Scientific theories vs “I have a theory. . .”
Lamarckian vs Darwinian evolution
Artificial selection
Gene flow
Genetic Drift
Natural selection
- Directional selective pressures
- Sexual selection
- Balancing selection

Natural selection is limited by historic constraints
“Irreducible complexity” is really dumb

Nature of Science

Facts

↓

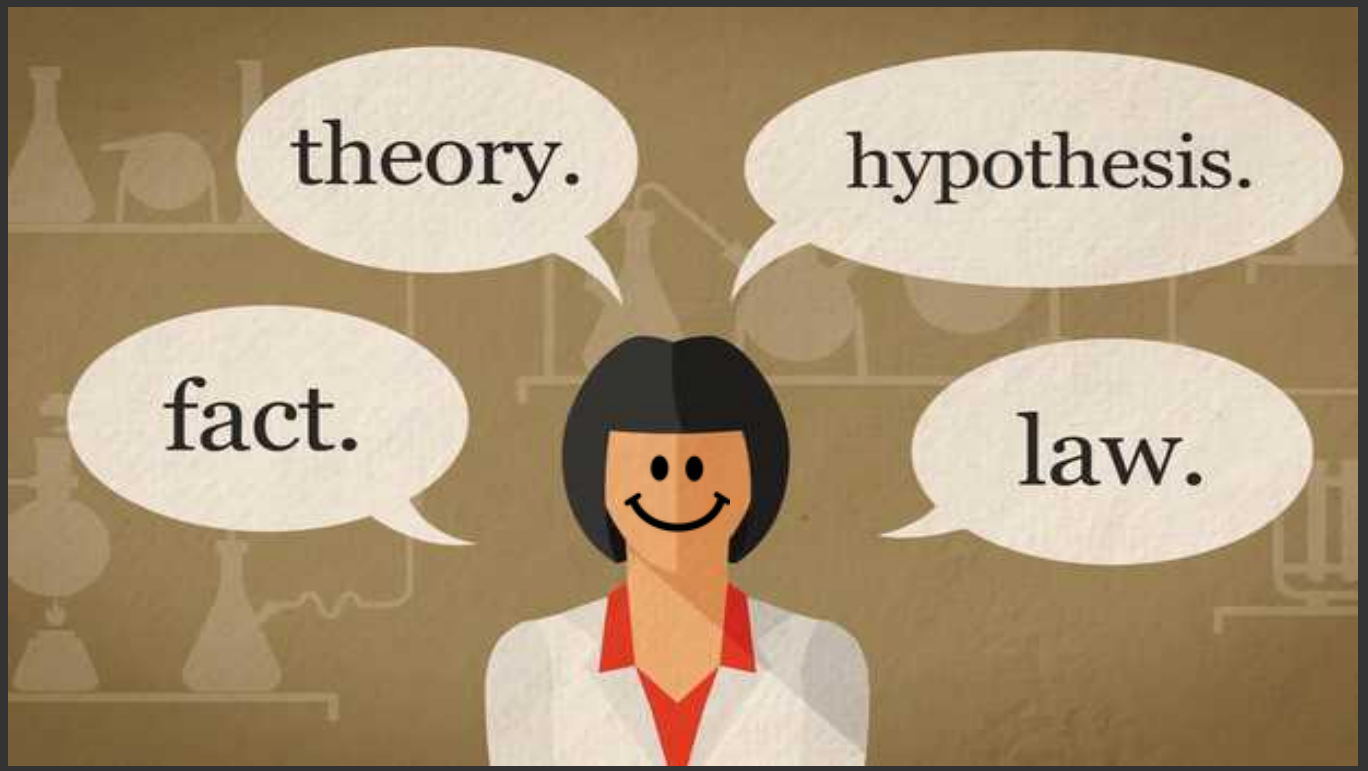
Hypotheses

↓

Theories

↓

Laws



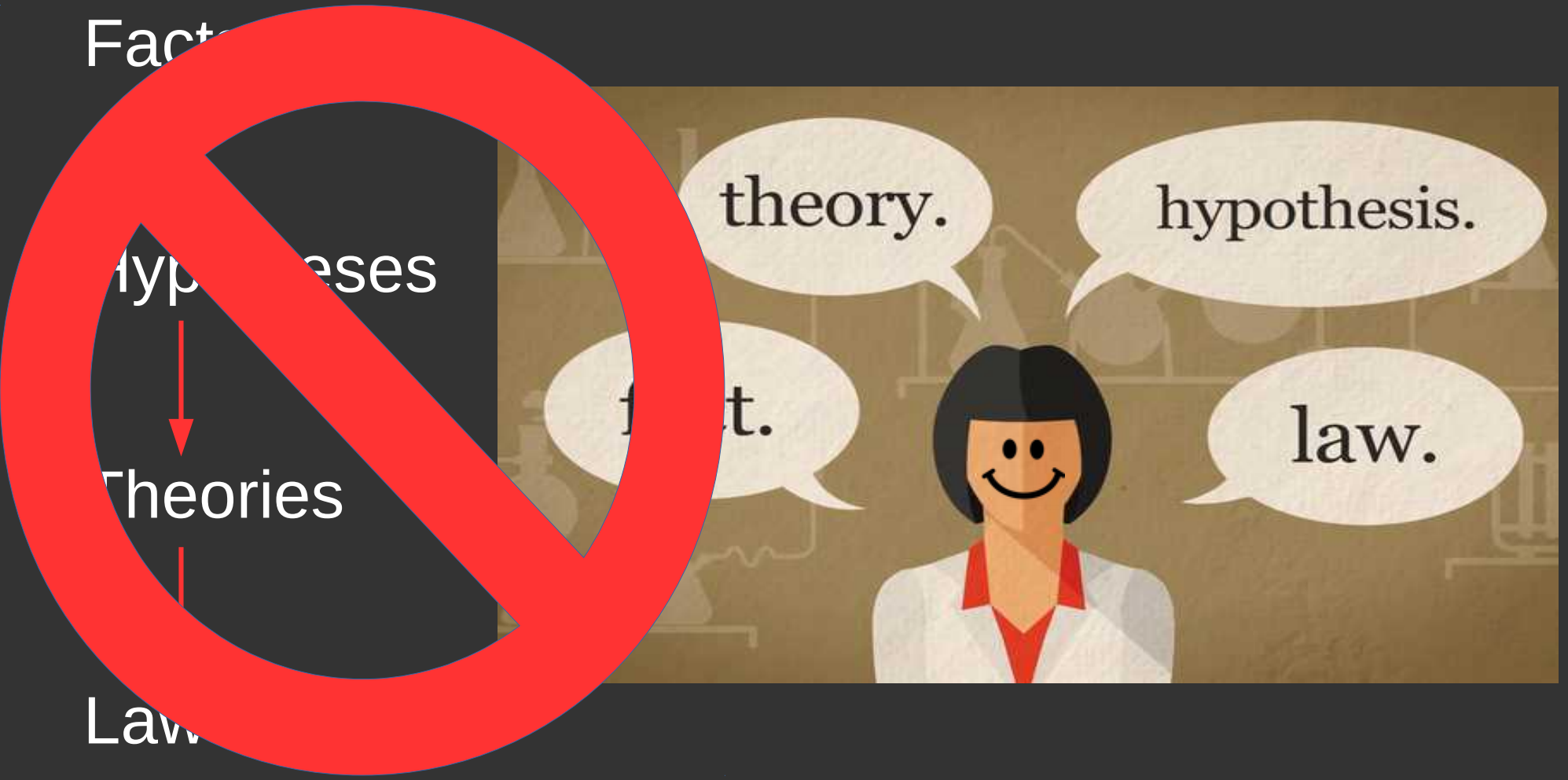
Nature of Science

Fact

Hyp eses

Theories

Law



Nature of Science

Facts: Observations

Laws: Detailed *descriptions* of some aspect of nature based on repeated observation

Hypotheses: A testable and falsifiable *explanation* of observation

Theory: Detailed *explanation* for observations that has passed countless tests and makes useful predictions

Nature of Science

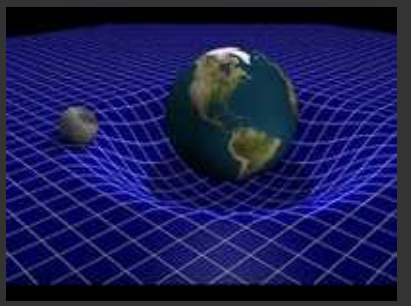
Facts: Observations

Laws: Detailed descriptions of some asp
nature based on repeated observation

$$F_g = \frac{Gm_1m_2}{r^2}$$

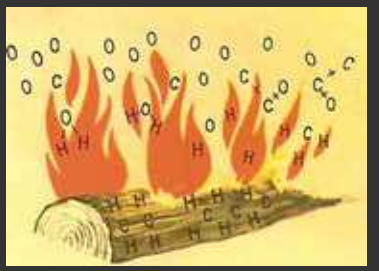
Hypotheses: A testable and falsifiable *ex*
of observation

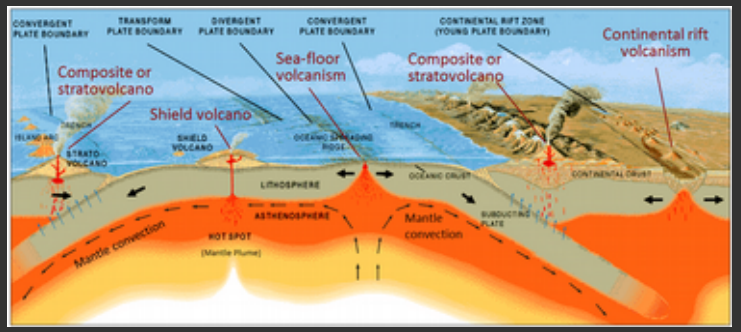
Theory: Detailed *explanation* for observa
has passed countless tests and makes u
predictions

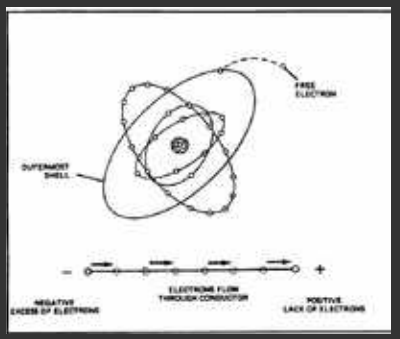


Some scientific theories

Plate tectonics
Germ theory of disease
Oxygen theory of combustion
Heliocentrism
Electron theory of electricity
General and special relativity
Gravity???





