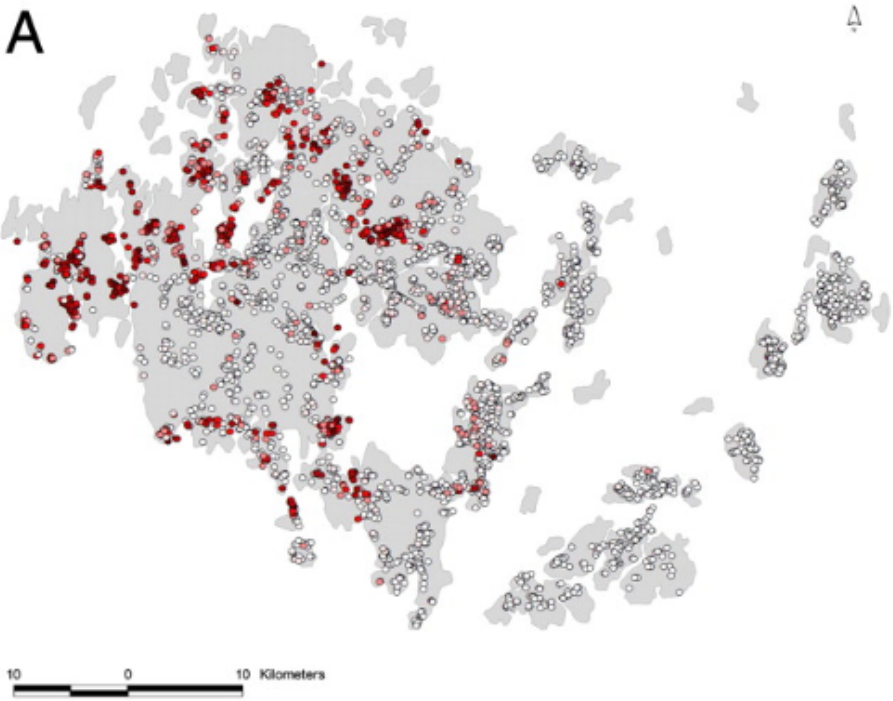
Population structure

BIOL 434/509

Most species are spread out over space, either continuously or separated into local discrete populations.

Local population = **subpopulation** = **deme**: various terms used to indicate a local collection of individuals somewhat separated from other members of the same species.



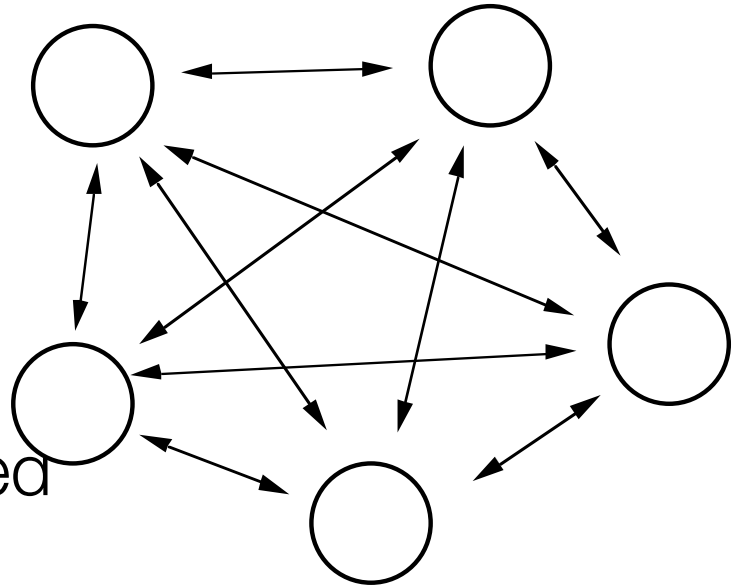
Variance in allele frequency

Allele frequencies can vary over subpopulations over space, because of genetic drift or local selection. Described by F_{ST}.

Dispersal between populations (sometimes called migration) helps to homogenize allele frequencies over space.

