Genetic Drift

Random genetic drift

- A violation of Hardy-Weinberg Principle
- Hardy-Weinberg conditions assume an infinitely large population size
- Genetic drift is a random sampling process that operates when population size is finite
- The evolutionary effects of genetic drift increase as population size decreases
- Important for conservation biology given small and fragmented populations

Isolating genetic drift: An ‘ideal’ population

- A simplified reference population in which gene frequency change within and among population subdivisions is due solely to genetic drift.
- An idealised population meets the HW conditions of no evolution *except* for the inclusion of genetic drift.
- Genetic drift is included into the model by allowing for finite, as opposed to infinite, population sizes.

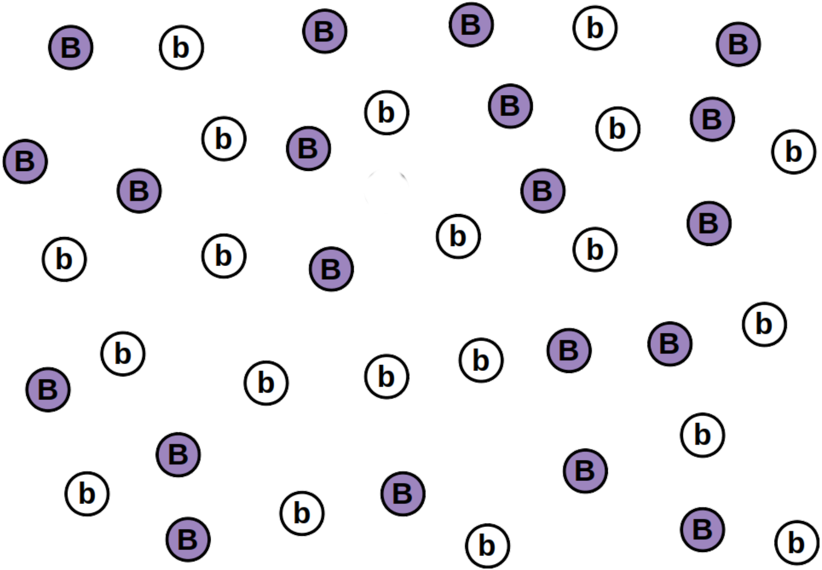
In an idealised population, genetic drift will be the only evolutionary force affecting gene frequency change.

Ideal population assumptions

1. Finite population size (i.e., genetic drift can operate).
2. No selection at any stage in the life cycle.
3. No mutation.
4. No migration.
5. Mating occurs at random within population subdivisions.
6. Discrete, non-overlapping generations.
7. The number of breeding individuals is constant over population subdivisions and constant over time.

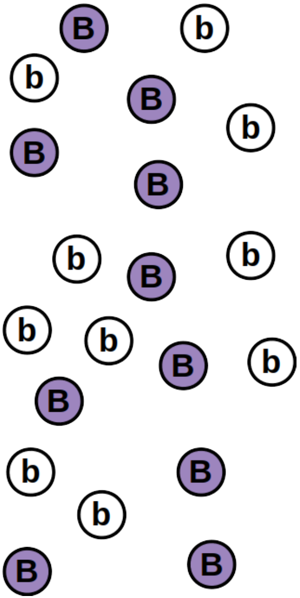
Assumption 7 permits extension of the typical HW conditions to multiple populations and generations.

Chance events can alter allele and genotype frequencies



Chance events can alter allele and genotype frequencies

- 20 B alleles and 20 b alleles
- $\Pr(B) = 0.5$ & $\Pr(b) = 0.5$
- Might expect next generation to also be 50% B alleles?
- But **probabilities can change in 1 generation due to chance sampling**
- By chance, due to finite population size, could get a bit more than 50% B or b



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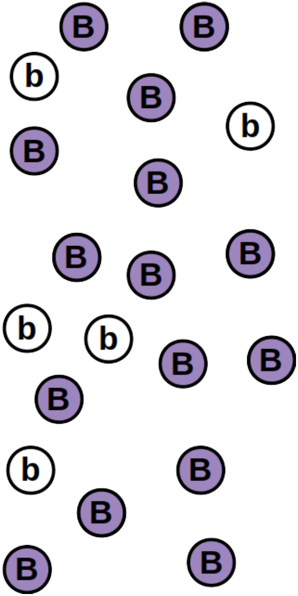