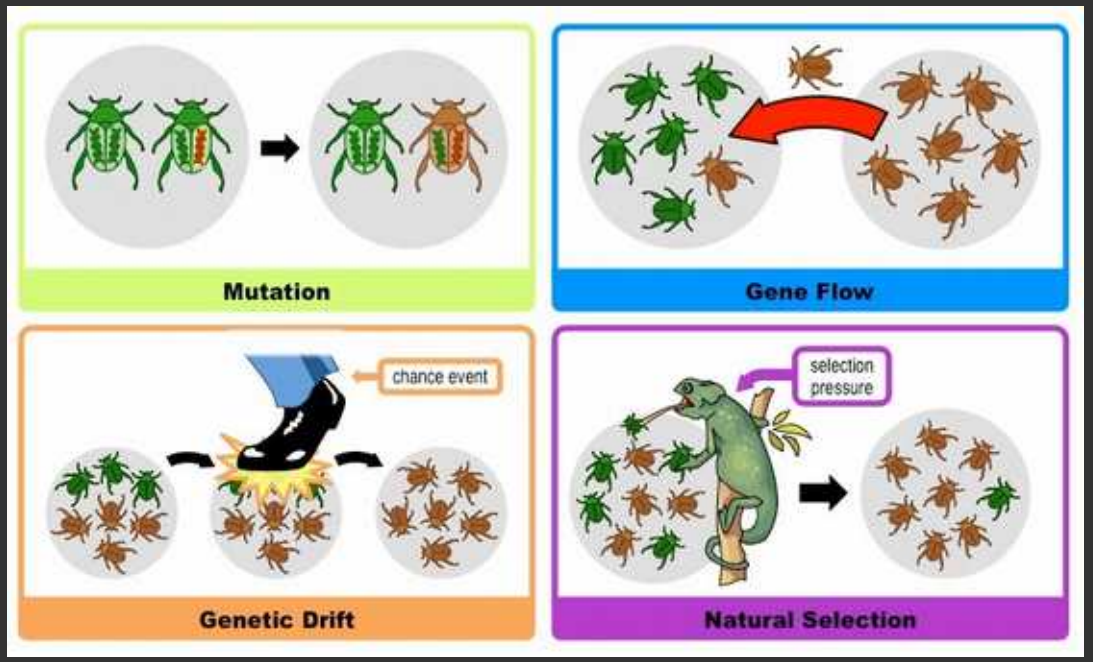


Evolution of organisms over time is just a boring fact

Natural selection is a theory explaining evolution
It generates correct predictions

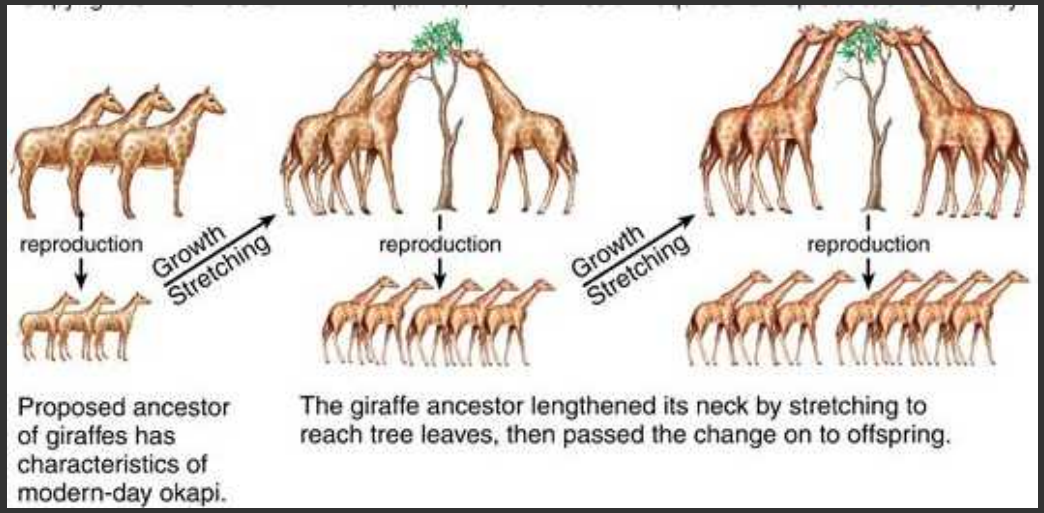
Other mechanisms include:

