How is genotype determined?

- How does DNA code for the making of proteins?
- How do the two copies of DNA you carry work together to create your phenotype?
- How do you get your two copies of any chromosome or locus through meiosis?

Meiosis

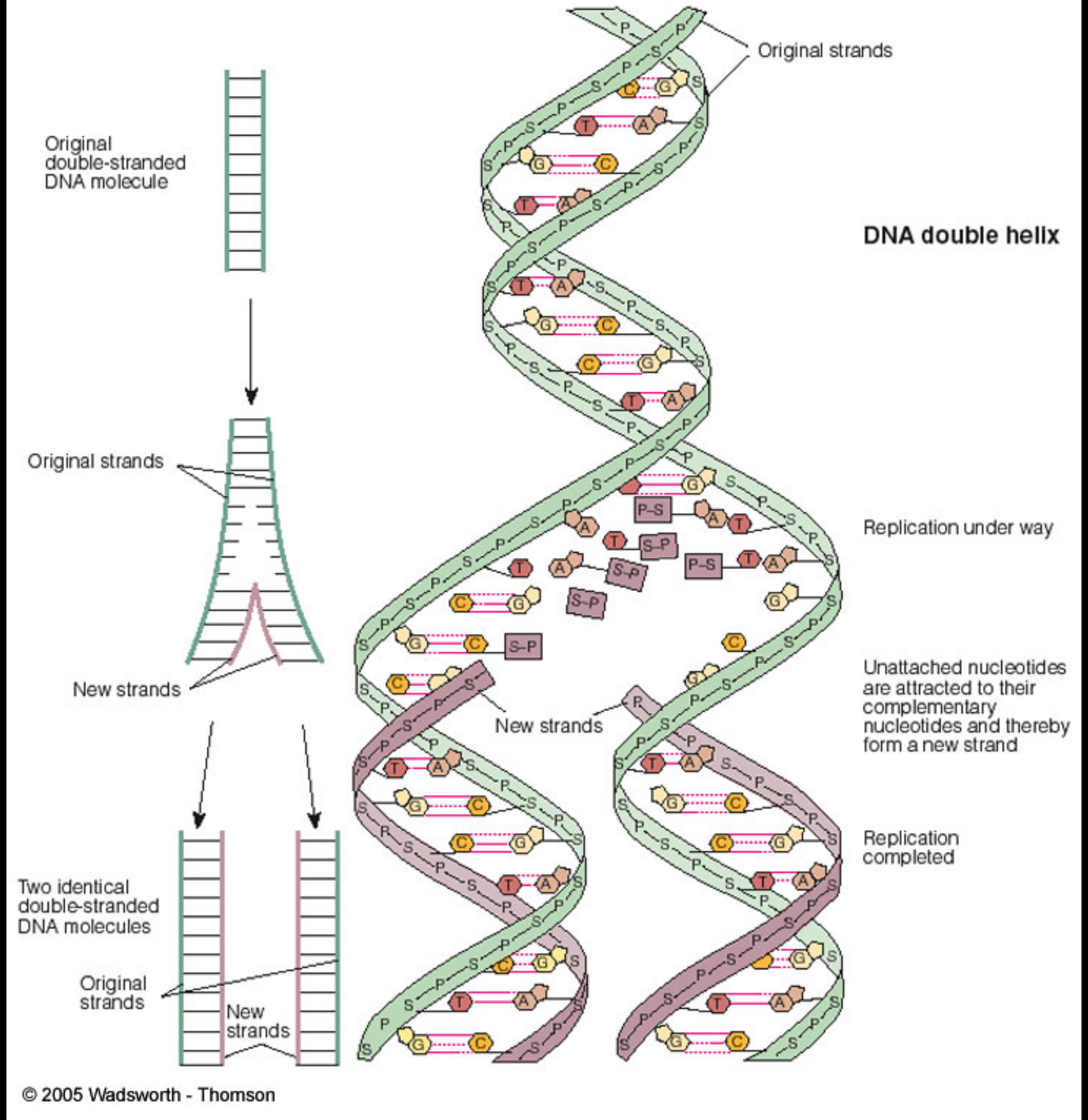
- How does meiosis divide cells?
- What are haploid and diploid cells?
- Describe the process of meiosis?
- When and how during meiosis is variation introduced?
- How do you get new genotypes?

Variation comes from

- Recombination
- Crossing Over
- Mutation

Mutation

- Change in base sequence of DNA
- Occurs during replication stage of meiosis (or mitosis)
- MAY change the amino acid change and therefore the protein


Original strands
Original double-stranded DNA molecule
DNA double helix
Original strands
Replication under way
New strands
New strands
Unattached nucleotides are attracted to their complementary nucleotides and thereby form a new strand
Replication completed
Two identical double-stranded DNA molecules
Original strands
New strands
© 2005 Wadsworth - Thomson

Kinds of Mutations

- Substitution - replace one base with another
- Frame Shift -
  - Insertion- an extra base gets pulled in
  - Deletion- a base gets omitted

Do all mutations change the protein created?

