Genetic Diversity

Preview

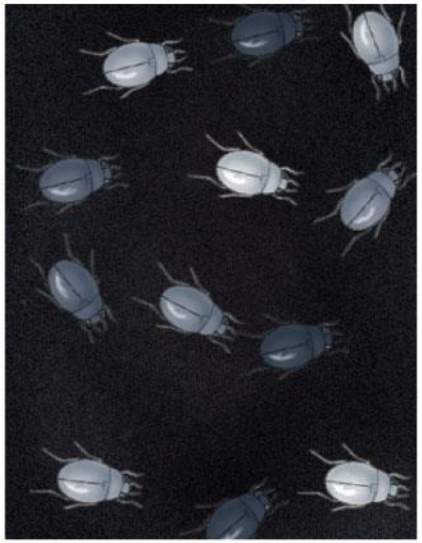
1. What is Genetic Diversity?
2. Measuring Genetic Diversity
3. Genetic Diversity Loss

1.

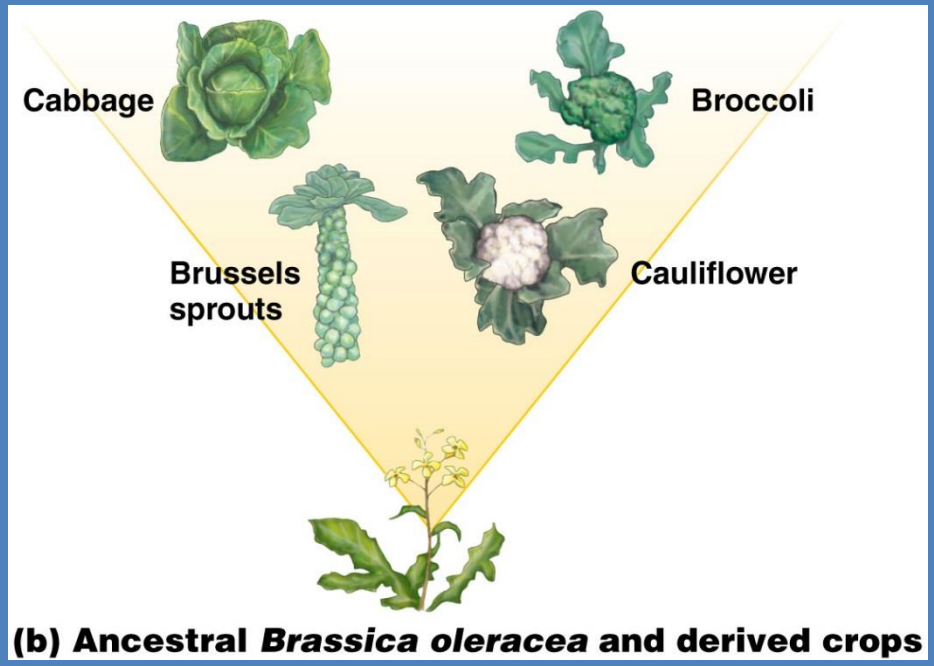
What is Genetic Diversity?

- Differences in DNA type and/or expression among:
  - Individuals
  - Populations
  - Communities
  - Ecosystems

1.



1 **Population with varied inherited traits**



Withgott and Laposata 2012

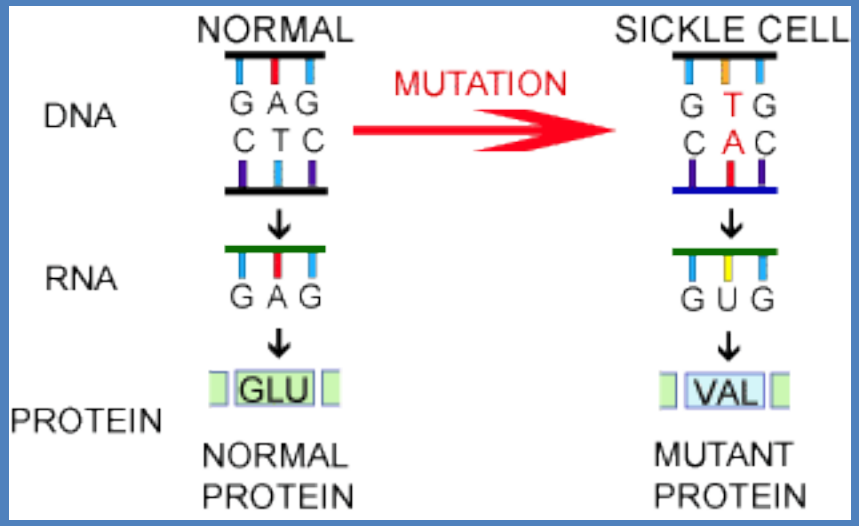
Reece et al. 2014

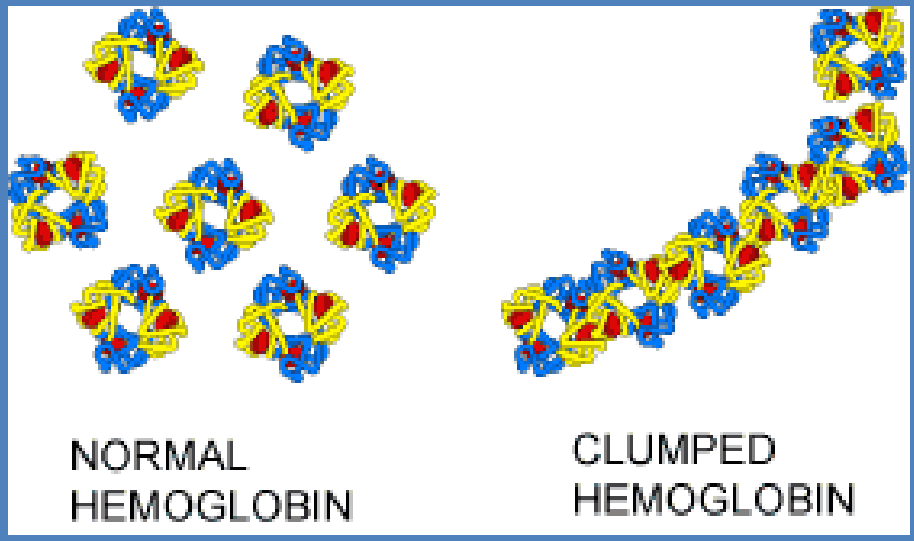
www.dogbreedsfact.com

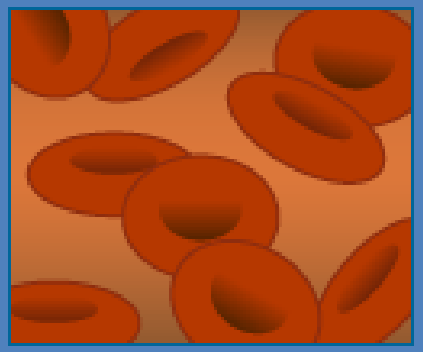
Measuring Genetic Diversity

- Sickle-cell trait
  - Gene provides instructions for making hemoglobin
  - Two types
    - normal instructions; normal hemoglobin; normal blood cells (S)
    - Abnormal instructions; abnormal hemoglobin; sickle-shaped blood cells (s)

2.







evolution.berkeley.edu

2.