(When dispersal leads to offspring of migrants successfully establishing within the recipient population, this is called gene flow.)

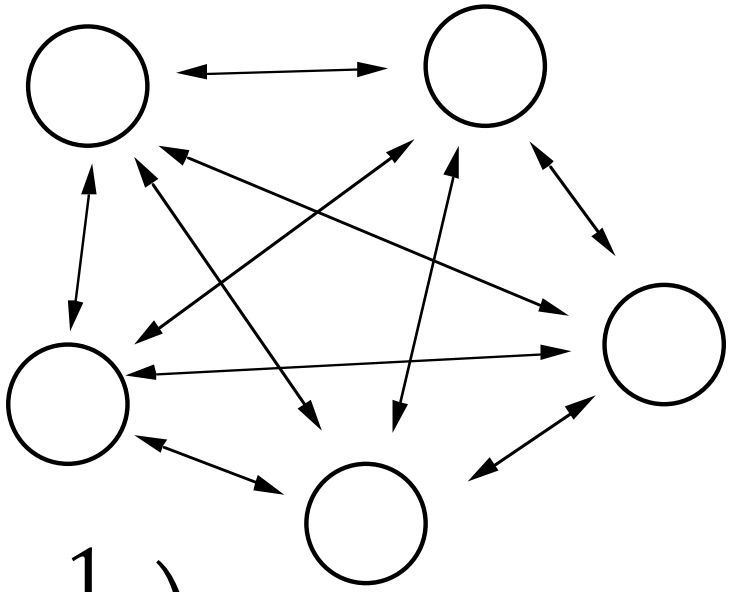
The island model



All subpopulations are the same effective size N_e, and all subpopulations are equally connected to all other subpopulations by gene flow.

Each subpopulation replaces a fraction *m* of its members each generation with migrants from other subpopulations, and these migrants come from any other subpopulation with equal probability.

The island model



$$F'_{ST} = \frac{1}{2N_e} + (1-m)^2\left(1-\frac{1}{2N_e}\right)F_{ST}$$

$$\hat{F}_{ST} = \frac{1}{(2N_e)(1-(1-m)^2)\left(1-\frac{1}{2Ne}\right)}$$

$$\cong \frac{1}{4N_e m+1}$$

Wright's distribution

The distribution of allele frequencies in an island model at equilibrium is:

$$\psi(p) = C\, p^{4N_e\mu+4N_em\bar{p}-1} q^{4N_e\nu+4N_em\bar{q}-1} \overline{W}^{2N_e}$$

$\bar{p}$ and $\bar{q}$:average allele frequencies over all populations

μ :mutation rate from *A* to *a*

ν is the mutation rate from *a* to *A*

$\overline{W}$ is the mean fitness of the subpopulation (likely a function of *p* itself),

C is a renormalization constant:

$$C = \frac{1}{\int_0^1 p^{4N_e\mu+4N_em\bar{p}-1} q^{4N_e\nu+4N_em\bar{q}-1} \overline{W}^{2N_e} dp}$$