Mutation
Genetic Drift
Gene flow

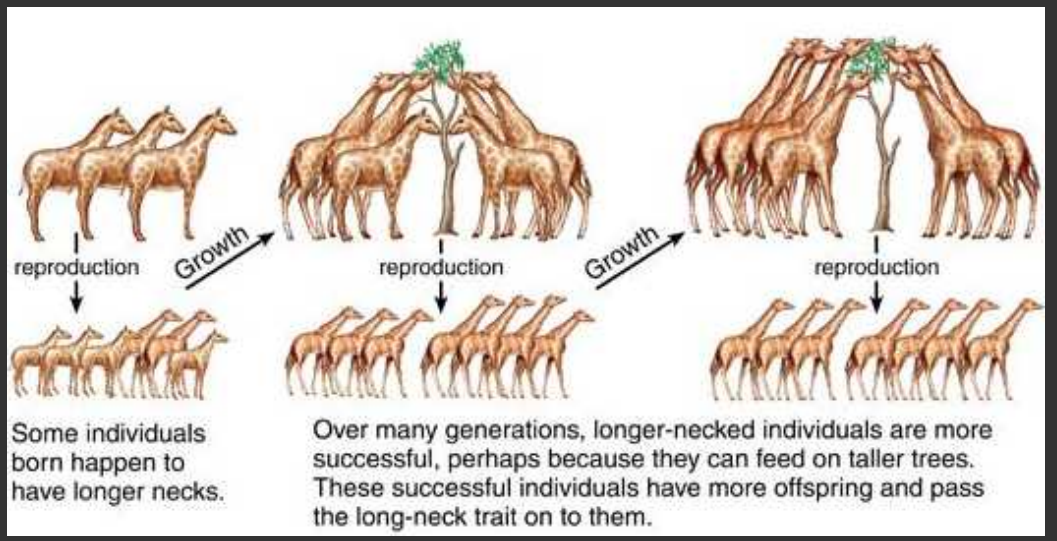


Lamarckian vs Darwinian Evolution

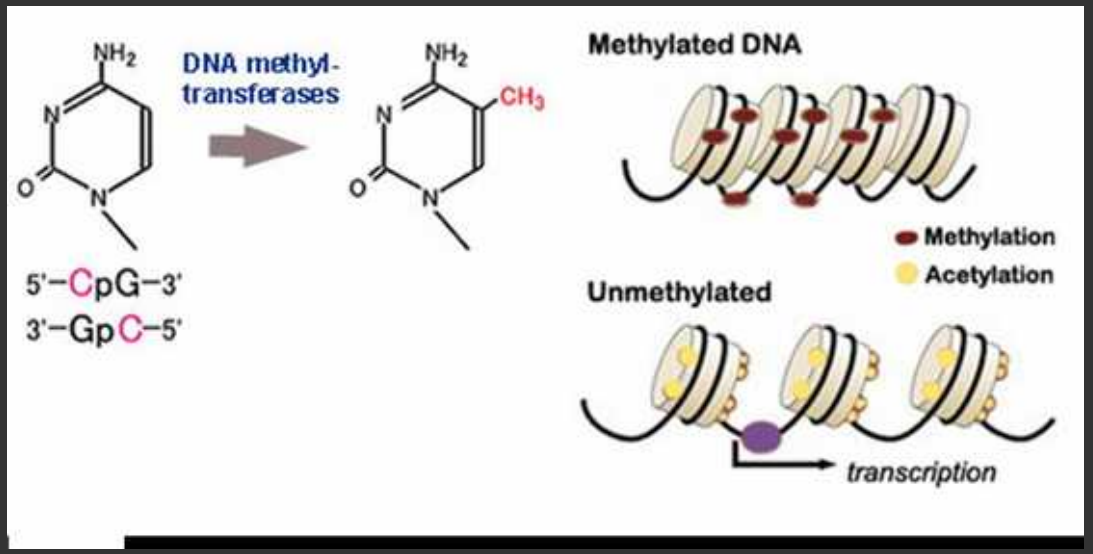
Lamarck:
Variation is acquired



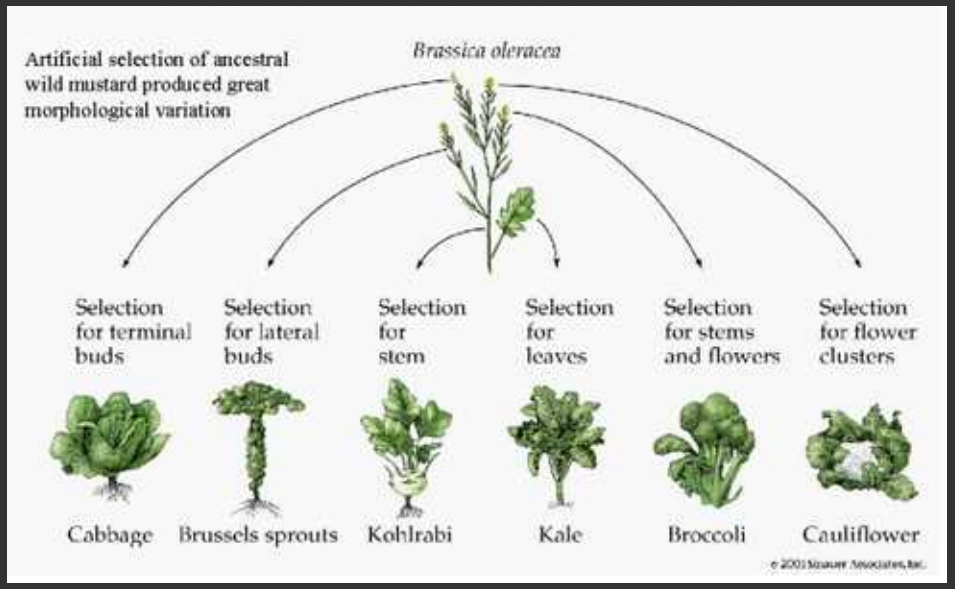
Darwin:
Variation is inherited

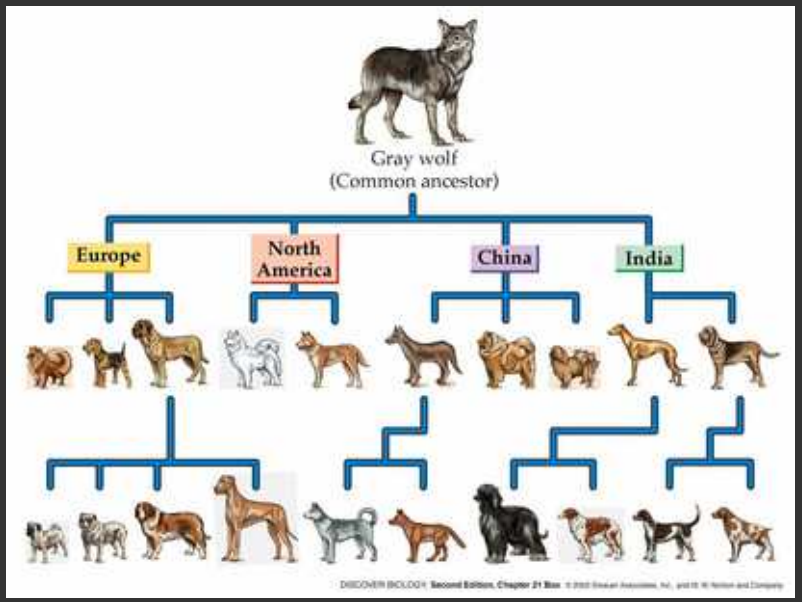


Some acquired traits can be heritable



Artificial vs Natural Selection





Heike crabs in the Sea of Japan

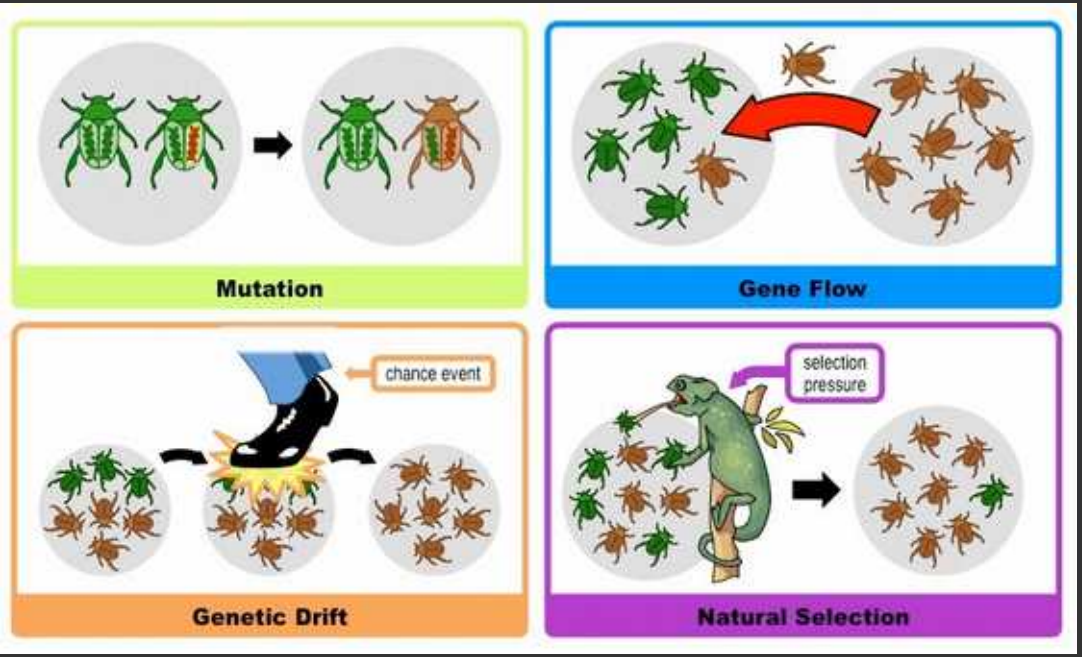
Mechanisms of Evolution

Mutation

Gene Flow

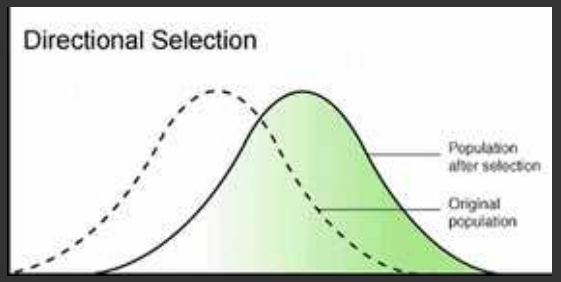
Genetic Drift

Natural Selection

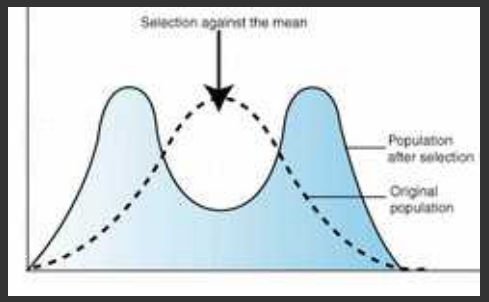


Natural Selection

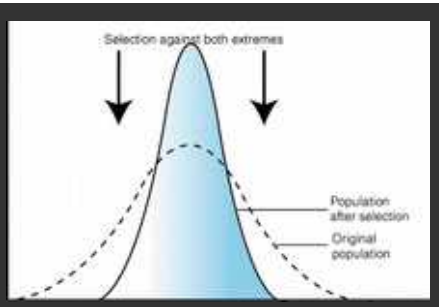
