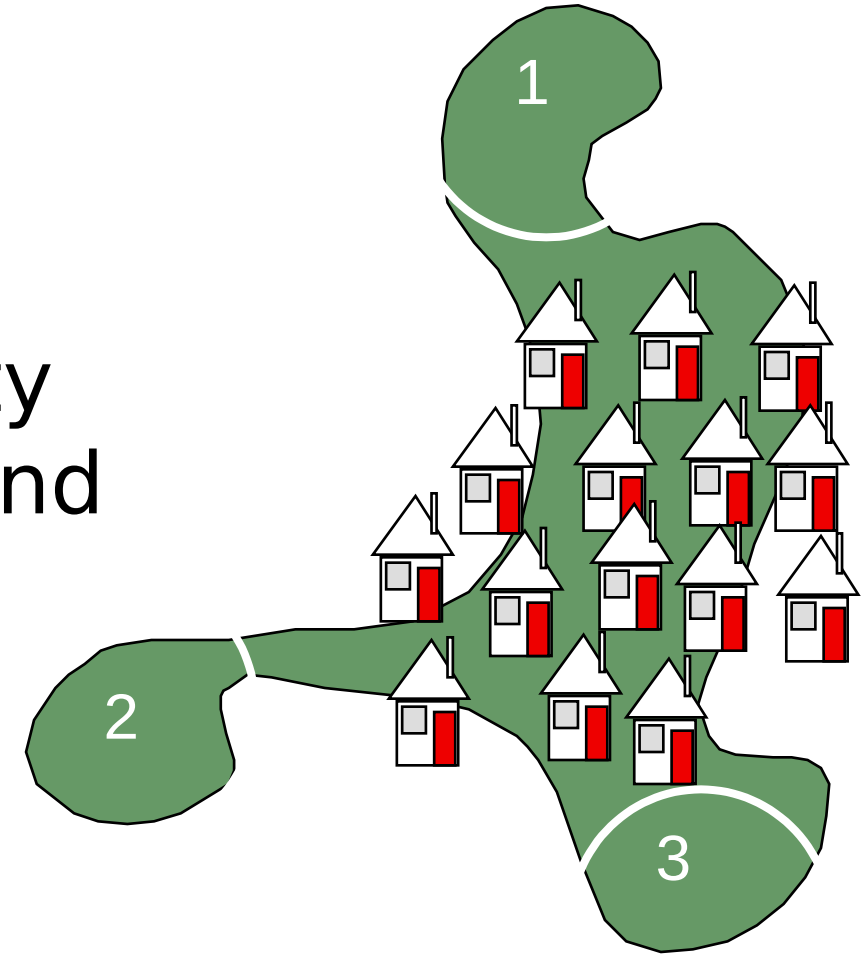
# $N_e$ and population fluctuation

- effective population size is extremely sensitive to population bottlenecks
- calculated based on *Harmonic mean*

(do not worry about how to calculate this!)

# Drift is often the product of reduced gene-flow

- when populations become fragmented, interrupted gene flow will often lead to:
  - increased homozygosity via drift and the Wahlund Effect.
  - inbreeding depression
  - reduced adaptability
    - less variation to resist environmental challenges, disease, parasitism.



# Measures of Diversity

## Components of Heterozygosity

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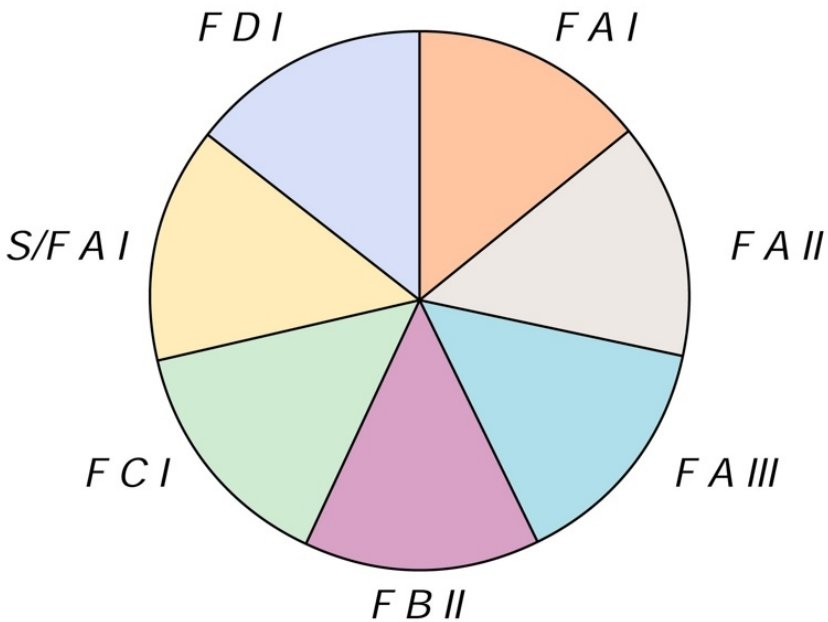
# Collared Lizards