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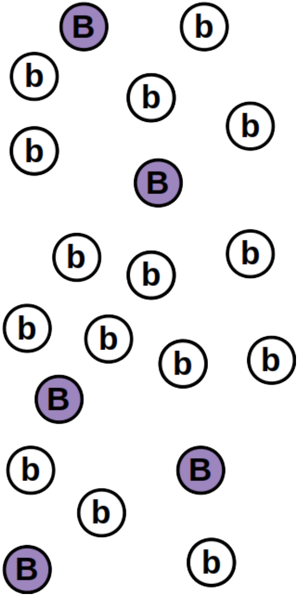

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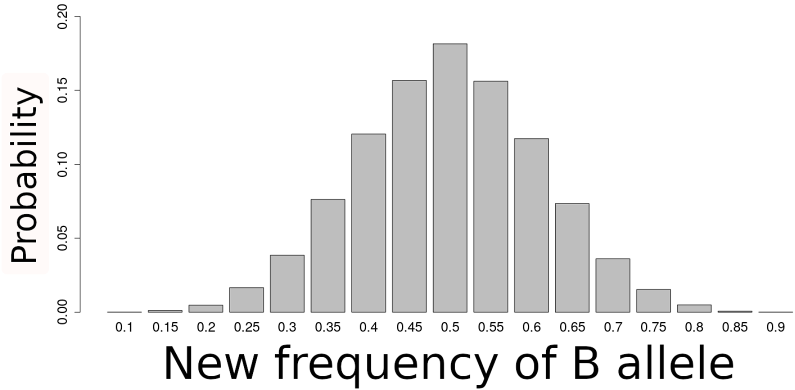
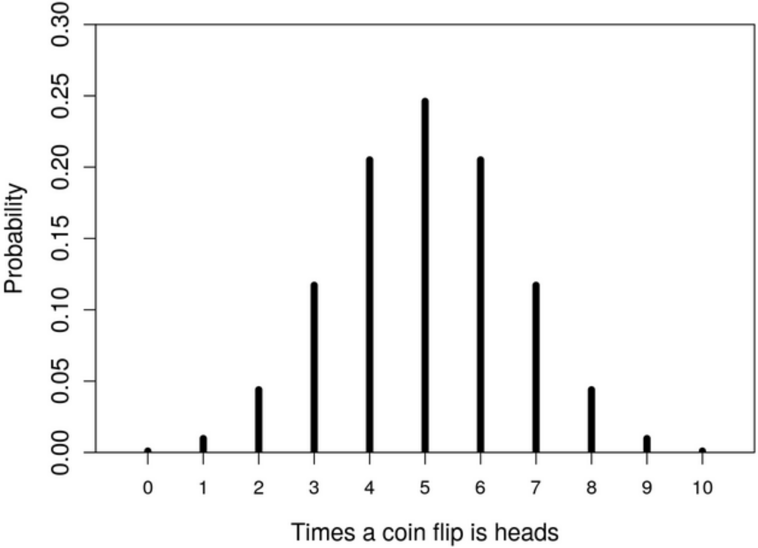


If sampling 20 alleles at random, then Pr(B) = 0.5 only about 18% of the time!

Chance events can alter allele and genotype frequencies



Probability of a fair coin landing heads N times after 10 flips.

An important distinction

- **Natural selection** is genotype-specific differential survival or reproductive success that happens for a reason.
- **Genetic drift** is differential survival or reproductive success that just happens by chance

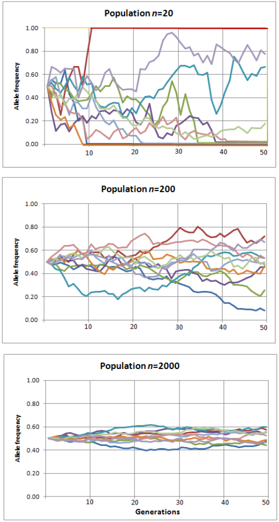
Mathematical relationship between genetic drift and population size

$$\Delta p \approx \frac{p\,(1-p)}{2N}$$

- Δp is the per generation change in allele frequency
- N is the size of an ideal population

Allele frequency change due to drift over time

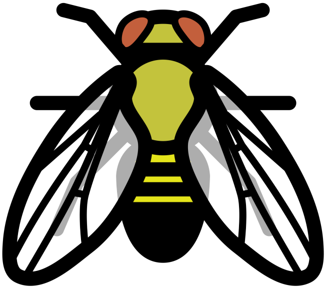
- Allele frequencies change more at low population size
- Can lead to extinction or fixation of alleles
- Reduces genetic diversity
- Decreases heterozygosity
- Can decrease the fitness of small populations



[1]Image: Professor Marginalia, CC BY-SA 3.0.