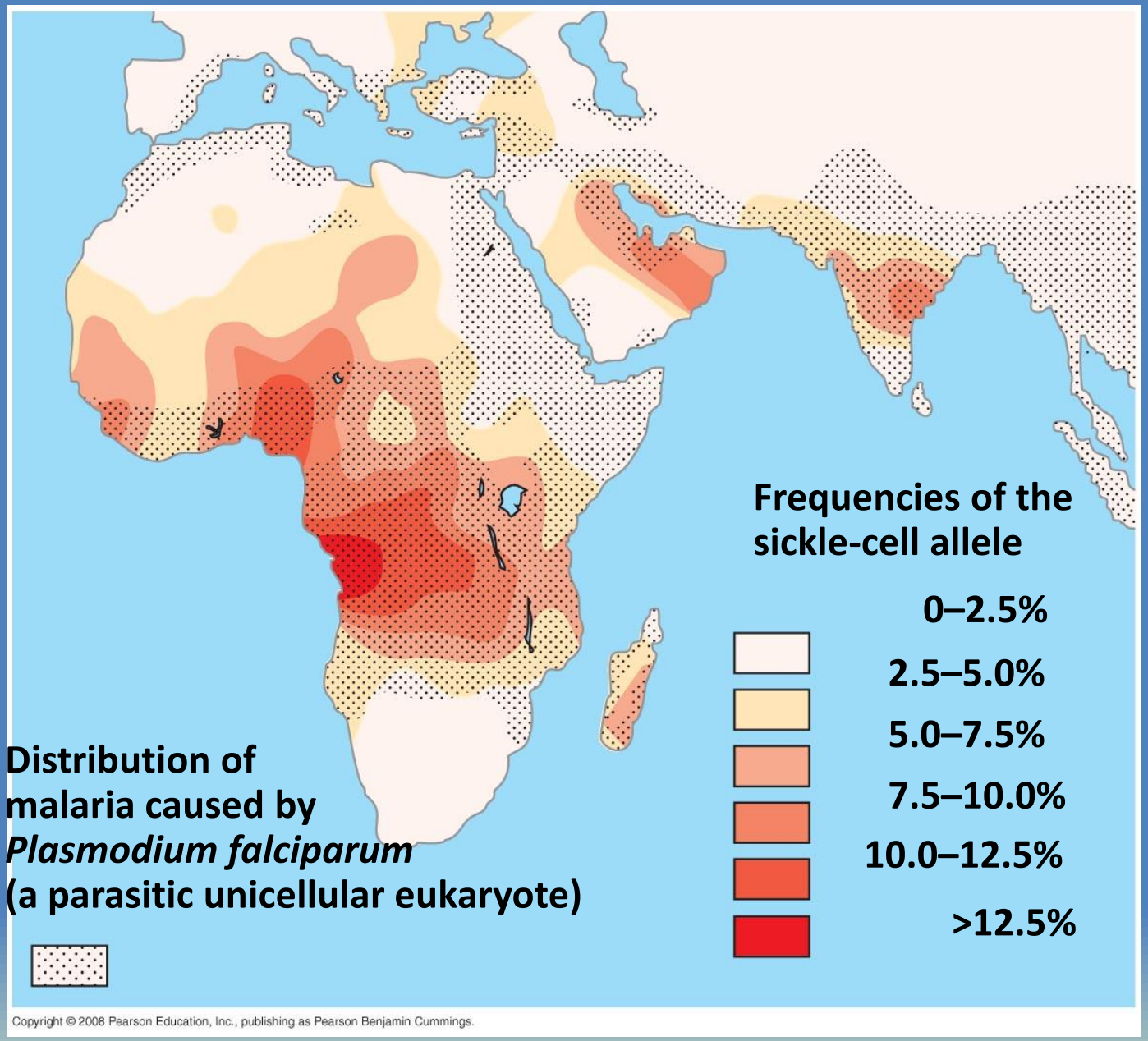
Measuring Genetic Diversity

- Sickle-cell anemia cont'd
  - Genetic combinations
    - 2 normal (SS) → healthy
    - 2 abnormal (ss) → early death
    - 1 normal, 1 abnormal (Ss) → no symptoms of disease

2.

Correlation between:

1. Distribution of sickle-cell gene
2. Distribution of malaria



Reece et al. 2014

2.

Measuring Genetic Diversity

- Knowing genetic diversity allows us to understand
  - Patterns of natural selection
  - Probability of disease
  - Status of local vs. global populations

2.

Measuring Genetic Diversity

- Two important measures
  - Polymorphism
  - Heterozygosity
- Measurement usually involves indirect methods
  - E.g., electrophoresis

2.

Measuring Genetic Diversity

- Polymorphism (P)
  - Proportion of genes that are polymorphic
  - Measure frequency of most common allele
    - Below 95% = polymorphic
    - At or above 95% = not polymorphic
  - Rare alleles (frequency <0.05)

2.

Measuring Genetic Diversity

- Heterozygosity (H)
  - Proportion of individuals in a population heterozygous for a particular gene OR
  - Proportion of genes at which the average individual is heterozygous

2.