Wright's distribution

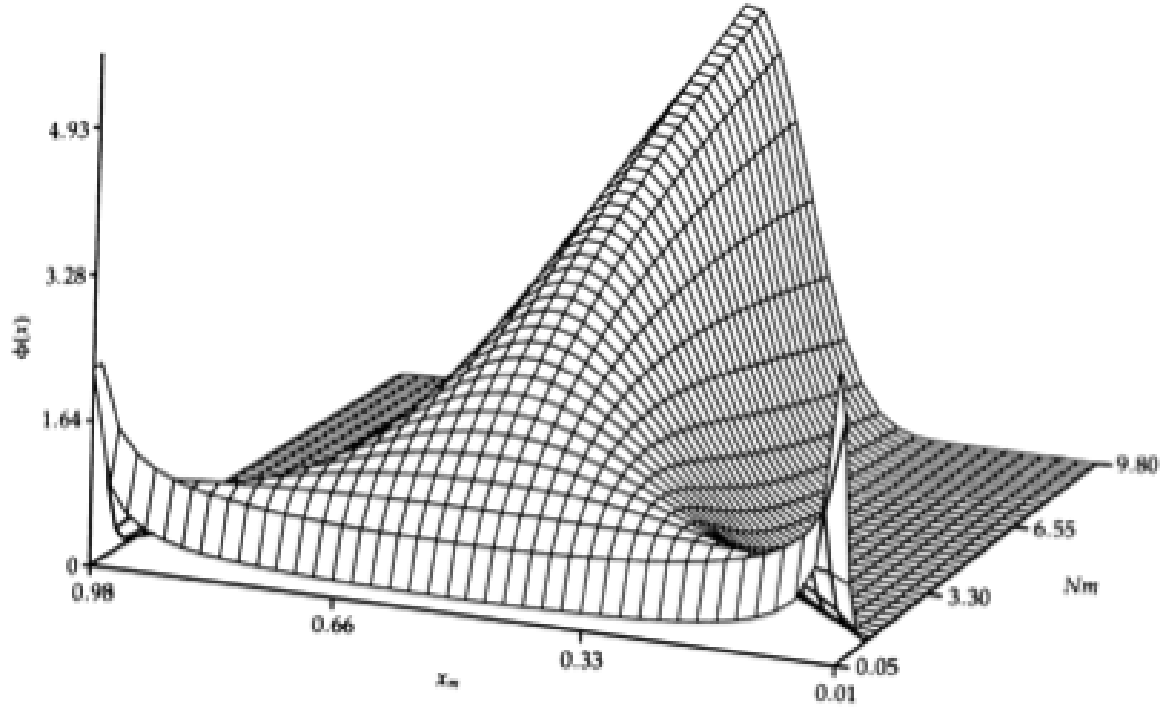
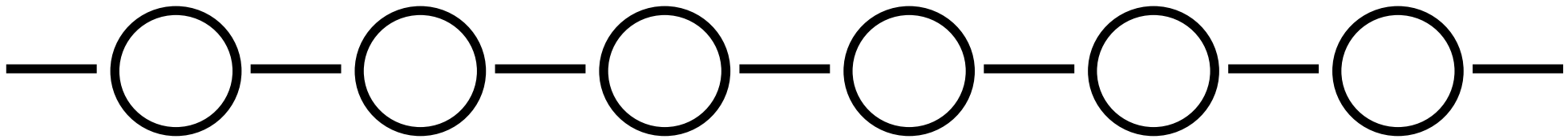


Figure 16. Wright's island model. The solution to the diffusion approximation (Equation 6.26) gives $\phi(x)$, the proportion of populations having allele frequency x, for a range of levels of migration Nm. With very low levels of migration, most populations are near fixation, but with high levels of migration (where migrants have an allele frequency $x_m = 0.5$), the populations tend to have intermediate allele frequencies.

Isolation by distance

Isolation by distance: subpopulations that are more physically distant exchange fewer migrants than do more close populations.