The Buri Experiment: Genetic drift in action

- *Drosophila melanogaster*
- 107 experimental populations
- N = 16 flies per population
- Eye colour alleles *bw* and bw^{75}
  - Initially in equal frequency
  - Not under selection
- 19 generations of genetic drift

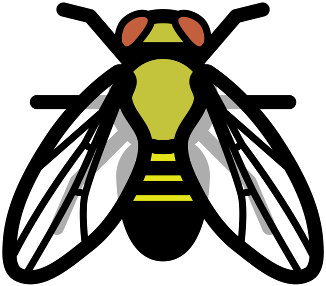


[1] Buri, P. (1956). Gene frequency in small populations of mutant *Drosophila*. *Evolution*, 367-402. [Link]

[2] Image: Public Domain.

The Buri Experiment: Genetic drift in action

- Will genetic drift be high or low?
- What will happen to genetic variation?
- Will some alleles go extinct, or to fixation?



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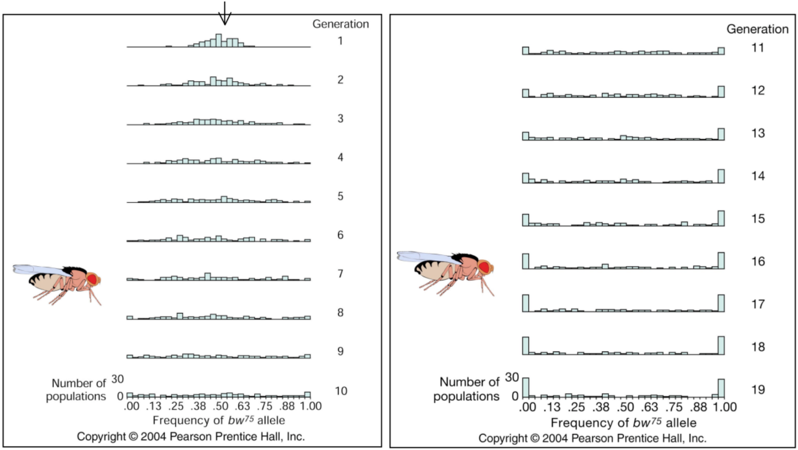

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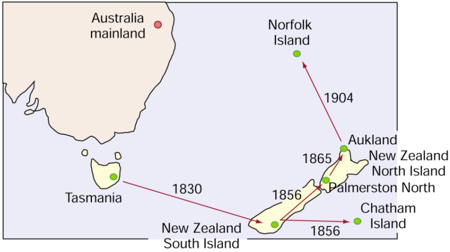
[2] Image: Freeman S. & Herron J. C. (2004). *Evolutionary analysis*. Pearson Prentice Hall.

The founder effect

When a small number of individuals found a new population or colonize a new habitat, the allele frequencies of this new small population are likely, simply by chance, to be very different from that of the larger population from which the founders were sampled. This is called the founder effect.

- A form of genetic drift
- Sampling process in which gene frequency change results due to the sampling of a finite number of individuals to form a new population.

The founder effect in the Silvereye, *Zosterops lateralis*



[1]Clegg, S. M., Degnan, S. M., Kikkawa, J., Moritz, C., Estoup, A., & Owens, I. P. (2002). Genetic consequences of sequential founder events by an island-colonizing bird. *Proceedings of the National Academy of Sciences*, 99:8127-8132. [Link]

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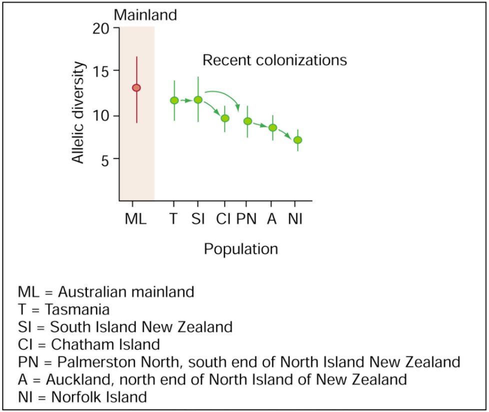
The founder effect in the Silvereye, *Zosterops lateralis*

Allelic diversity at six genetic marker loci has declined allong the silvereye's route of travel.



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Random genetic drift

- Causes allele frequency change from one generation to the next
- Increases genetic differentiation among populations
- Decreases allelic diversity
- Increases homozygosity and inbreeding
- Decreases levels of heterozygosity

Effects of genetic drift are elevated in small populations, making it especially relevant for conservation biology.