Directional Selection



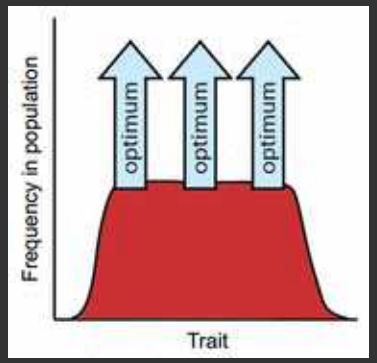
Disruptive Selection



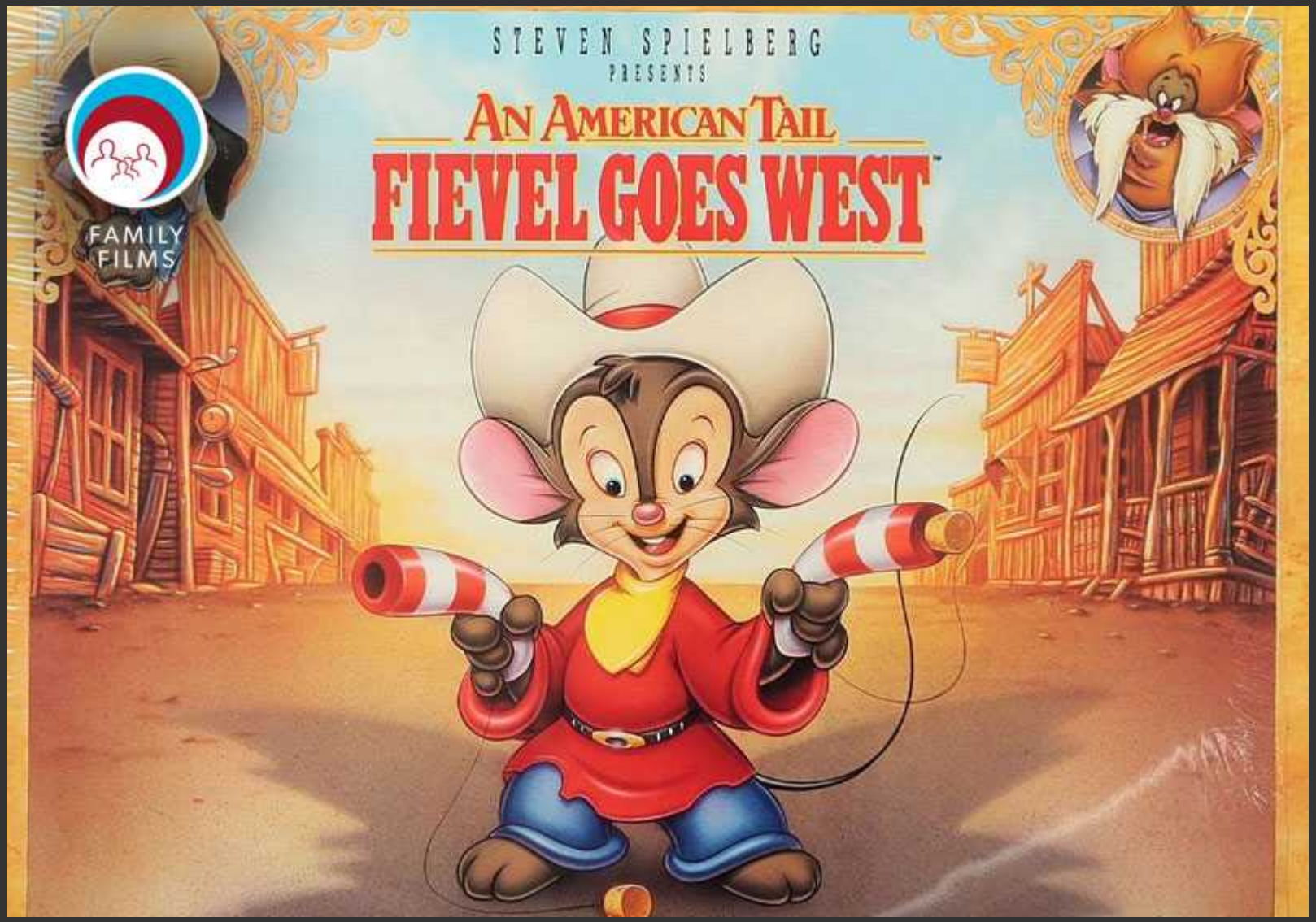
Stabilizing Selection



Balancing Selection



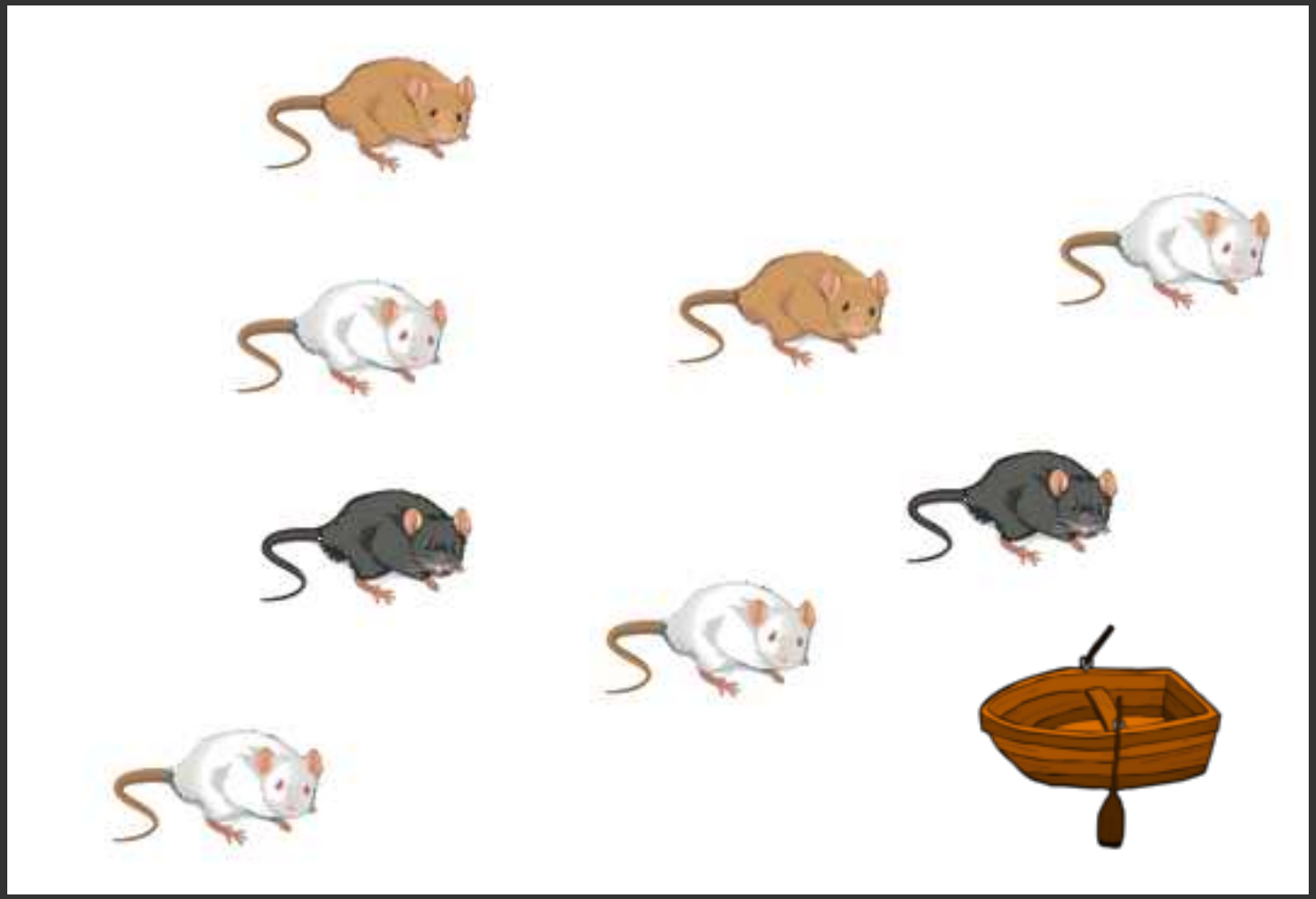
The saga of the island mice



The initial population of mice

Black	0.32
White	0.34
Brown	0.34

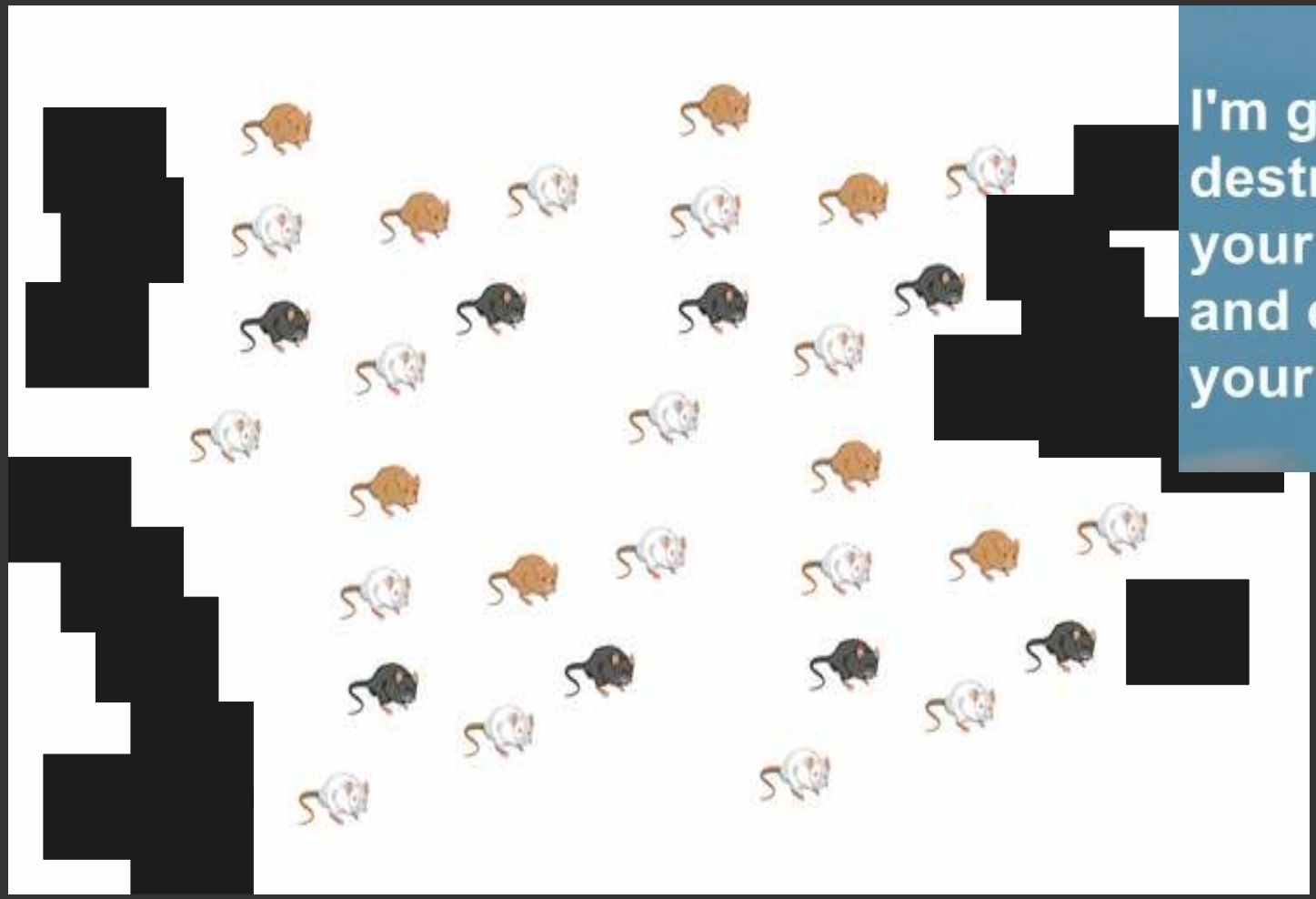
Some set sail to find a land free from cats



"Allele" frequencies:

Black=0.25 Brown=0.25 White=0.50

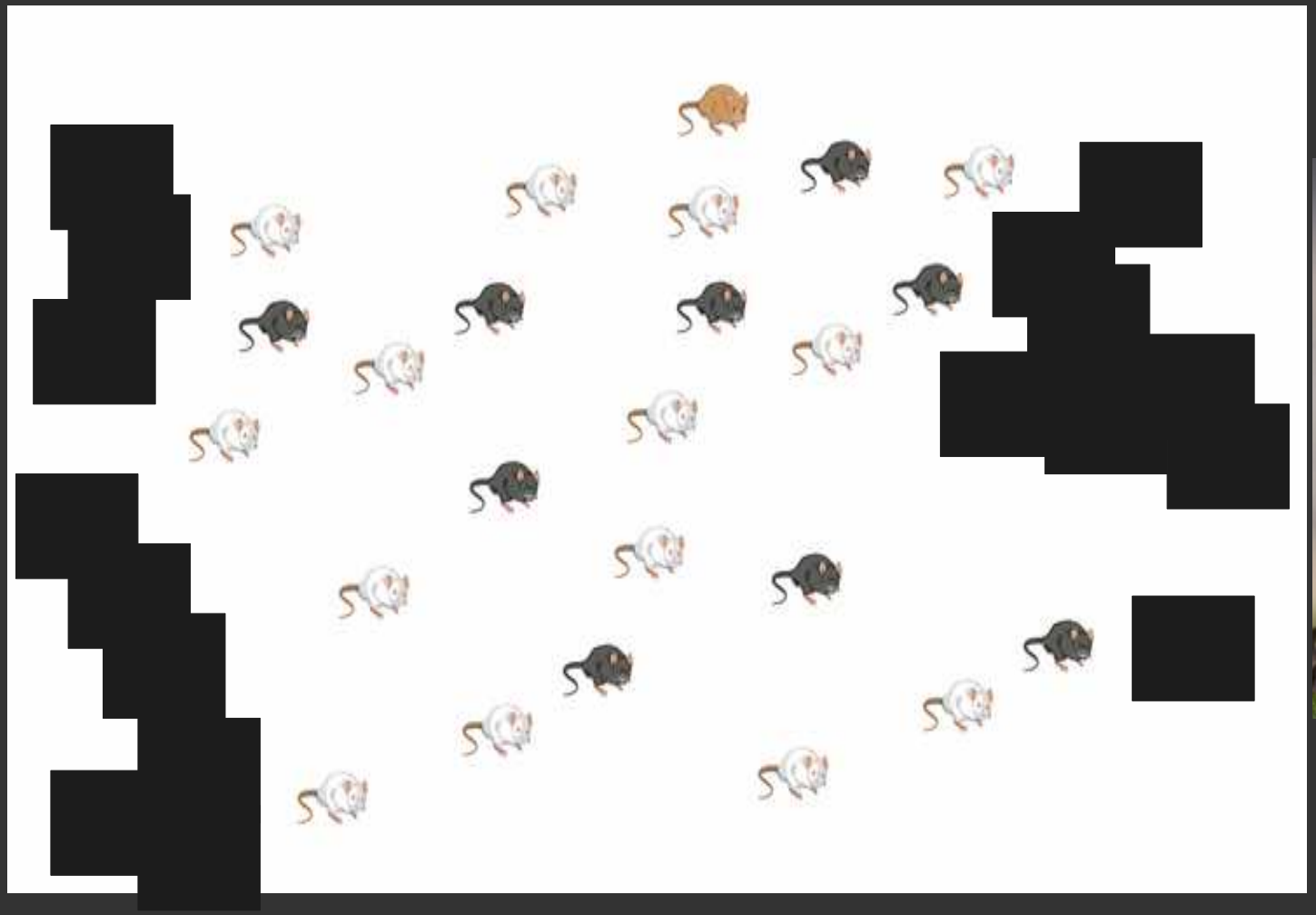
They came to an island full of white and black rocks (and evil birds)

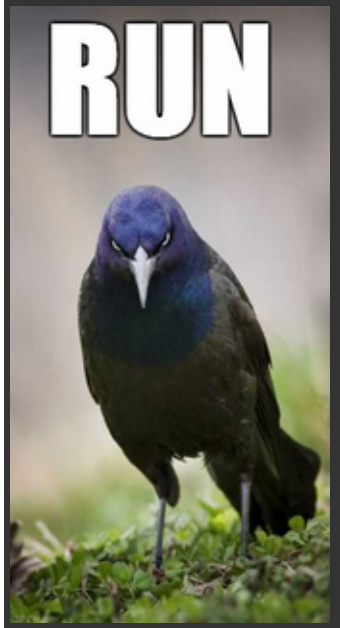


“Allele” frequencies in second generation:

Black=0.25 Brown=0.25 White=0.50

The brown mice couldn’t hide as well as black or white mice

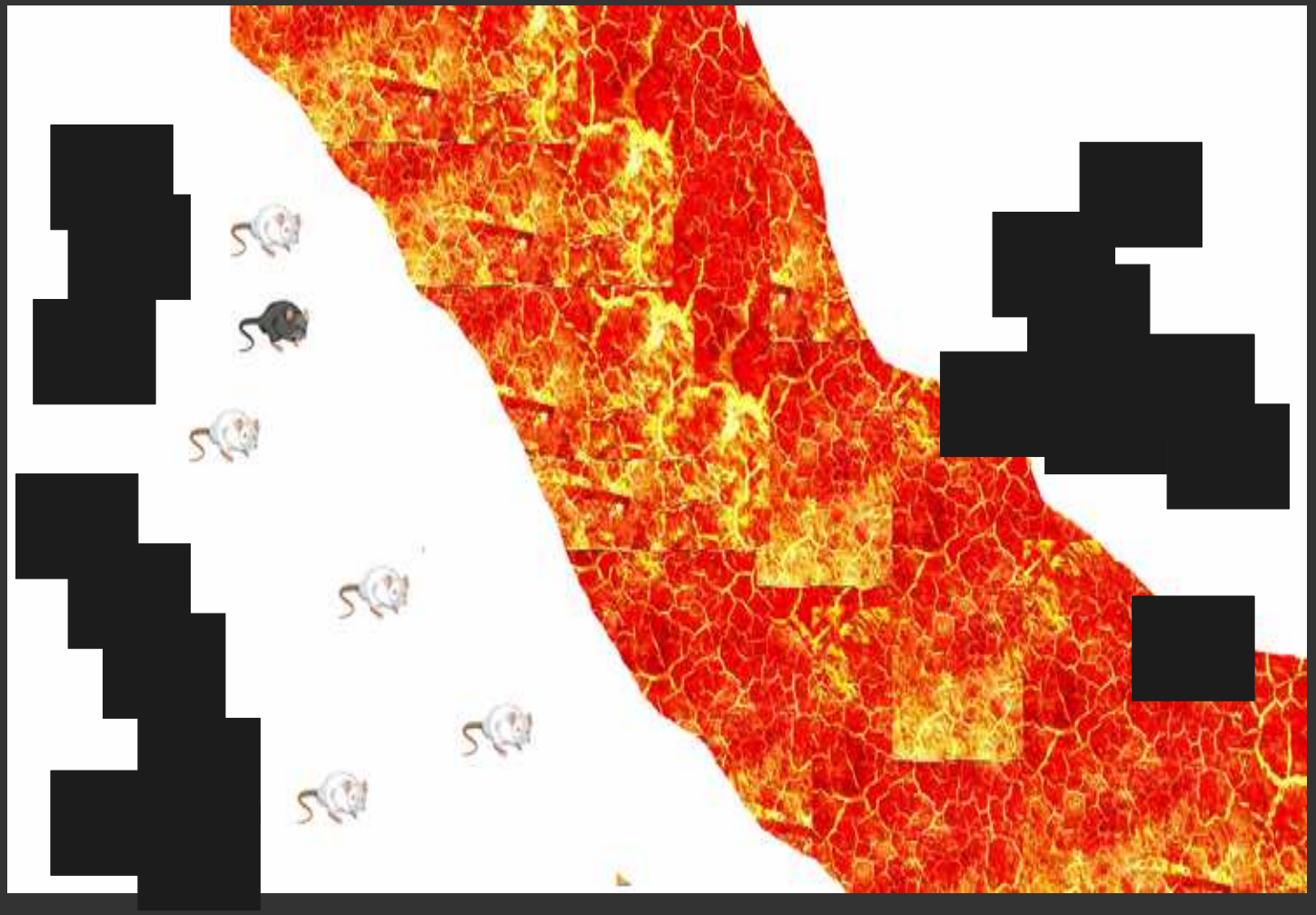




“Allele” frequencies, 3rd generation:

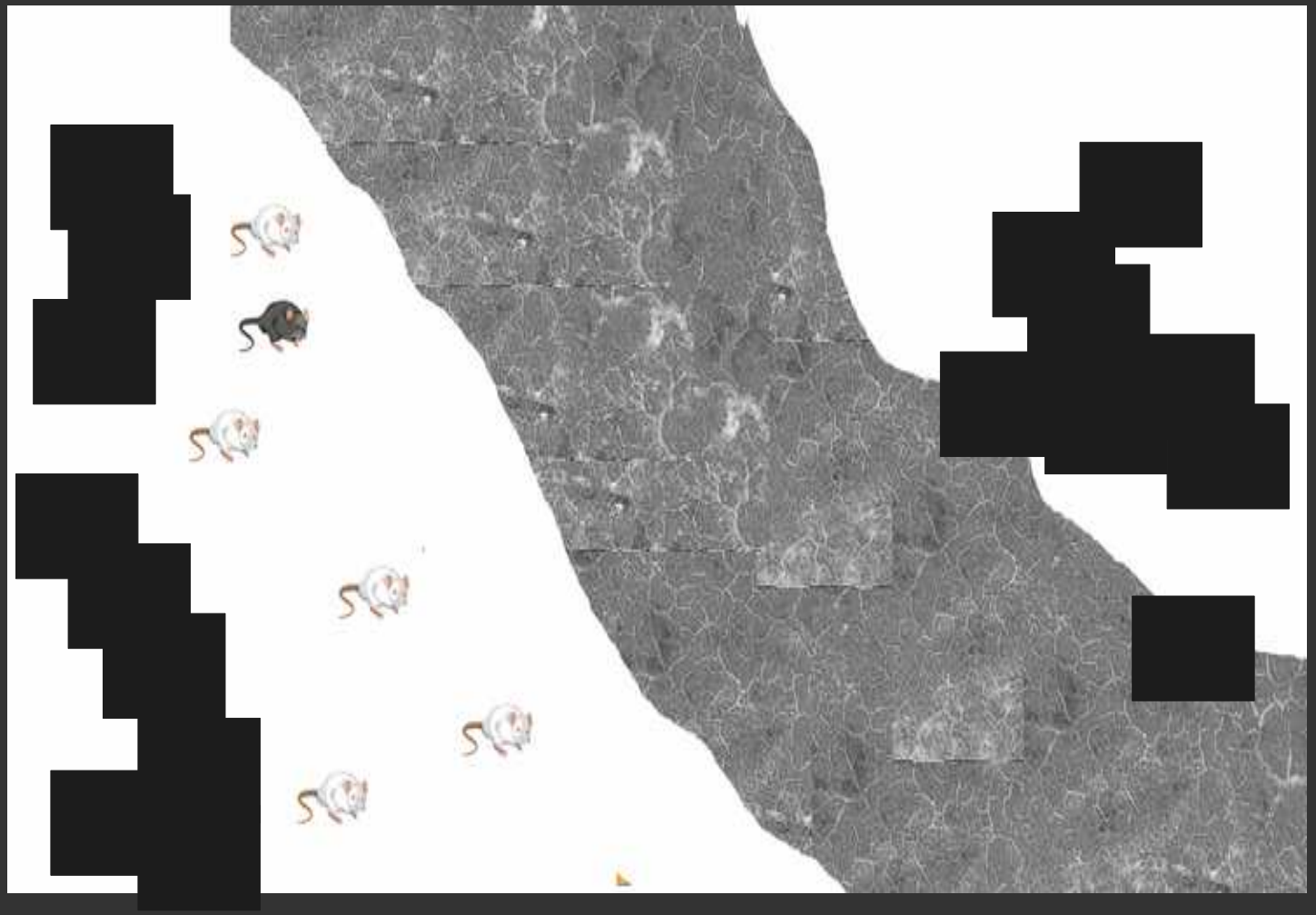
Black=0.37 Brown=0.04 White=0.58

Sadly, the island was a volcano, which killed most of the surviving mice



"Allele" frequencies, 3rd generation:
Black=0.17 Brown=0.00 White=0.83

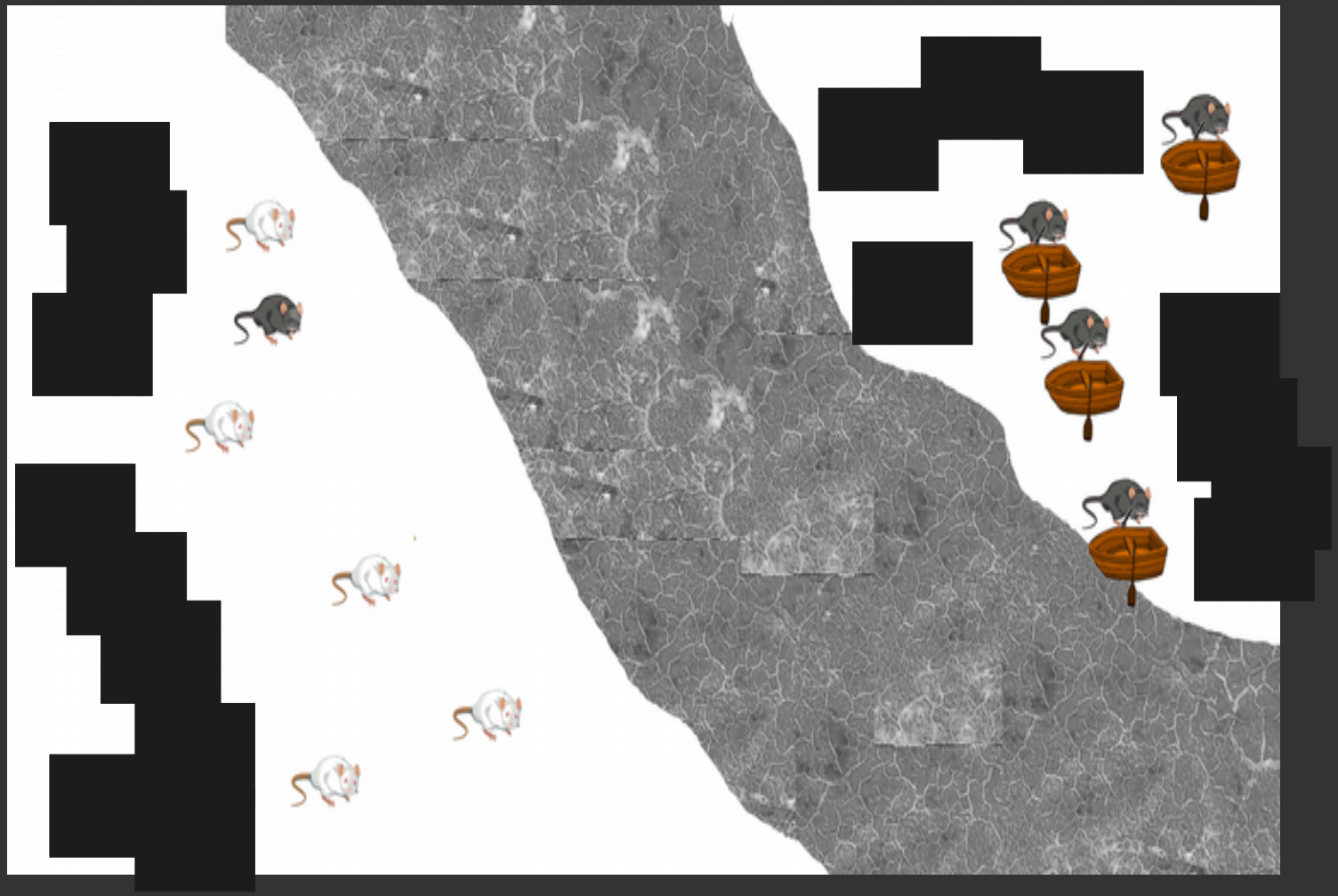
No brown mice were left. There was much sorrow.