Measuring Genetic Diversity

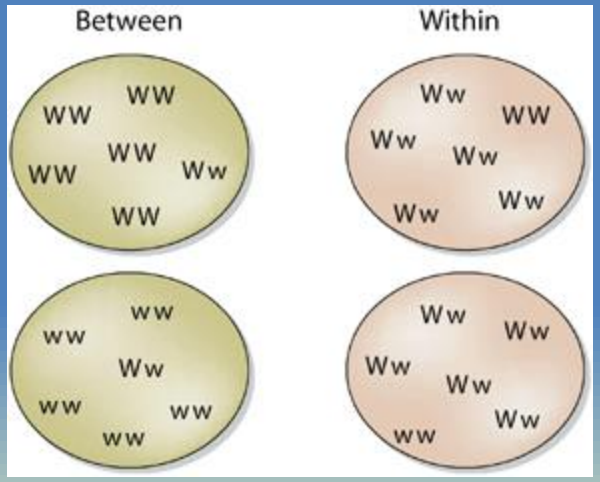
- Two handy equations
  - Hardy-Weinberg
  - $p + q = 1$
  - $p^2 + 2pq + q^2 = 1$
- How much heterozygosity did we observe?
- How much heterozygosity would be expected?

2.

Measuring Genetic Diversity

- Two levels of genetic diversity
  - Within population
  - Among (between) populations

Should preserve both

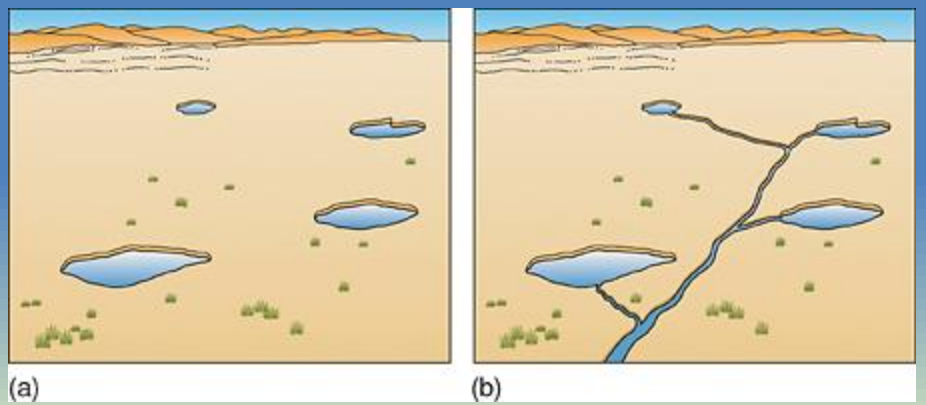


Could save either one

2.

Measuring Genetic Diversity

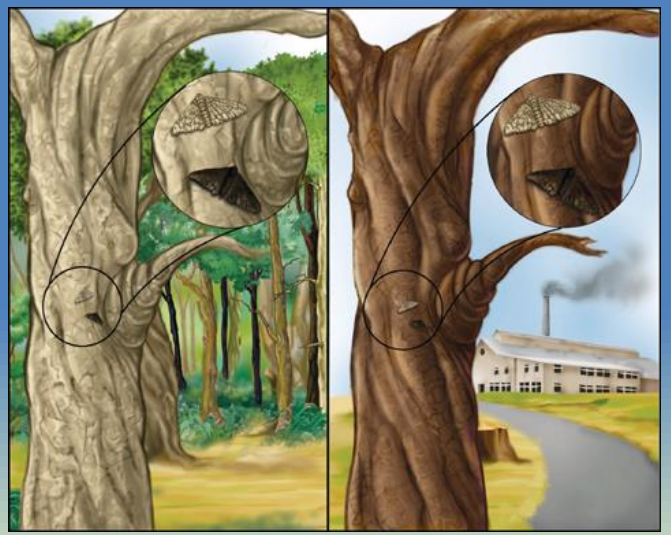
- Gene flow
  - Populations connected vs. isolated
  - Allows for greater within population diversity



3.

Genetic Diversity Loss

- Diversity values
  - Evolutionary potential
  - Higher diversity gives selection more to work with