- Relict populations in the Ozark Mountains
  - occupy small glades  (remnants of SW deserts) that were once isolated by savannah lands.
  - savannahs burned periodically.
- human intervention:
  - clear cutting & fire extinguishing
    - allowed oak-hickory forest to take over.
    - allowed red cedar to grow into glades.

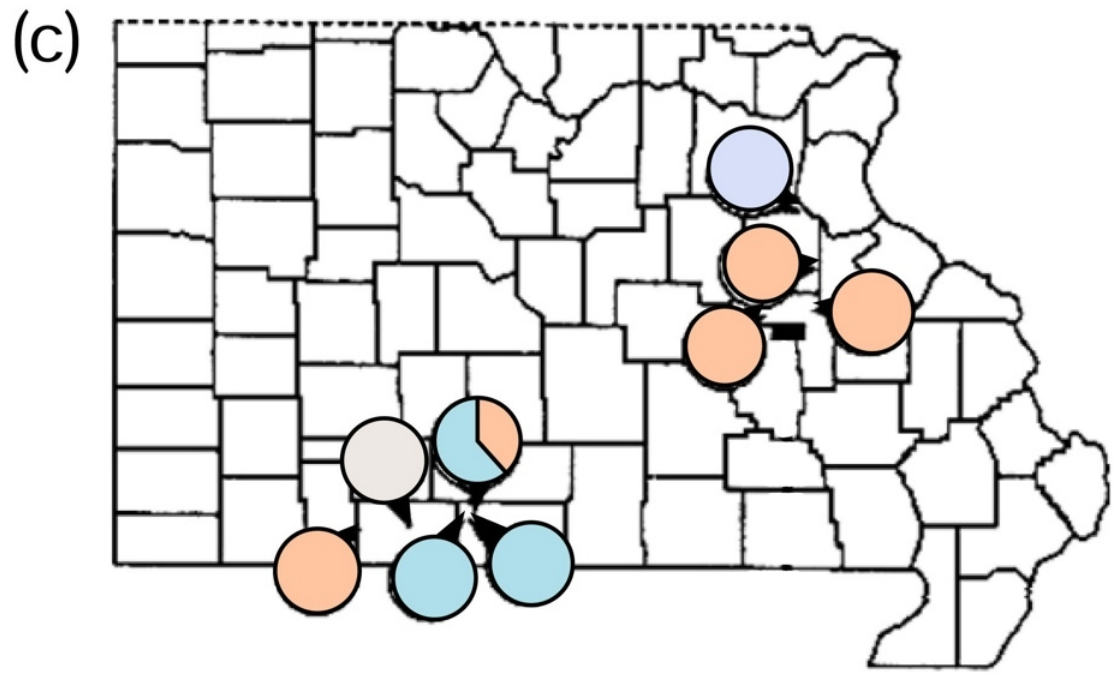
# Ozark Collared Lizards



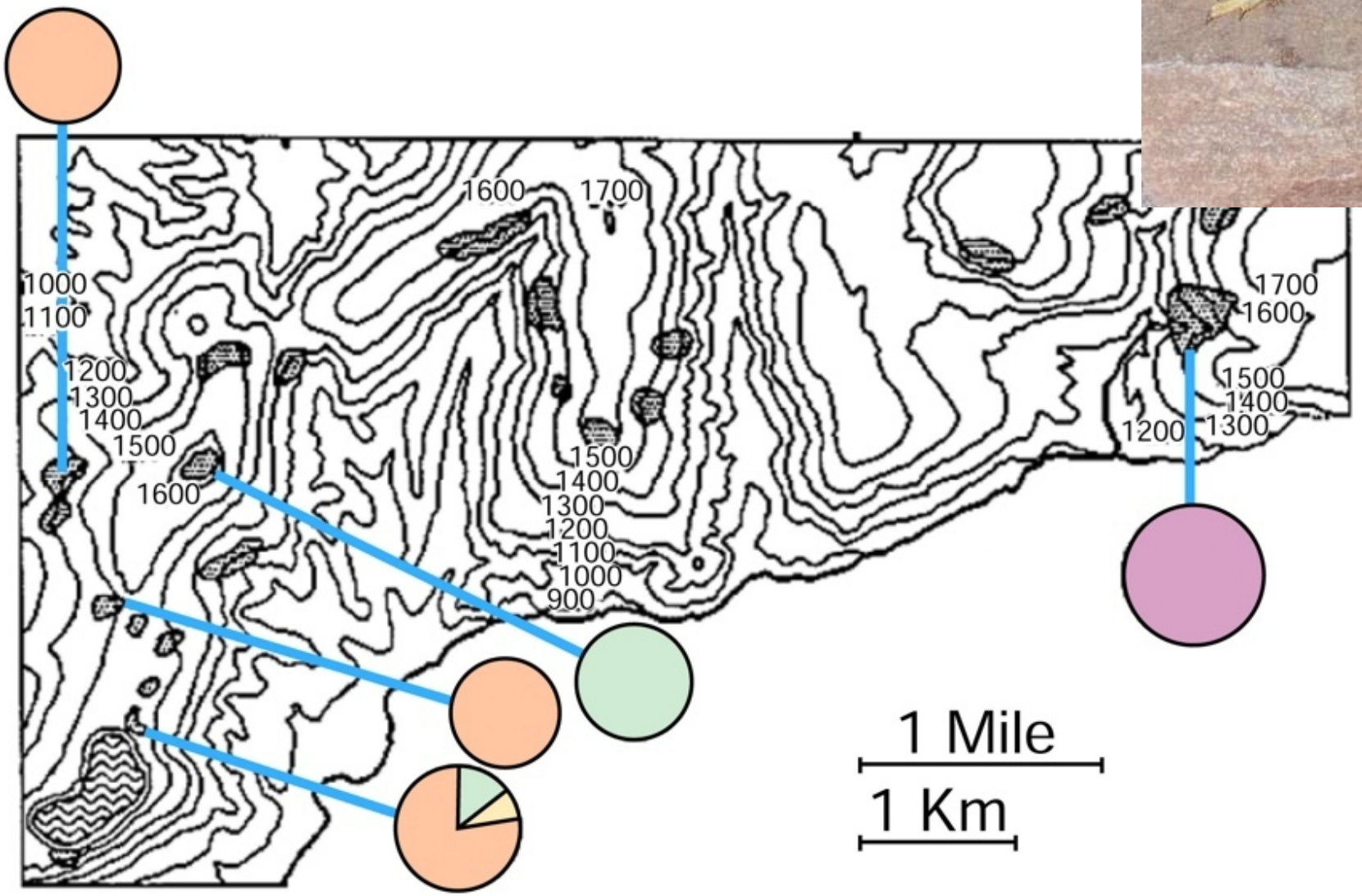

MDH allele *(s/f)*

mt DNA *(a-d)*

r DNA *(i-iii)*



# Habitat Fragmentation in Glade Populations



# Perils of Fragmentation

- Occupants of any given glade genetically homogeneous
  - unable to adapt to further changes in the environment
  - sitting ducks for diseases
  - ever more sickly due to inbreeding depression.
- Remediate via restoration of empty glade populations, creation of migration corridors with controlled burns.

# Wright's F statistics

(Has nothing to do with the F statistics used in ANOVA)

F (Fixation index) = the reduction in heterozygosity expected with random mating at any one level of a population heirarchy, relative to another more inclusive level.