Mutations?

- "Bad" - reduces the protein's ability to function causing reduction in fitness
- Neutral - no change in protein form or function
- "Good" - increases protein's ability to function, enhances fitness

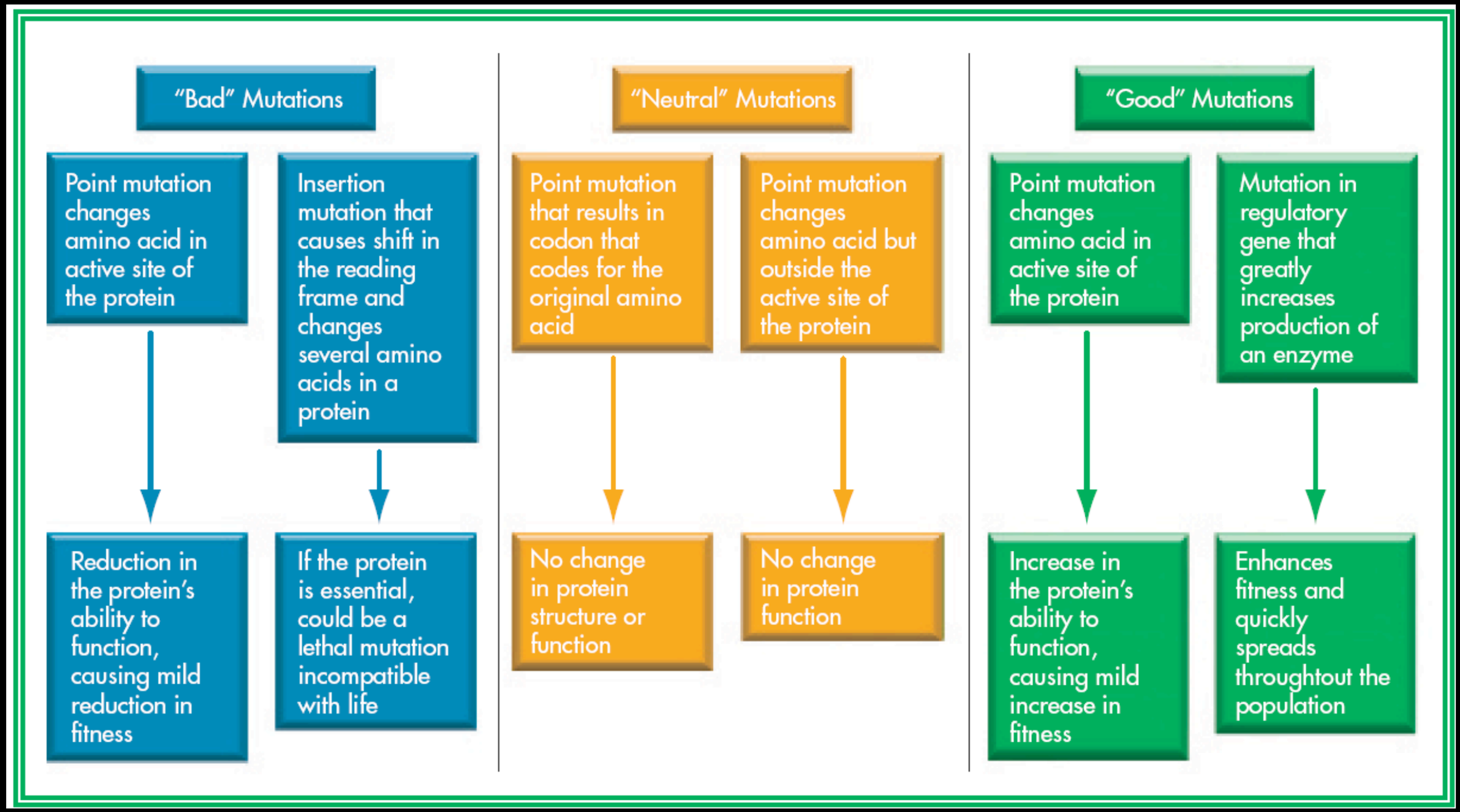

"Bad" Mutations
Point mutation changes amino acid in active site of the protein
Insertion mutation that causes shift in the reading frame and changes several amino acids in a protein
Reduction in the protein's ability to function, causing mild reduction in fitness
If the protein is essential, could be a lethal mutation incompatible with life
"Neutral" Mutations
Point mutation that results in codon that codes for the original amino acid
Point mutation changes amino acid but outside the active site of the protein
No change in protein structure or function
No change in protein function
"Good" Mutations
Point mutation changes amino acid in active site of the protein
Mutation in regulatory gene that greatly increases production of an enzyme
Increase in the protein's ability to function, causing mild increase in fitness
Enhances fitness and quickly spreads throughtout the population

Figure 3.15

How common is mutation?