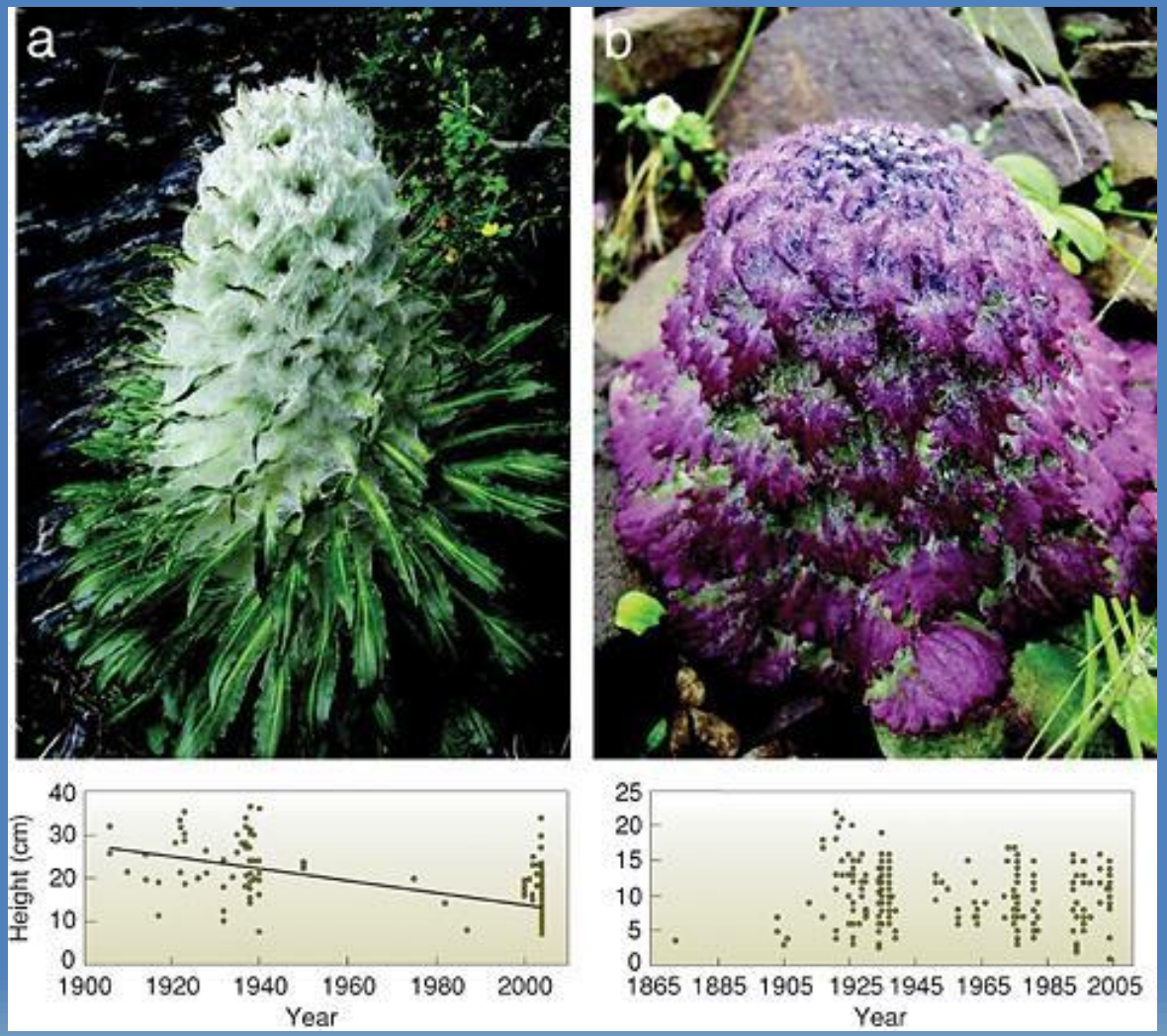


3.

Genetic Diversity Loss

- Loss of Fitness
  - Low fertility
  - High mortality
  - Inbreeding depression
  - Overcollecting

3.


a
b
Height (cm)
40
30
20
10
0
1900
1920
1940
1960
1980
2000
Year
25
20
15
10
5
0
1865
1885
1905
1925
1945
1965
1985
2005
Year

3.

Genetic Diversity Loss

- Why do inbred population lose fitness?
  - More homozygotes
  - Heterozygote advantage
  - Lower evolutionary potential

3.

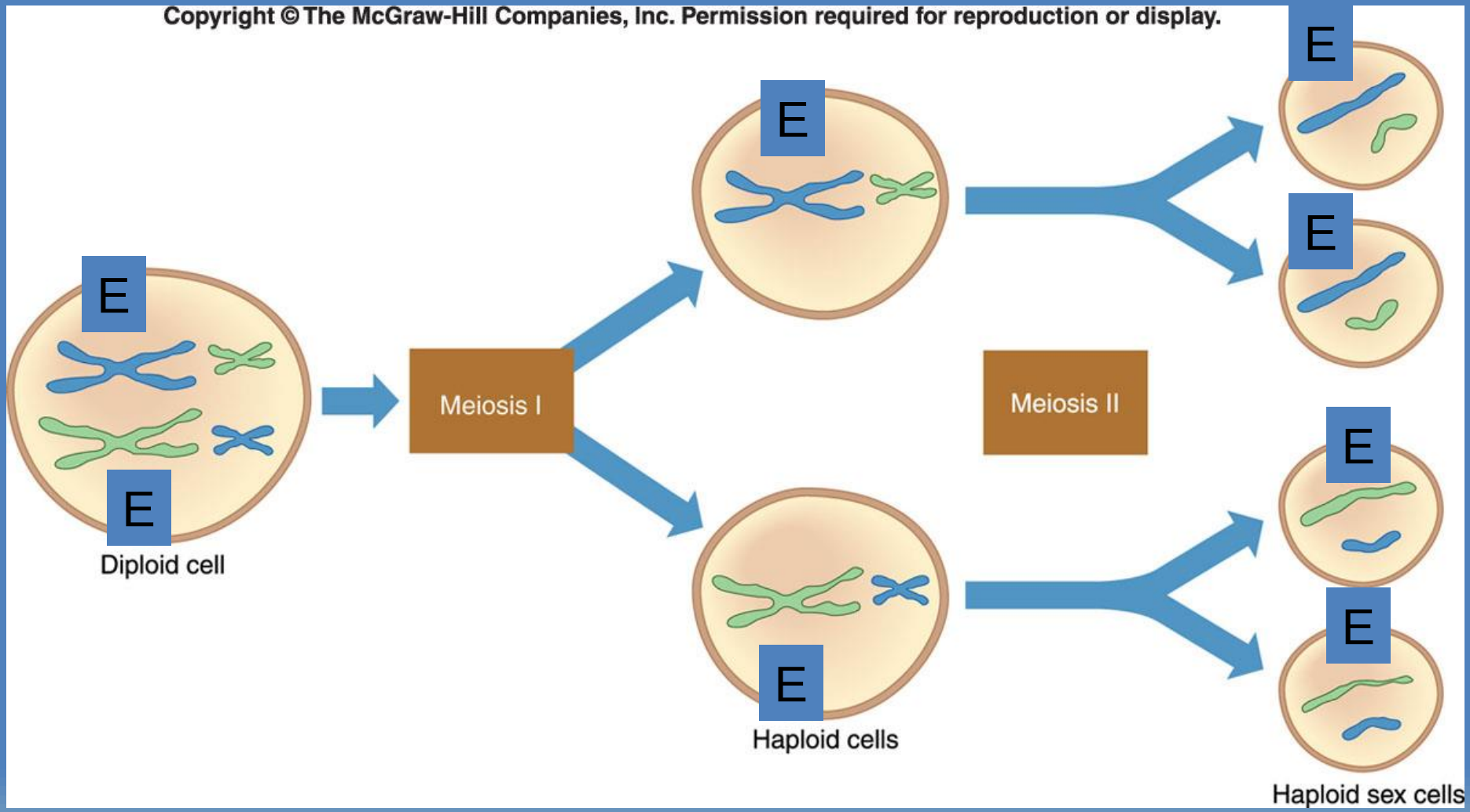
Genotype is either EE or Ee

3.

Genotype is ee

3.