“Allele” frequencies:

Black=0.17 Brown=0.00 White=0.83

Some new immigrants arrived on the island



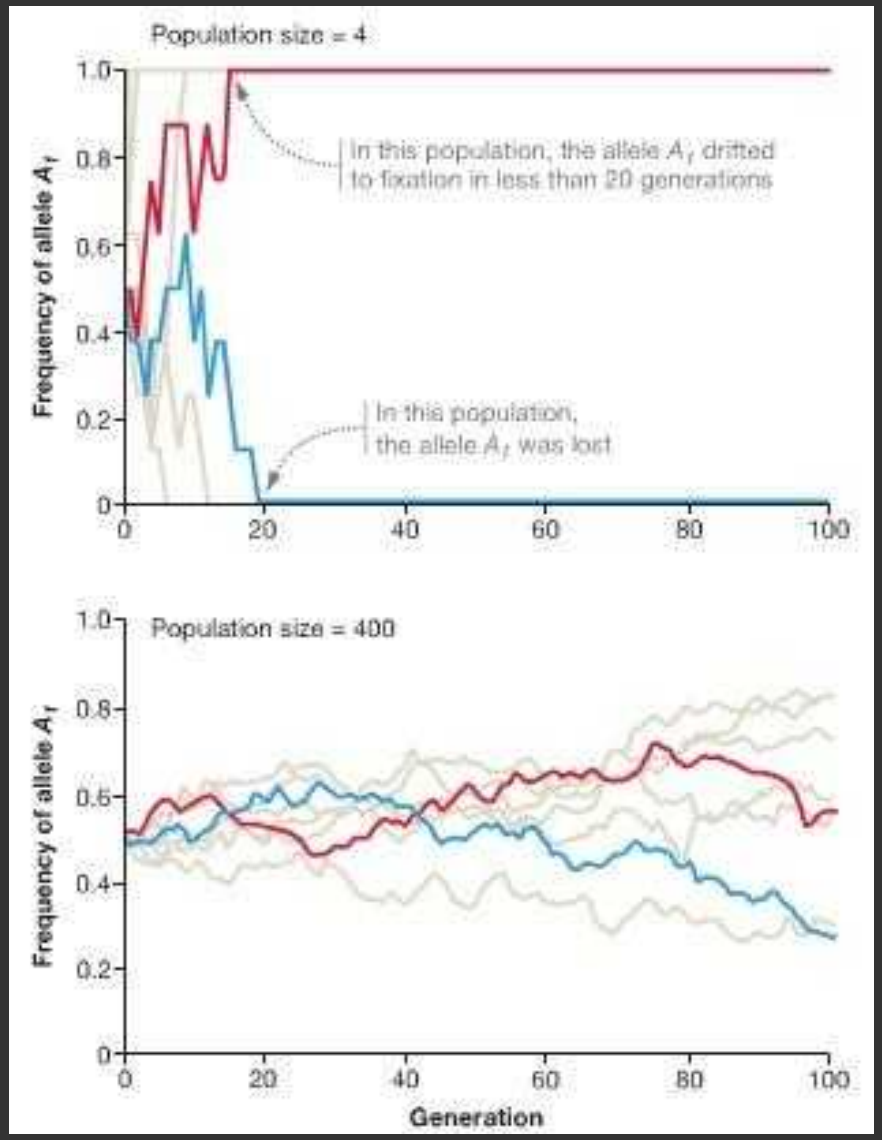
“Allele” frequencies:

Black=0.50 Brown=0.00 White=0.50

Then a cat went to the island and ate all the mice.

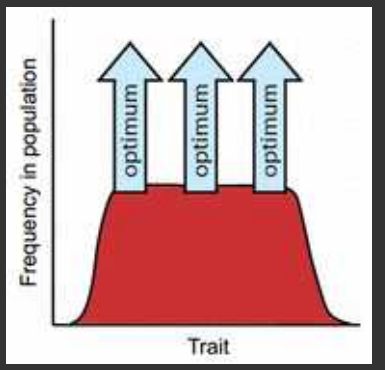
The end.