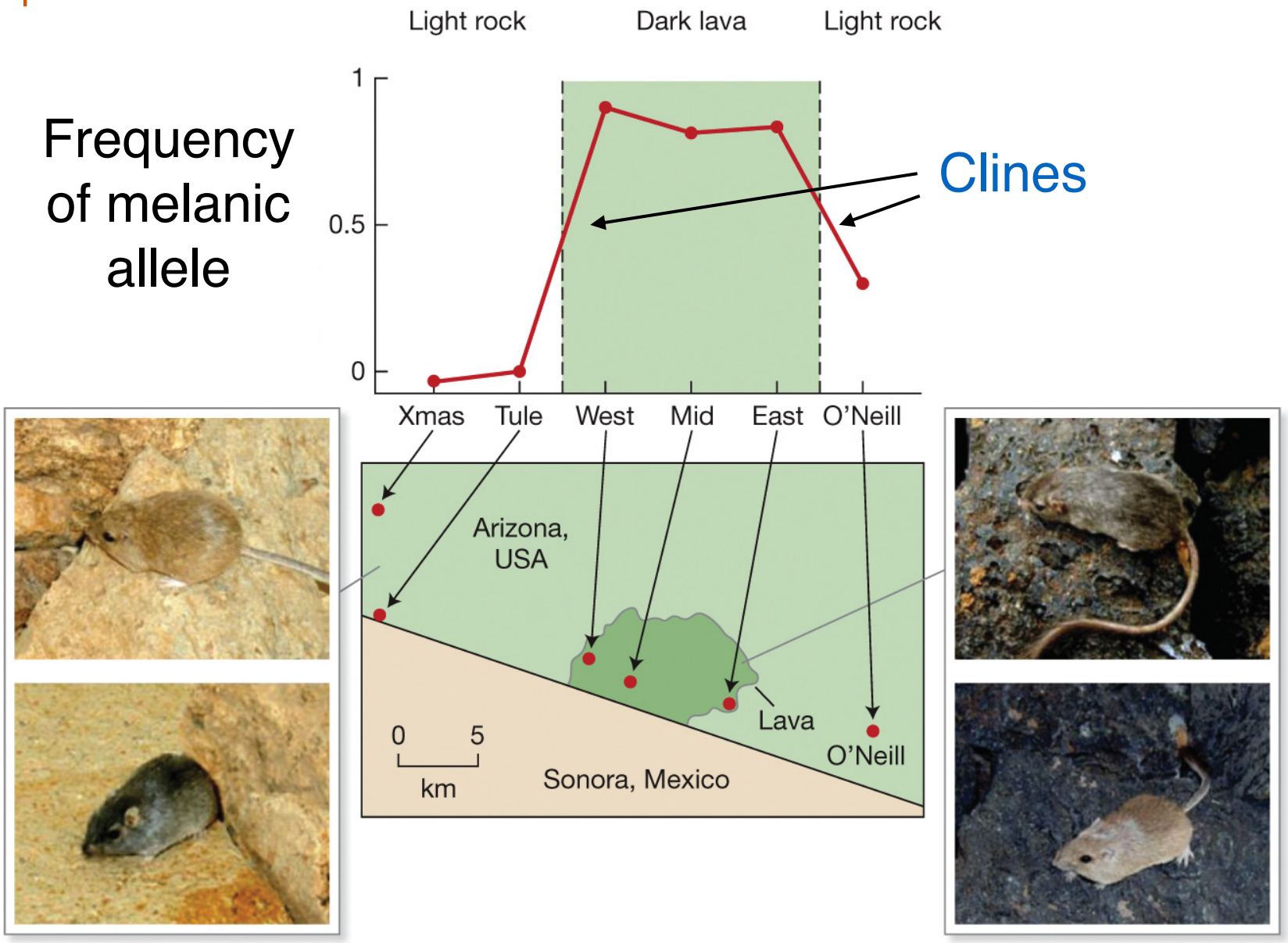
With isolation by distance, populations that are physically closer are likely to be more genetically similar.



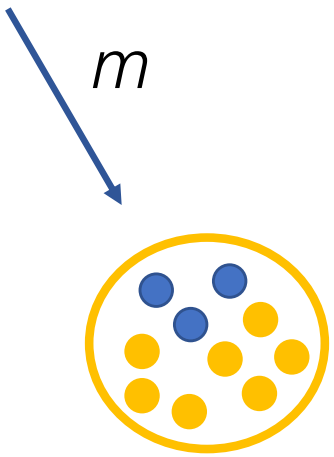
Selection in space

Local adaptation: When a population is better adapted to its local environmental conditions than to conditions elsewhere

Rock pocket mice



Migration–selection balance



Track the allele that is adaptive on the island in a haploid population.

$$p' = (1 - m)(p\frac{w}{\bar{w}})$$

Then at equilibrium between migration and selection:

$$\hat{p} \cong 0 \; if \; s = 0$$

or

$$\hat{p} \cong 1 - \frac{m}{(1 - m)s}$$