Homozygous Dominant



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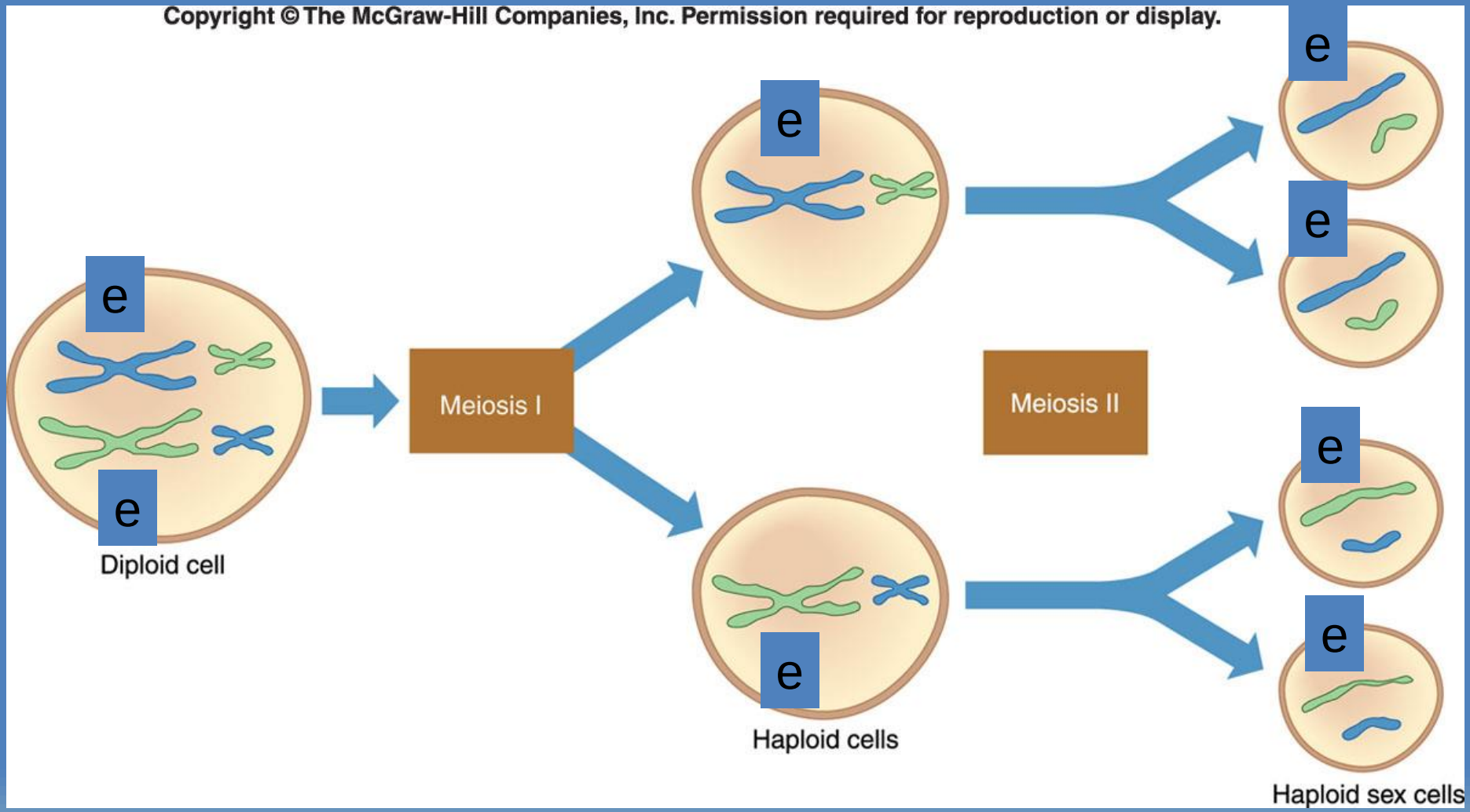
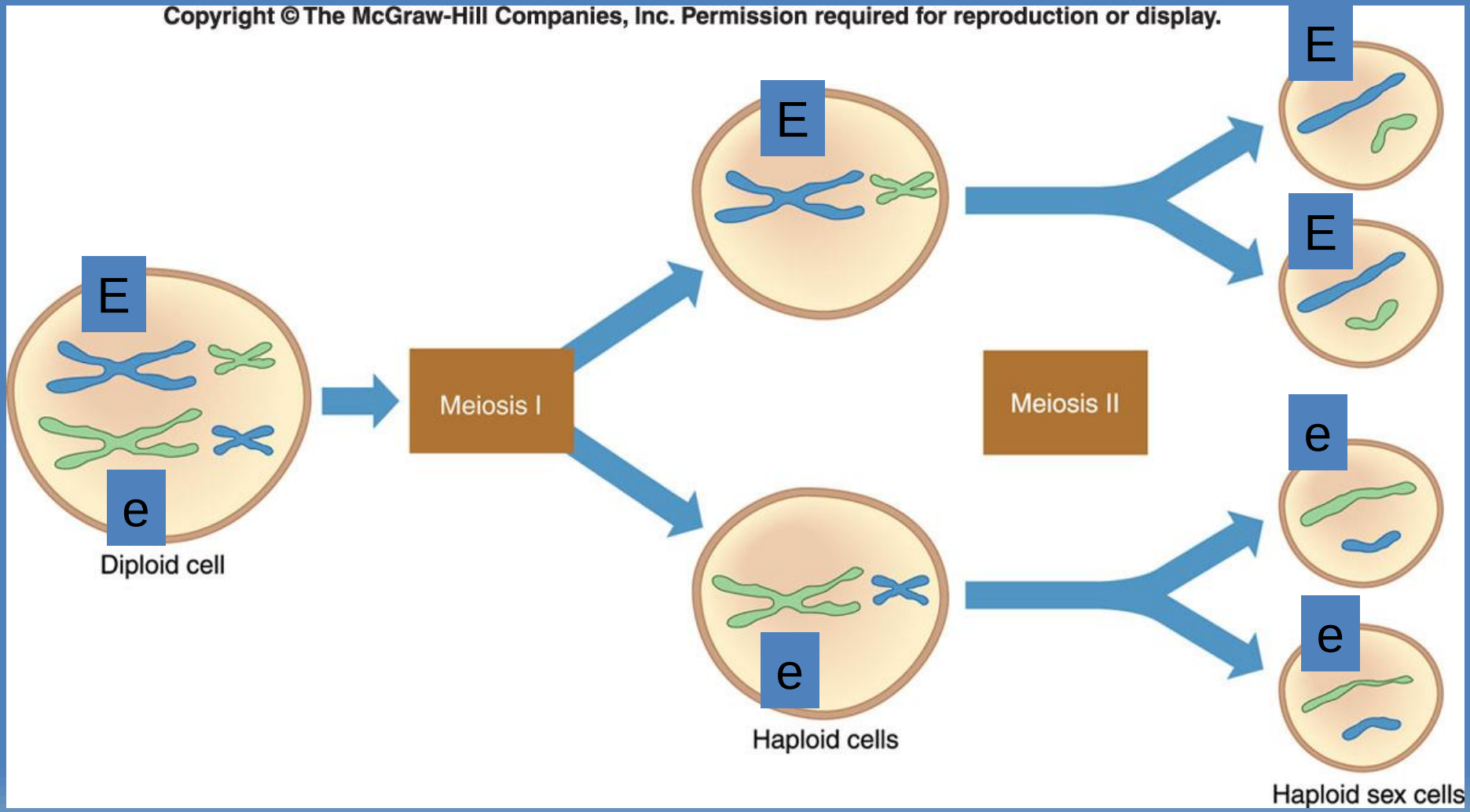
Homozygous Recessive



3.