- happens all the time
- assume a rate of one in 100 million bases
- repair mechanisms fix 99% for effective mutation rate of 10^{-10}
- gives a rate of 130 mutations per individual per generation
- (http://sandwalk.blogspot.com/2010/11/human-mutation-rates.html) [10]

How is phenotype created?

- phenotype = genotype + environment
- genotype = combination of the two particles of inheritance we carry for each locus
- plus other involved loci

Most human traits...

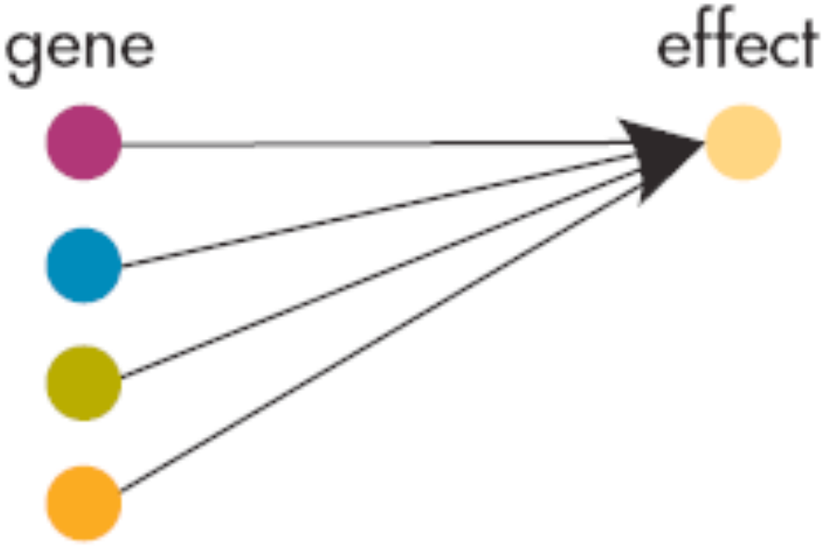
- Polygenic
  - controlled by 2 or more loci
- Affected by the environment
- Many genes PLEIOTROPIC
  - a single gene has multiple effects

Example: Height

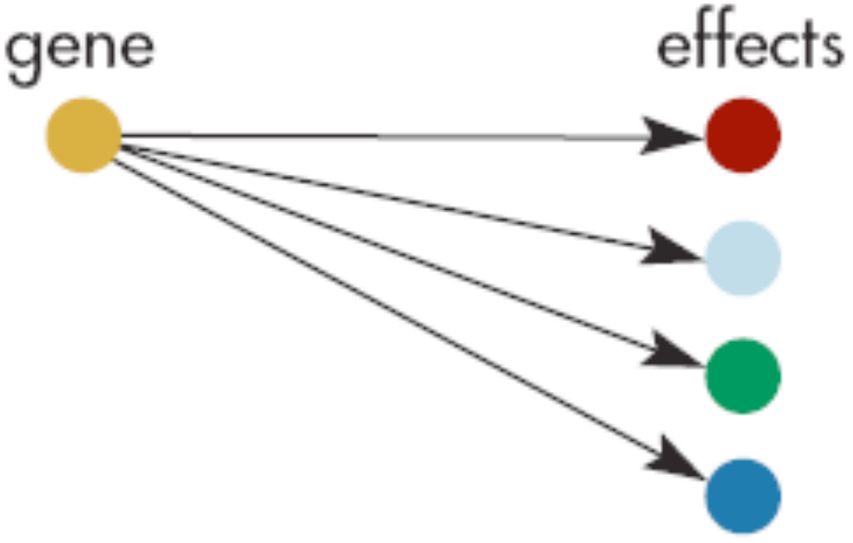
- phenotype = genotype + environment
- environment = diet, altitude, sleep, health
- genotype = pairs of alleles at at least 5 loci (4q35, 9p24, 13q12, 18q21, 22q13)

Polygeny vs. Pleiotropy

(a) Polygenic trait: many genes contribute to a single effect.



(b) Pleiotropy: one gene has multiple effects.