Genetic drift is stronger in smaller populations

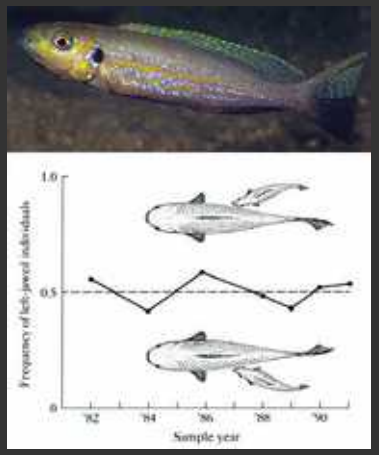


http://phyletica.org/teaching/drift-simulator/

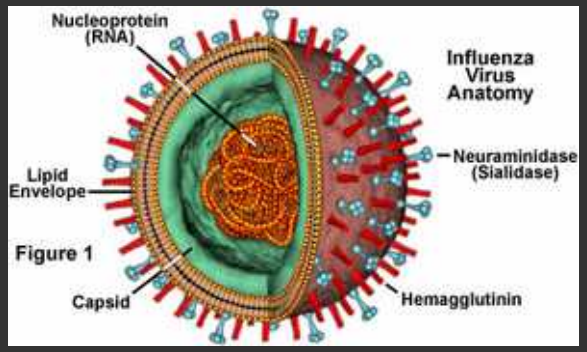
Balancing selection



Frequency-dependent selection

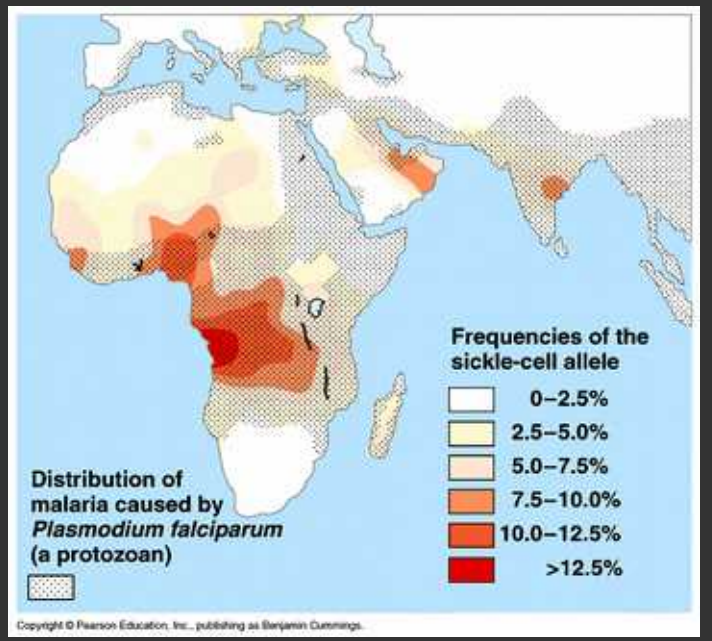


Perissodus microlepsis

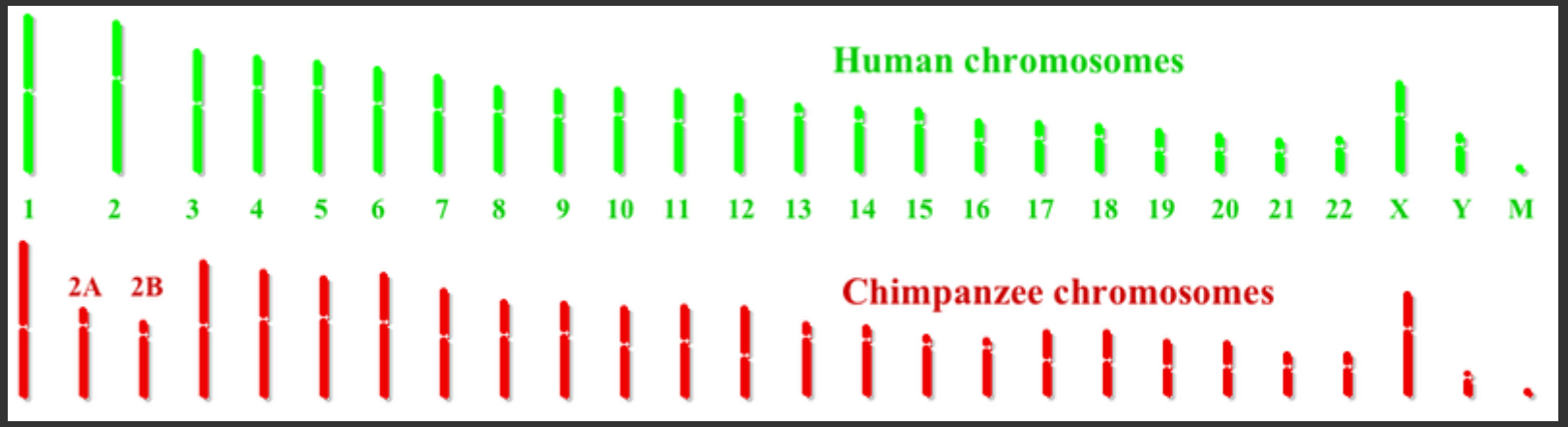


Influenzavirus A

Heterozygote advantage

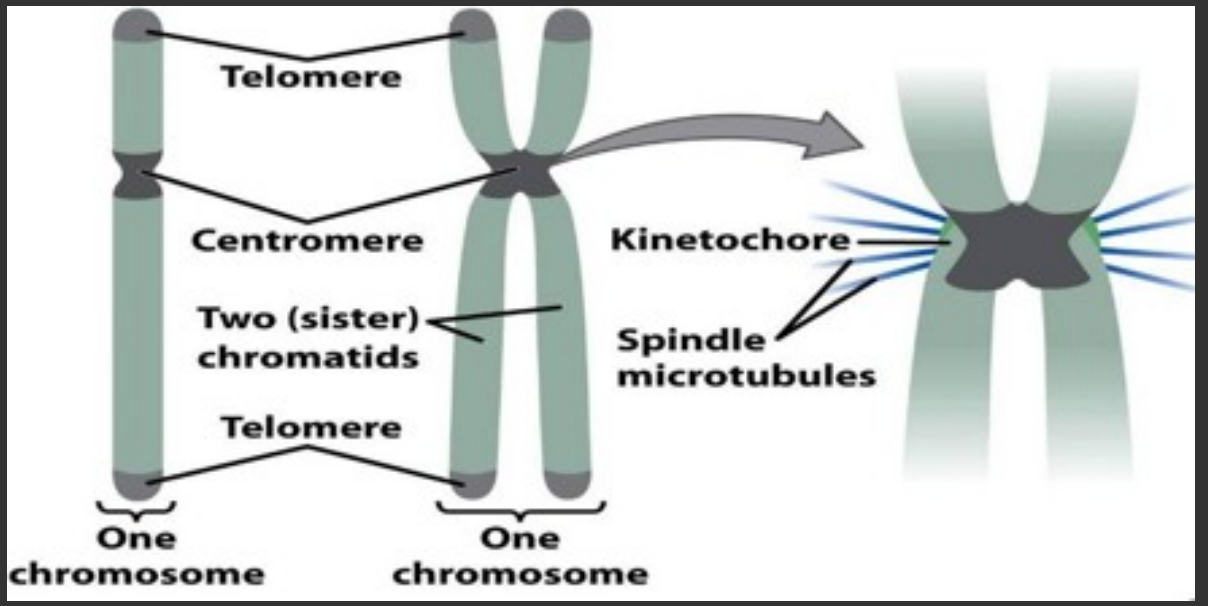


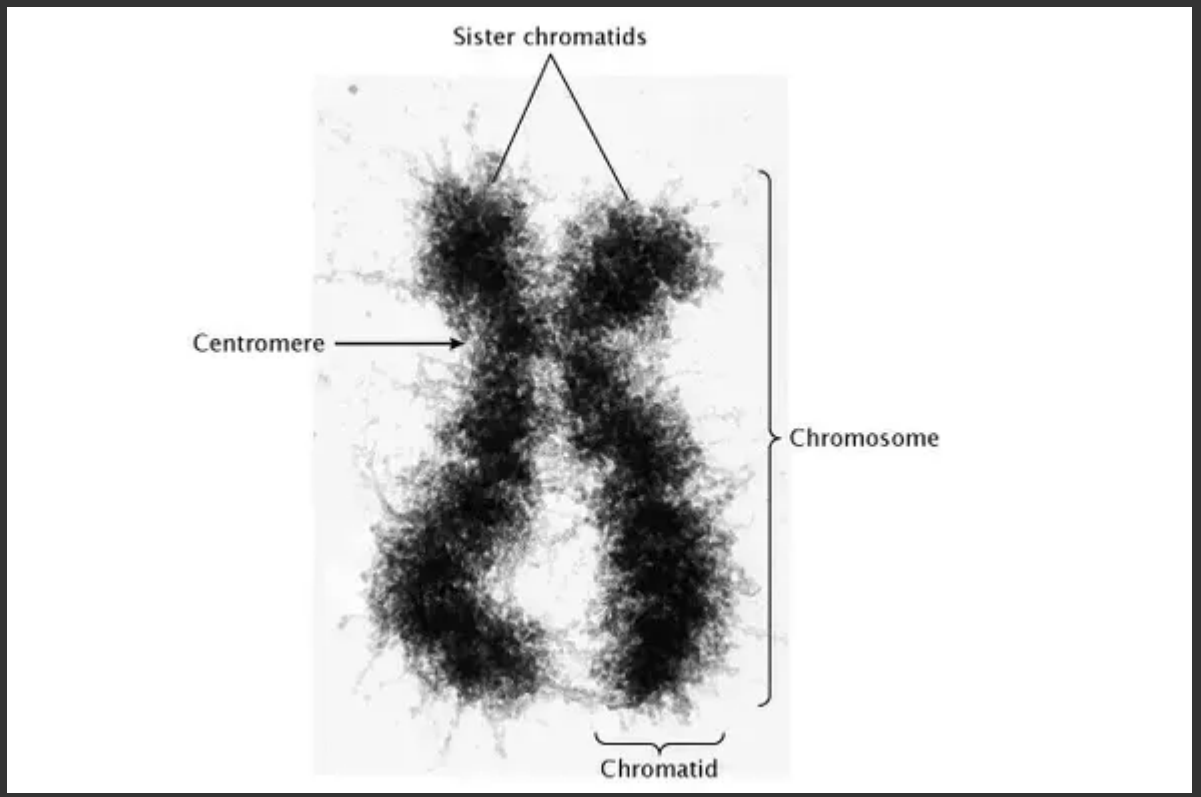
Environment can preserve variation in a population!



23 pairs

24 pairs


Telomere
Centromere
Two (sister) chromatids
Telomere
One chromosome
One chromosome
Kinetochore
Spindle microtubules


Sister chromatids
Centromere
Chromosome
Chromatid

Telomere

TTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTA
GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
TAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTA
GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
TAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTA
GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
TAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTA
GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
TAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTA
GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
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GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
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GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
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GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
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TAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTA
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GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
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GGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGG
GTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGTTAGGGT
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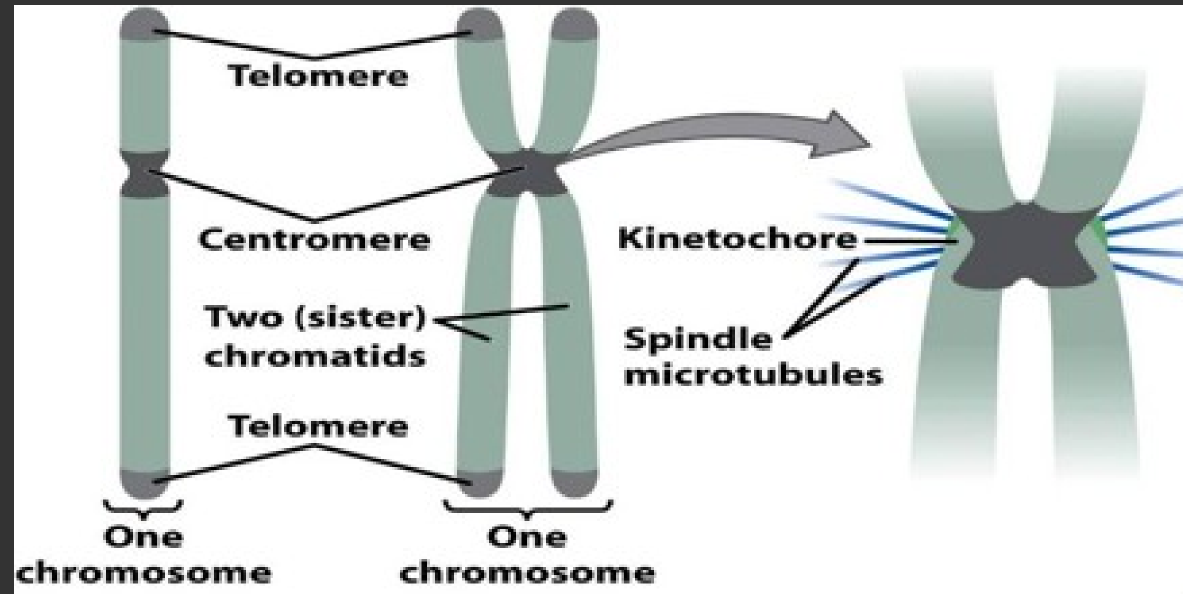
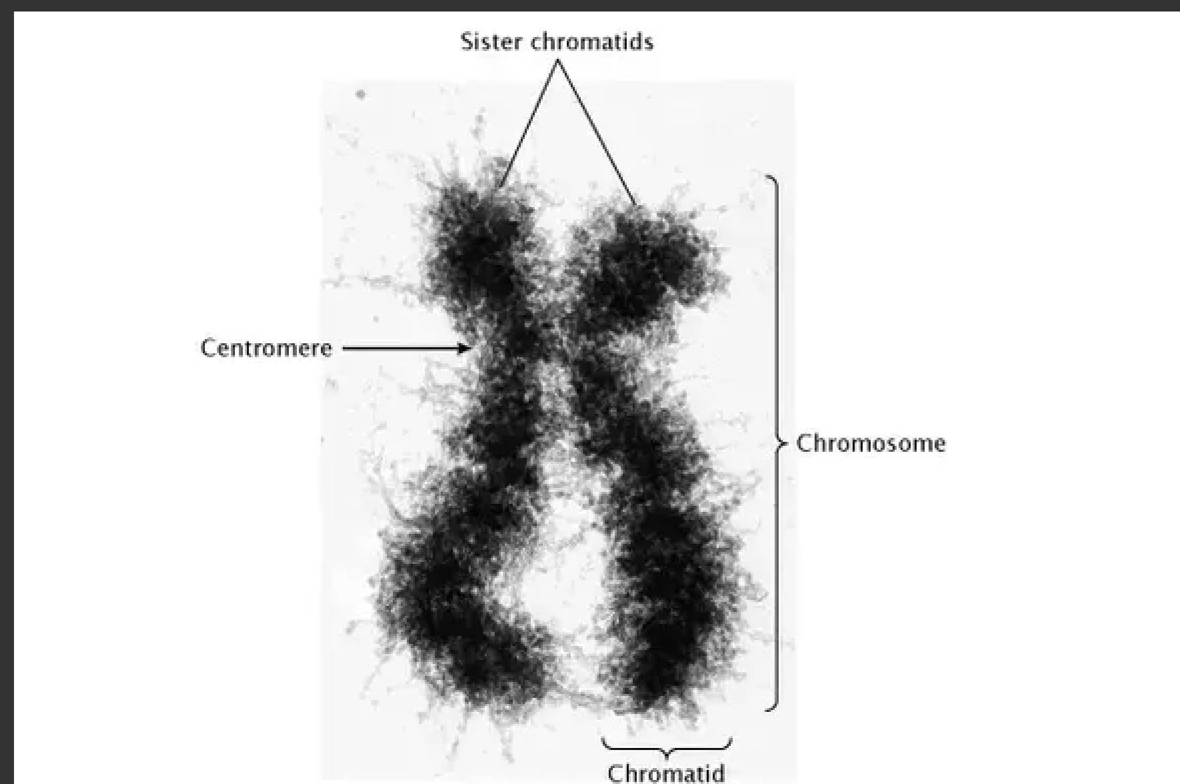
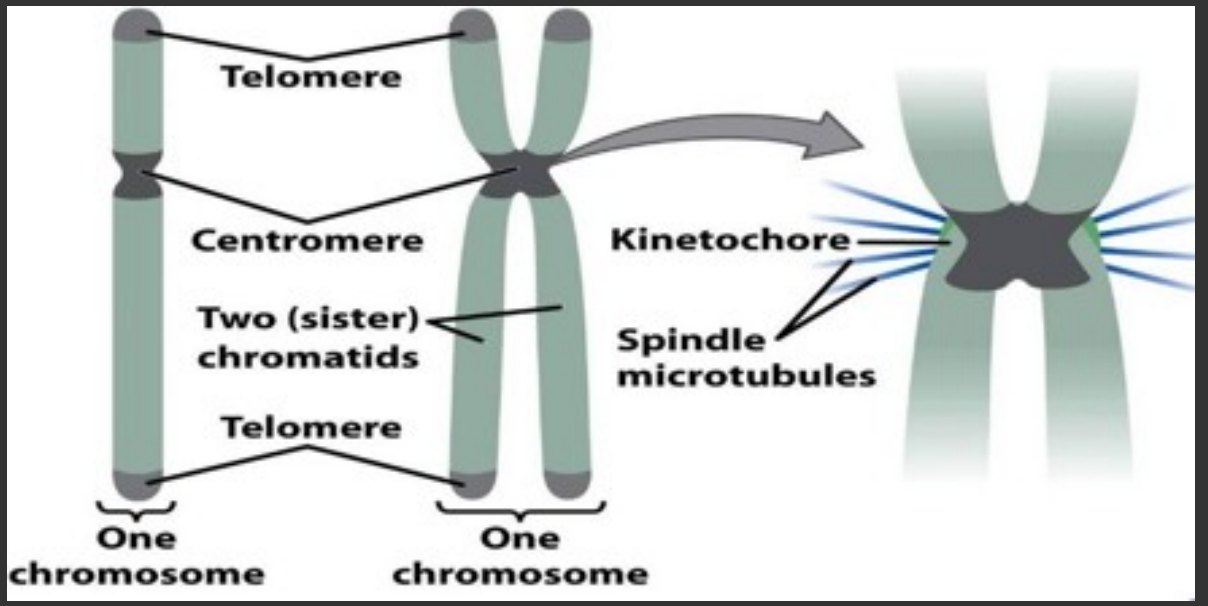