Heterozygous



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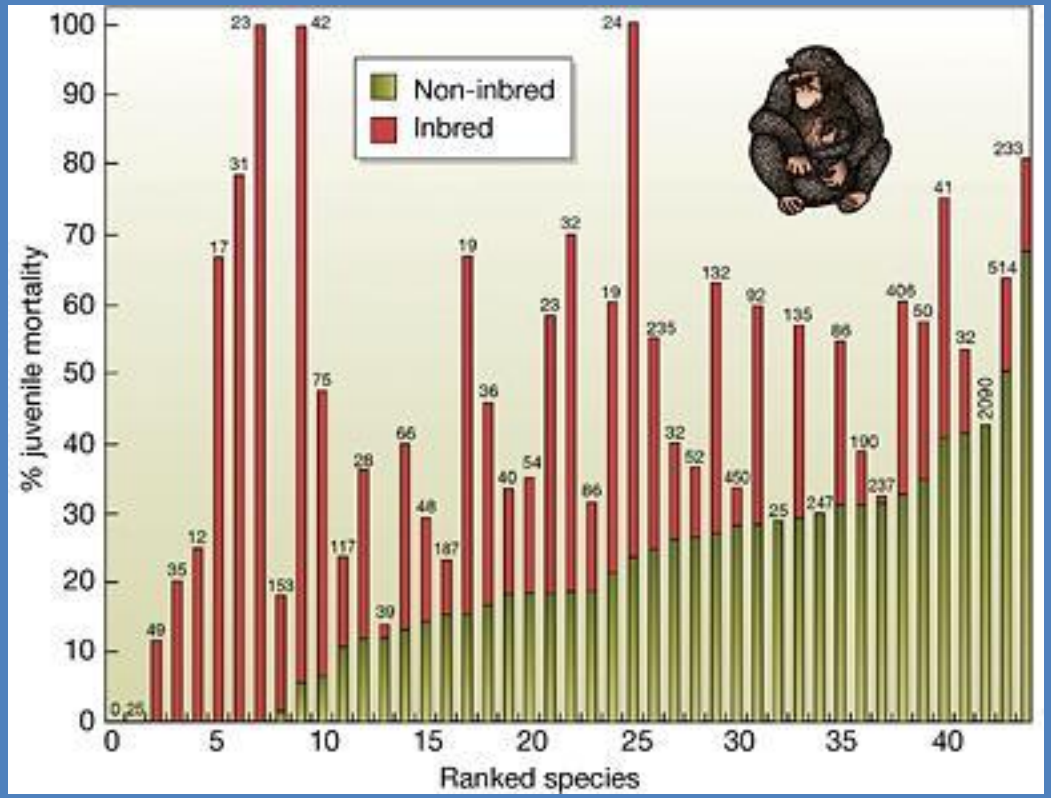
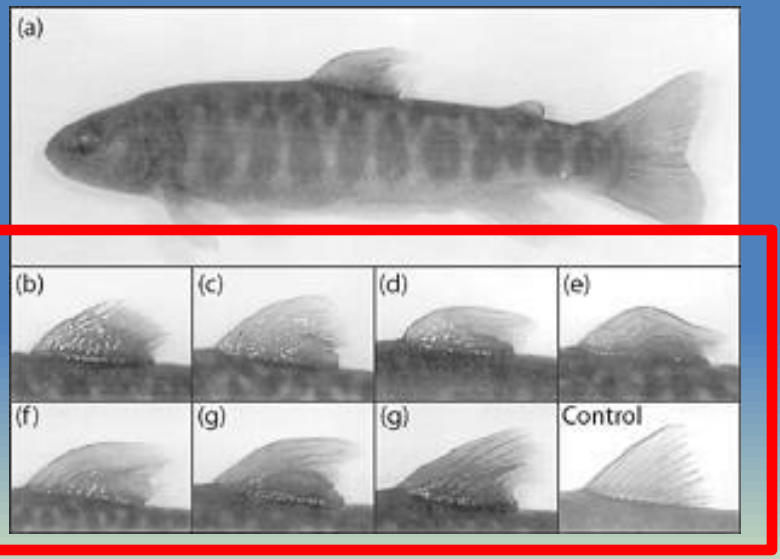