Pleiotropy in Marfan Syndrome

Mistake making fibrillin-1 -- builds elastic tissue

- thinness
- joint hypermobility
- limb elongation
- lens dislocation
- increased risk of heart disease

Modern Synthesis

- production and redistribution of variation
- Natural selection is one force than can act on this variation to cause change

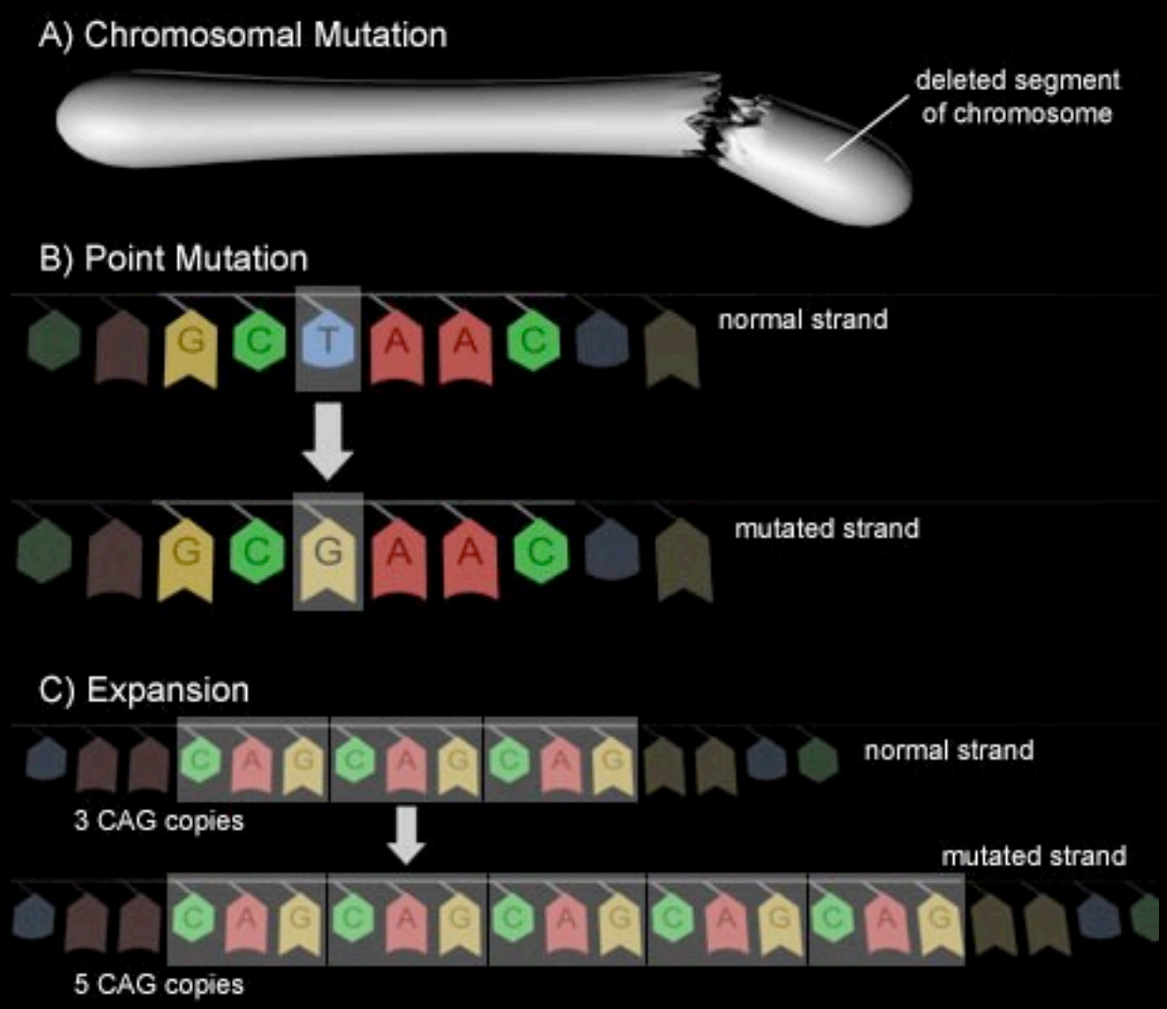
Evolution =
changes in gene frequencies
over time