Captive-bred animals



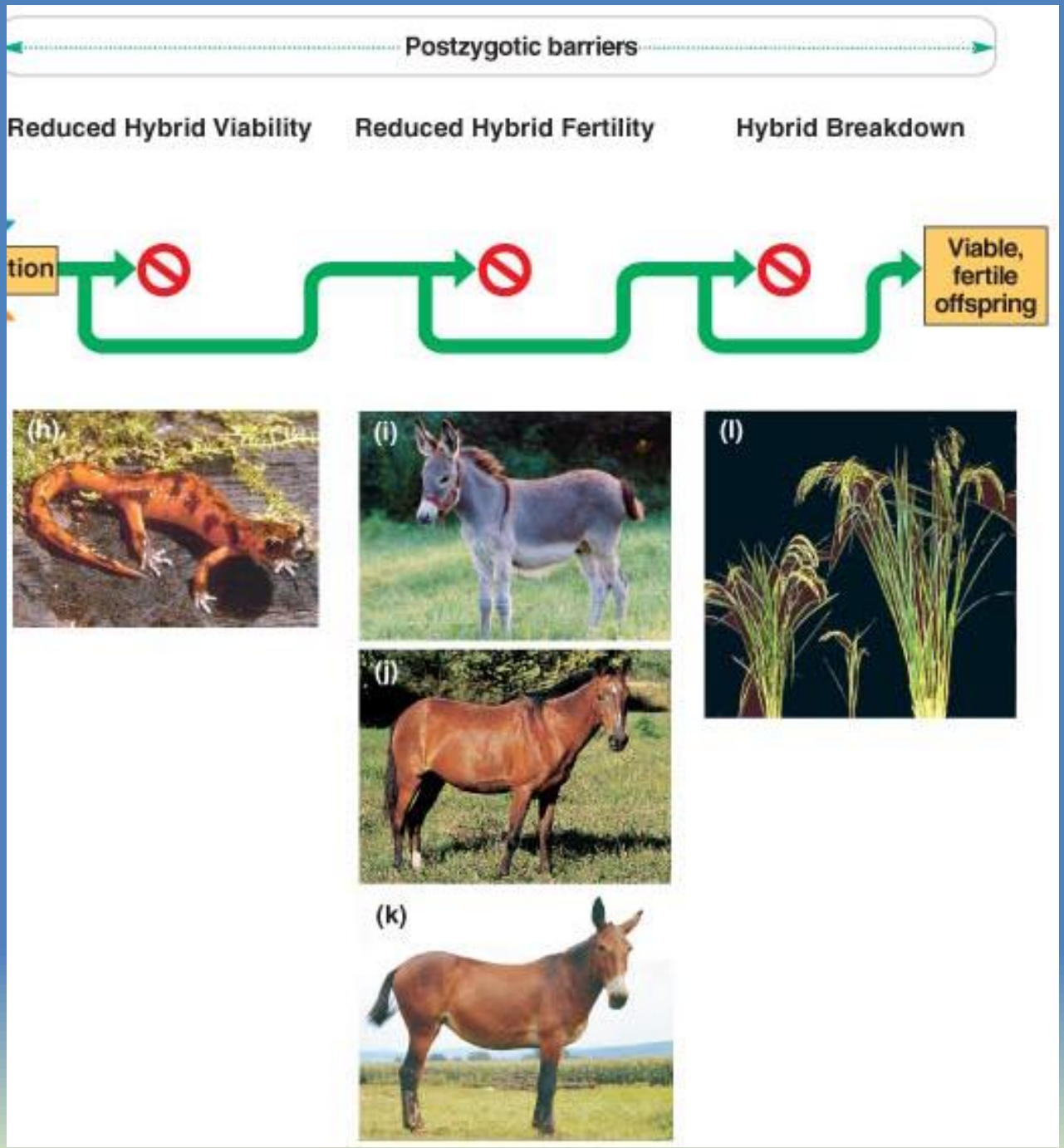
Inbreeding depression

3.

Genetic Diversity Loss

- Outbreeding depression
  - Occurs in species introductions
  - E.g., ibex reintroductions, hybrid breakdown

3.


Postzygotic barriers
Reduced Hybrid Viability
Reduced Hybrid Fertility
Hybrid Breakdown
tion
Viable, fertile offspring
(h)
(i)
(j)
(k)
(l)

3.

Genetic Diversity Loss

- Genetic Bottlenecks
  - Random event occurs
  - Subsequent generations do not represent full diversity of original population
  - Involves loss of alleles through genetic drift

3.

An average individual is heterozygous at 4-15% of its genes.

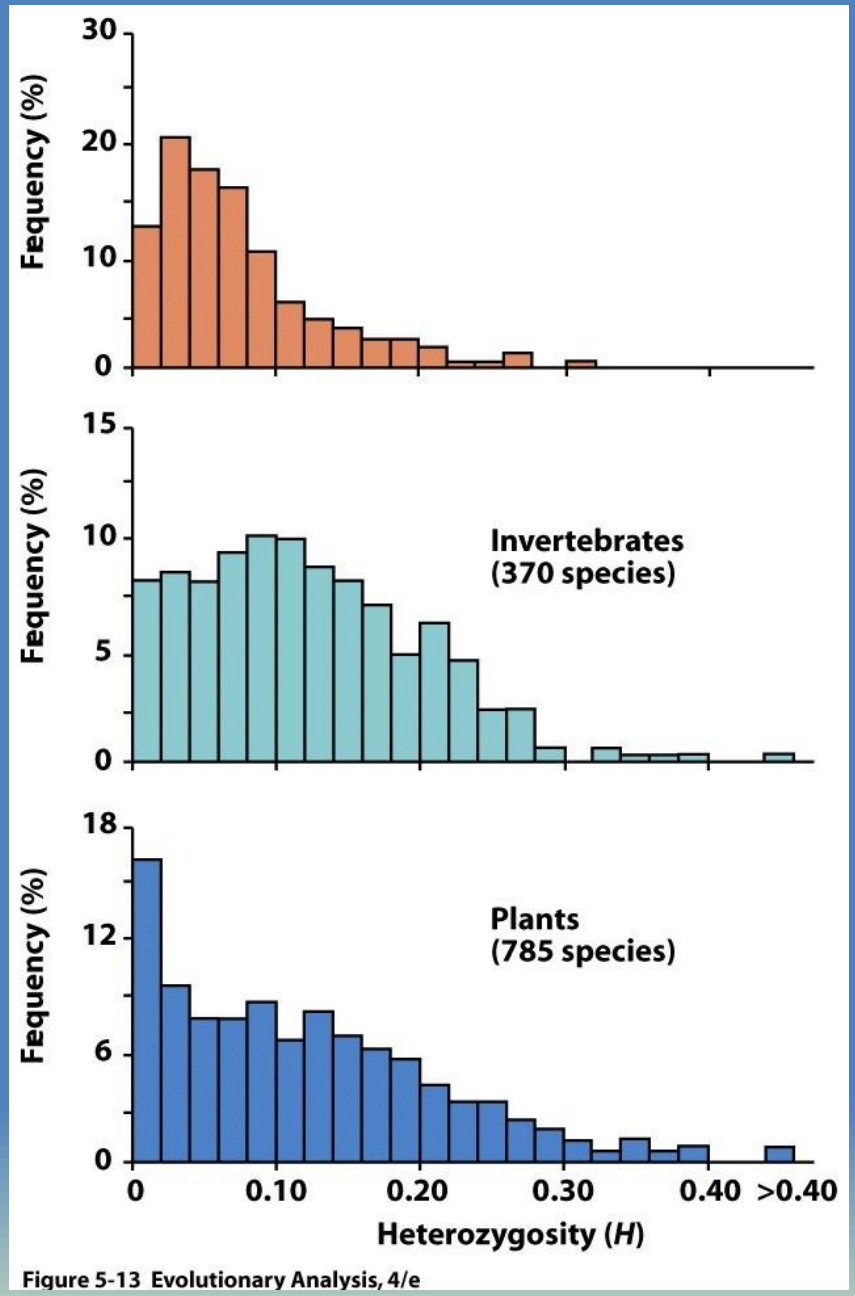


Figure 5-13 Evolutionary Analysis, 4/e

3.

(a) Typical *Mimulus lewisii*

(b) *M. lewisii* with an *M. cardinalis* flower-color allele

Changes to single locus can influence fitness

(c) Typical *Mimulus cardinalis*

(d) *M. cardinalis* with an *M. lewisii* flower-color allele

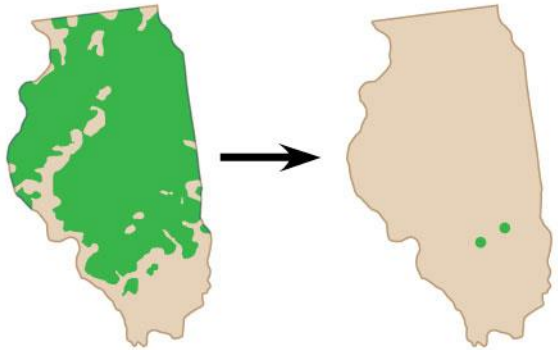
Figure 24.20

3.

Greater prairie chicken

Range of greater prairie chicken

(a)



Location	Population size	Number of alleles per locus	Percentage of eggs hatched
Illinois 1930–1960s 1993	 1,000–25,000 <50	 5.2 3.7	 93 <50
Kansas, 1998 (no bottleneck)	750,000	5.8	99
Nebraska, 1998 (no bottleneck)	75,000–200,000	5.8	96

(b)

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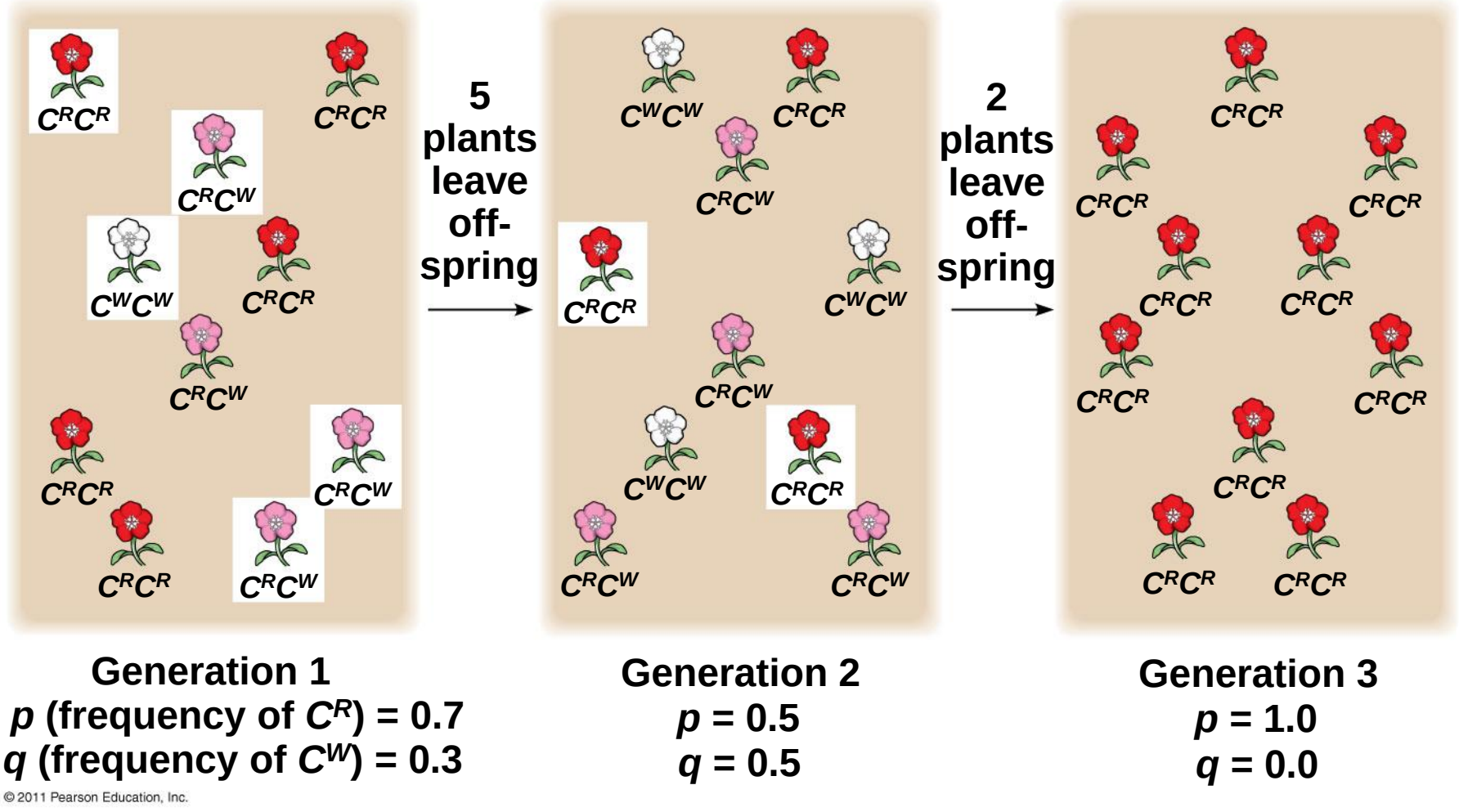
3.



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Genetic Diversity Loss

- Case Study: Cheetahs
  - –20,000 years ago: 4 species
  - –Today:
    - Single species
    - Fragmented habitat
    - Inbreeding depression

Resources

Publications

Hunter Jr., M. L., and J. Gibbs. 2007. Fundamentals of Conservation Biology, 3rd Edition. Blackwell, Malden.

Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., and R.B. Jackson. 2014. Campbell Biology, 10th edition. Pearson, New York.

Withgott, J. and M. Laposata. 2012. Essential Environment: The Science behind the Stories, 4th Edition. Pearson, New York.