Four Forces of Evolution

- Mutation
- Gene Flow
- Genetic Drift
- Natural Selection

Mutation

Figure Q-2: Types Of Mutations

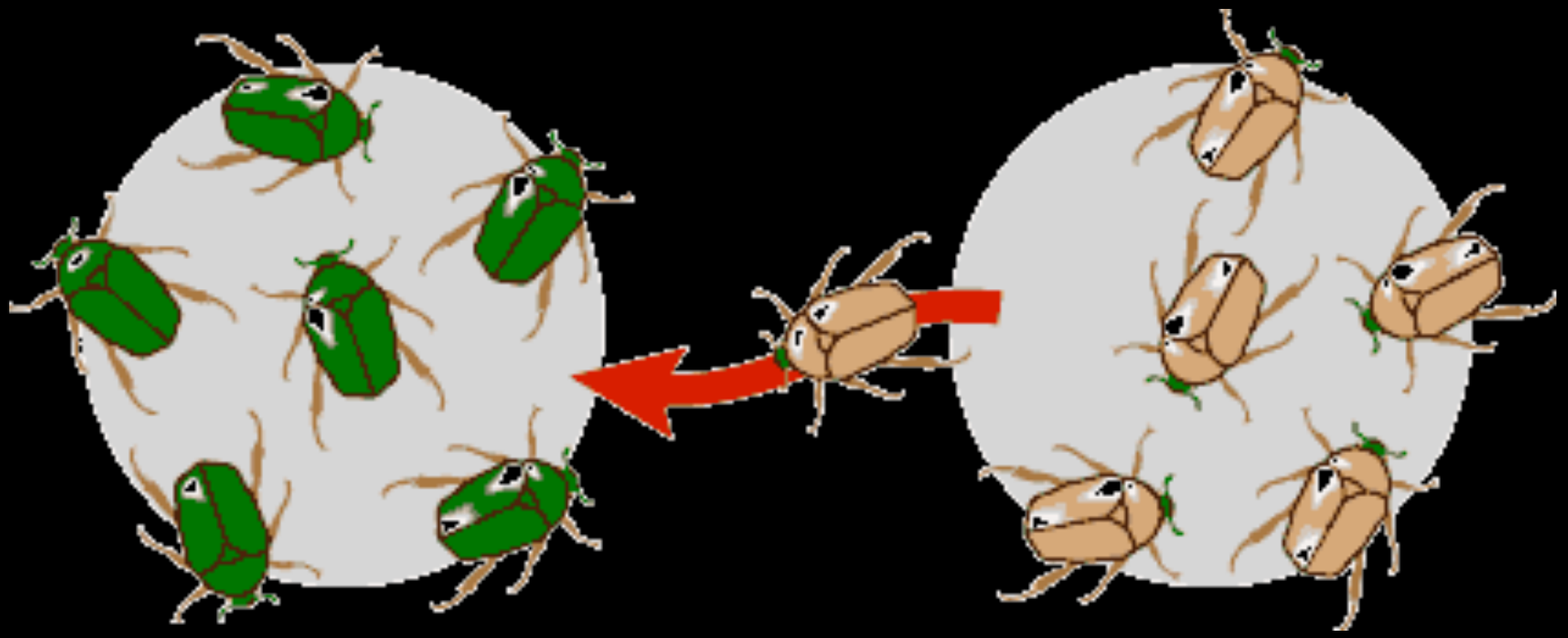


(A) Chromosomal mutations involve breaks in a chromosome. (B) Point mutations occur when one nitrogenous base is substituted for another - in this case, T becomes G. (C) Expansions occur when the number of copies of a codon is repeated. The expansion shown here involves CAG, just like the expansions in HD. However, expansions in HD can be much larger than the 2 extra copies of CAG shown here.

Mutation

- The only way to introduce new genetic variation
- Very common
  - many neutral
  - many deleterious enough to get removed quickly
  - some are incorporated

Gene Flow

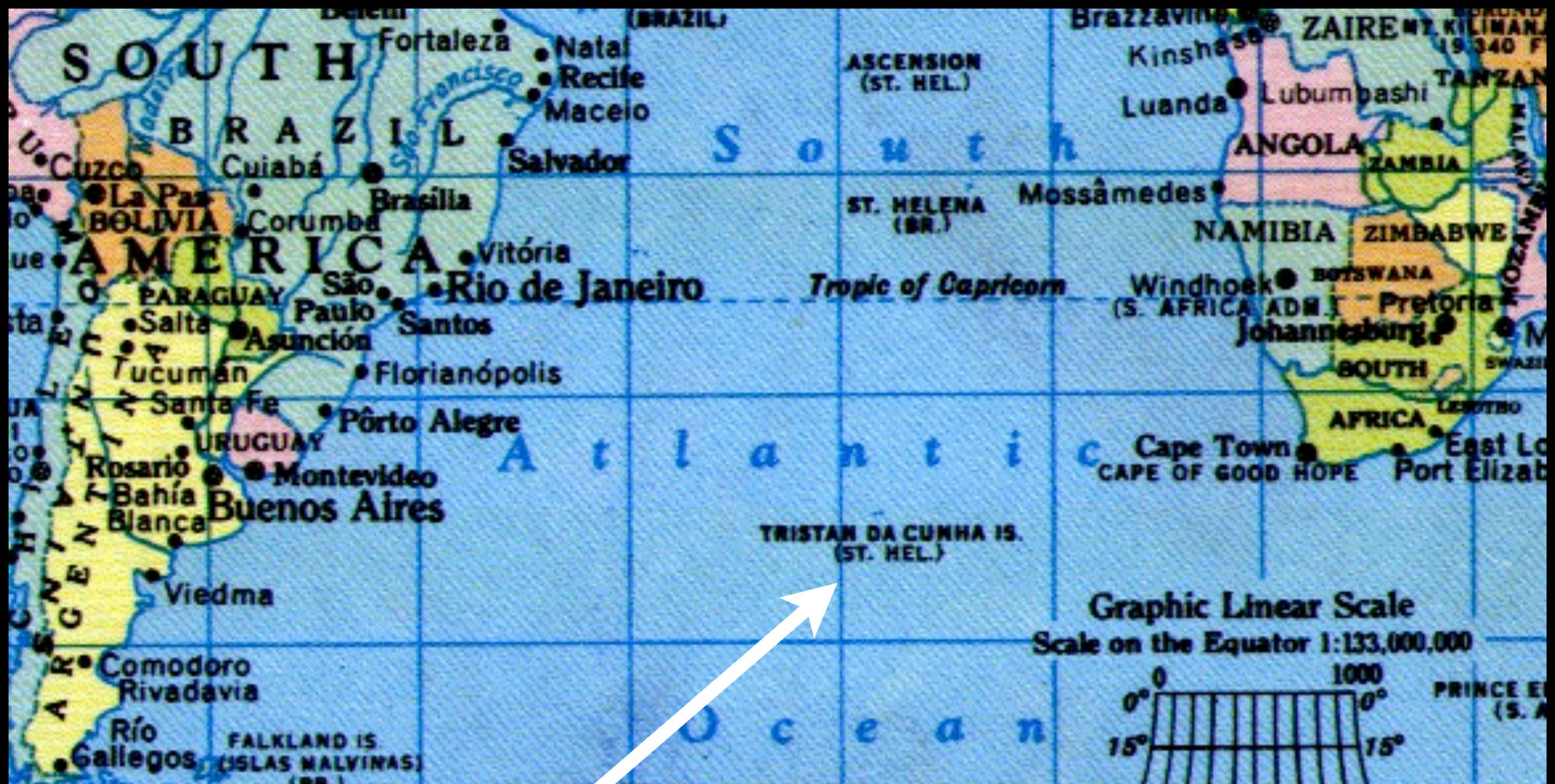


Movement of alleles within and between populations

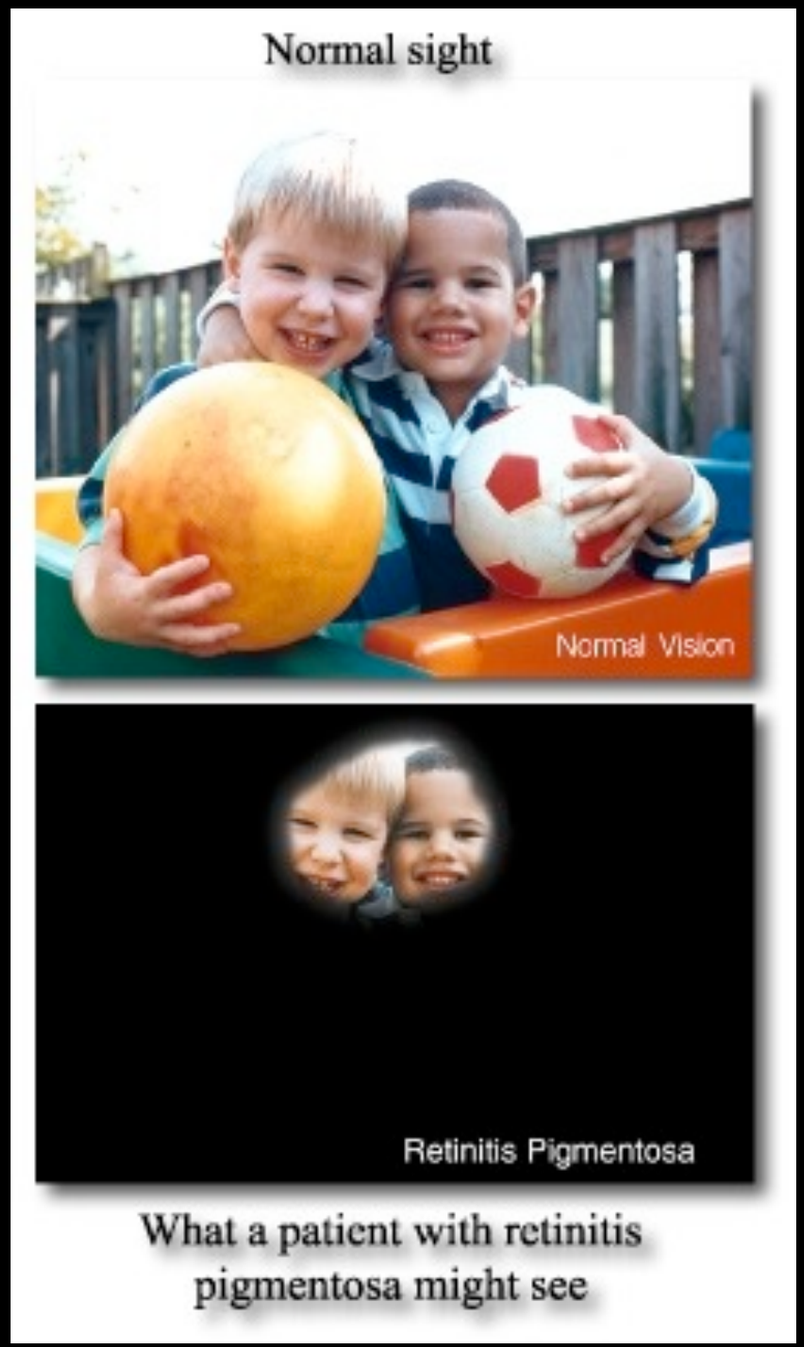
Genetic Drift

- The random factor
- Greatest effect in small populations
- Founder effect

Genetic Drift - Founder Effect

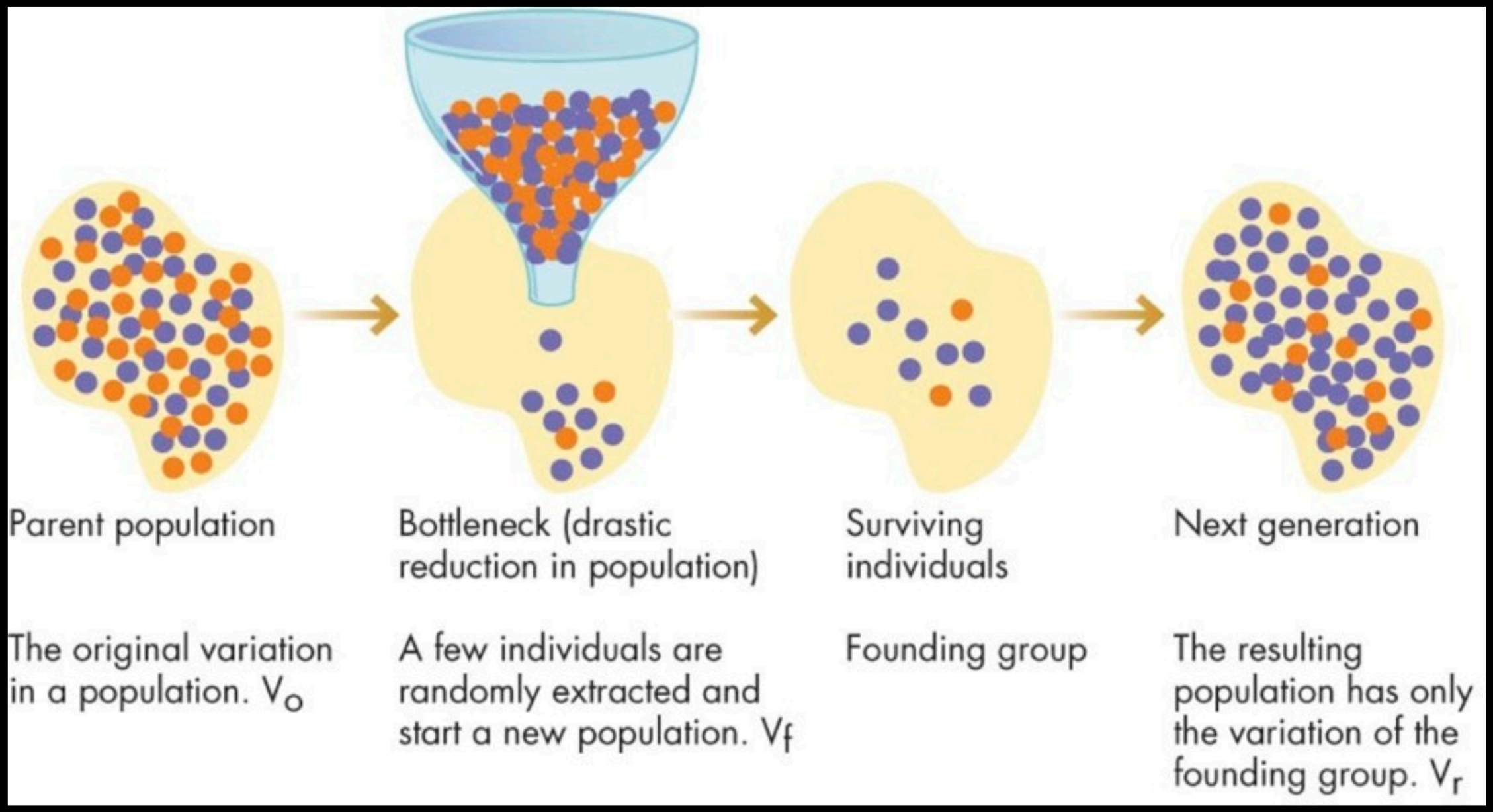


Clinodactyly



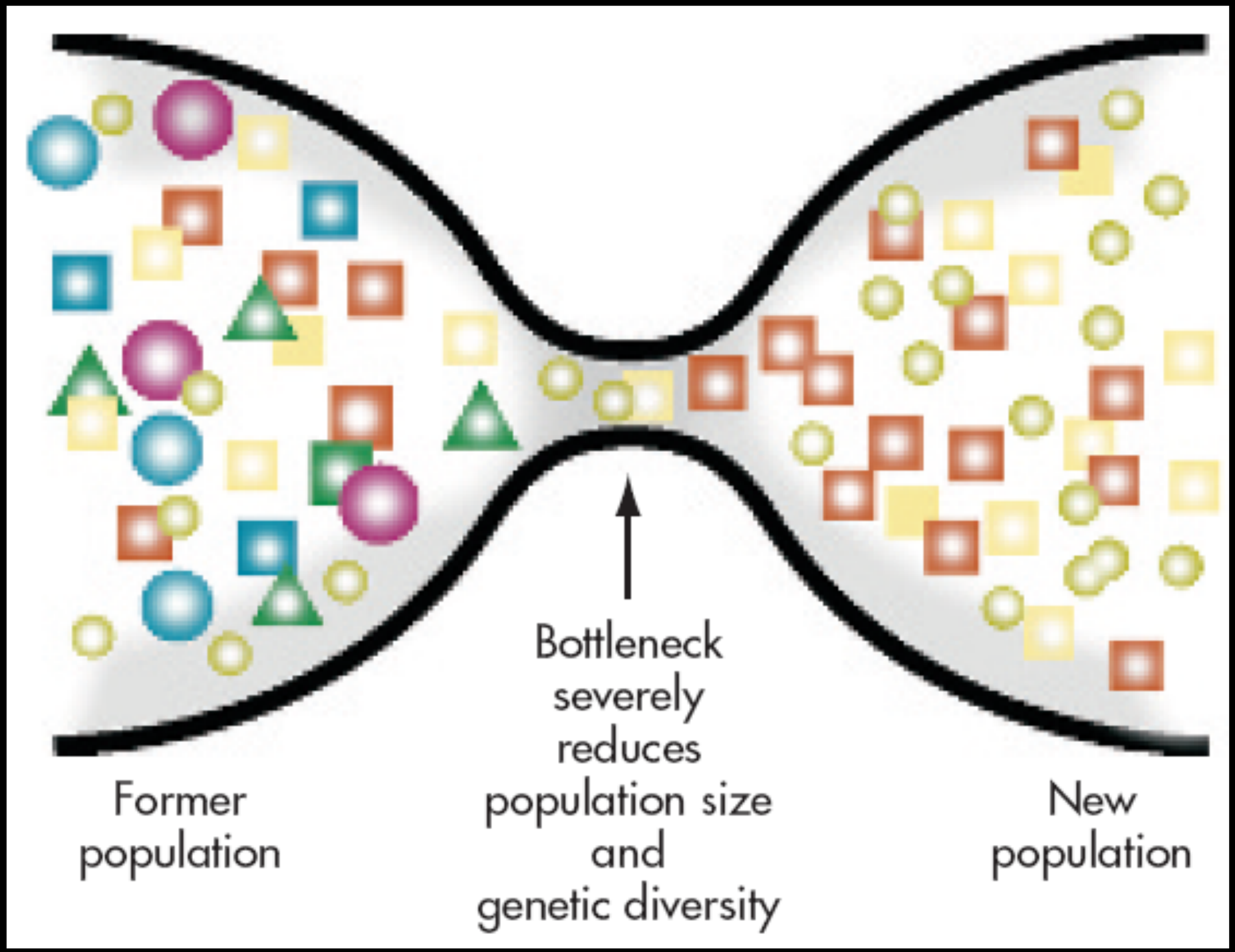
Retinitis pigmentosa

Genetic Drift - Bottleneck



Parent population	Bottleneck (drastic reduction in population)	Surviving individuals	Next generation
The original variation in a population. V_o	A few individuals are randomly extracted and start a new population. V_f	Founding group	The resulting population has only the variation of the founding group. V_r

Genetic bottleneck



Natural selection

- differential reproductive success over multiple generations
- some variations are more successful than others, leading to a change in the entire population over time

Natural Selection