Centromere


Telomere
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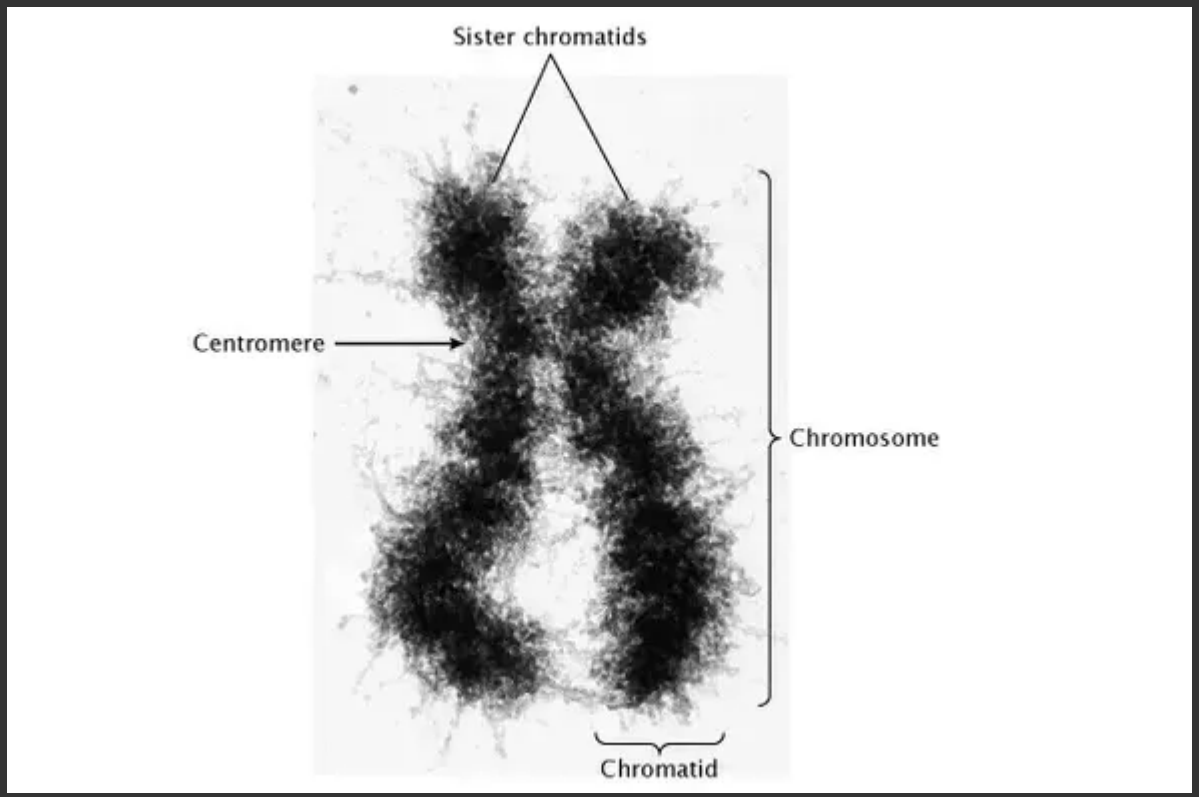
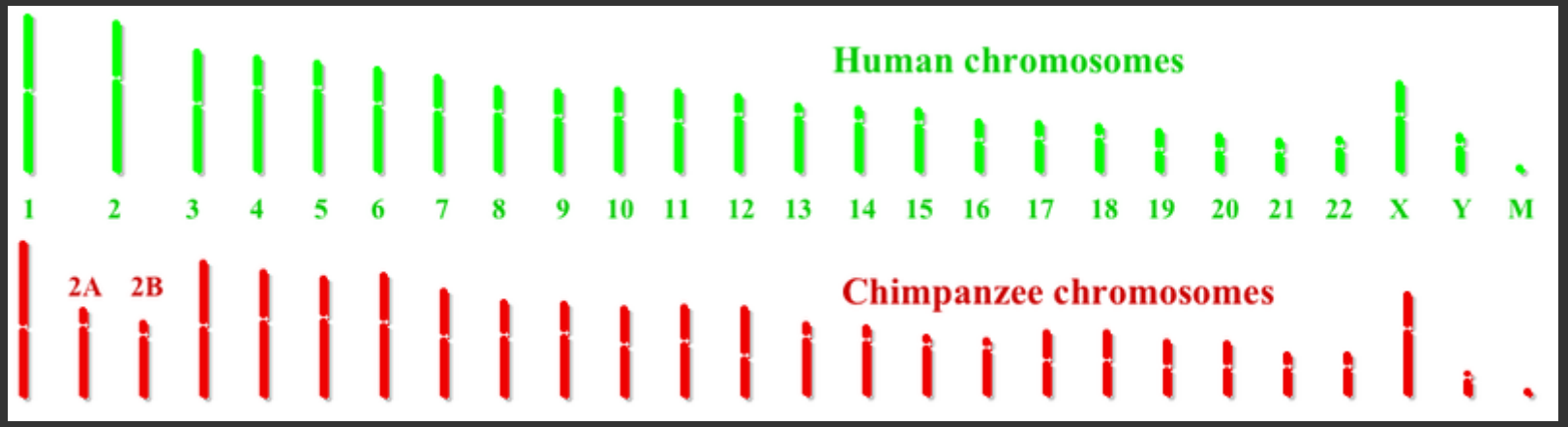
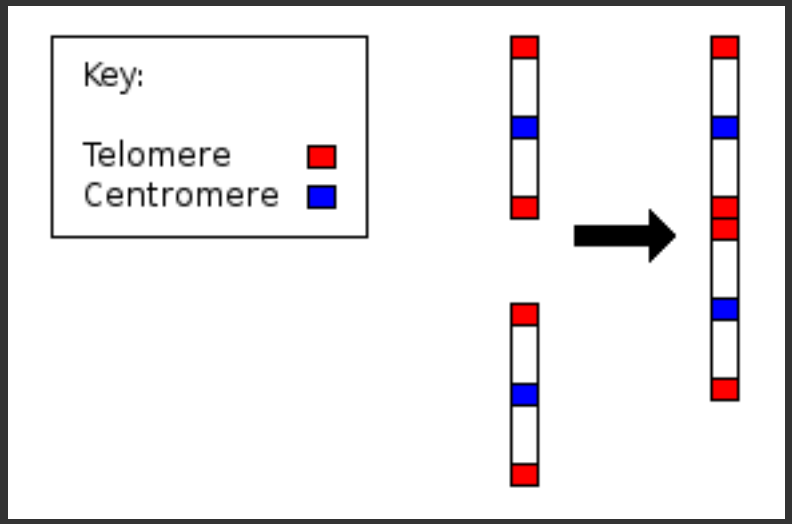

Sister chromatids
Centromere
Chromosome
Chromatid



Observation:

Humans have one fewer chromosome than all other apes.

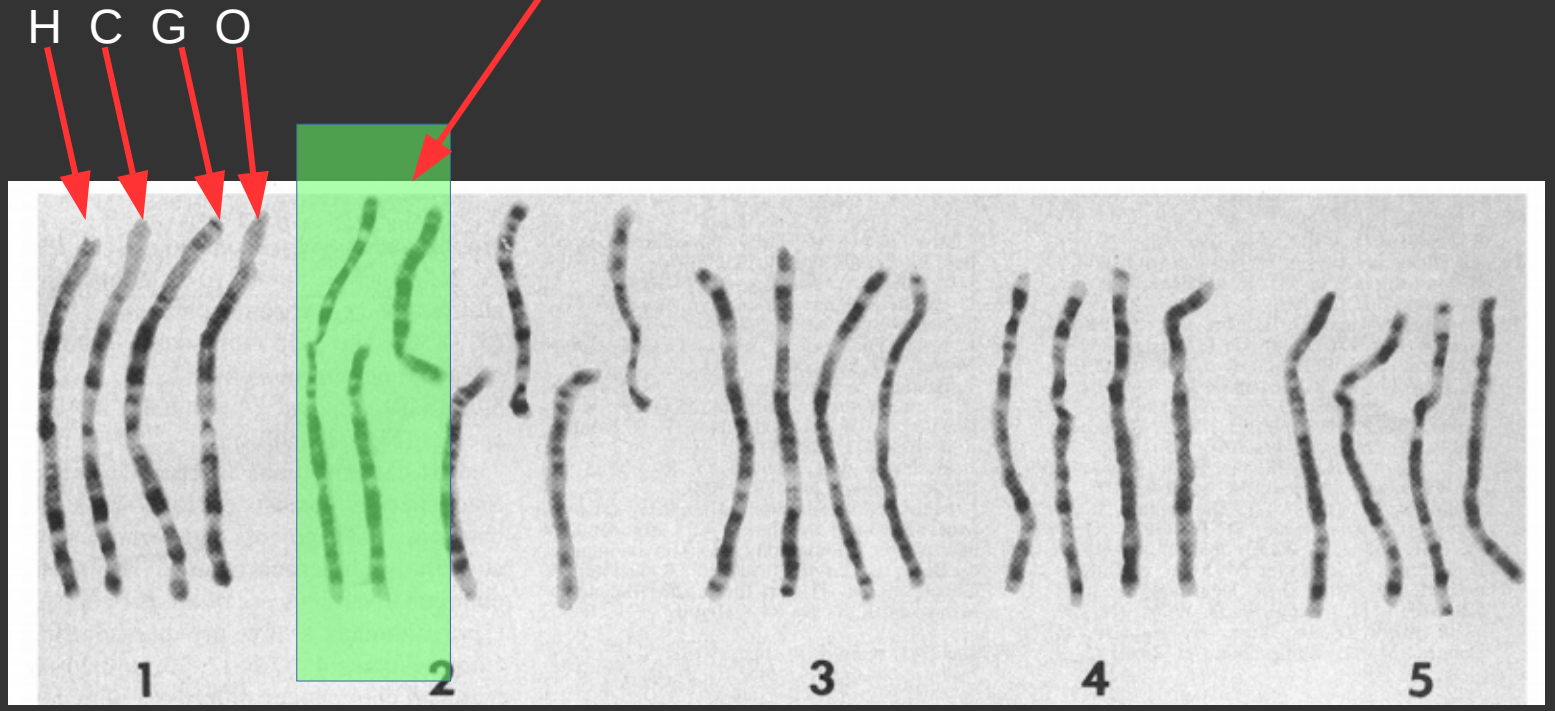
Hypothesis: "Missing" human chromosome is actually stuck inside another chromosome

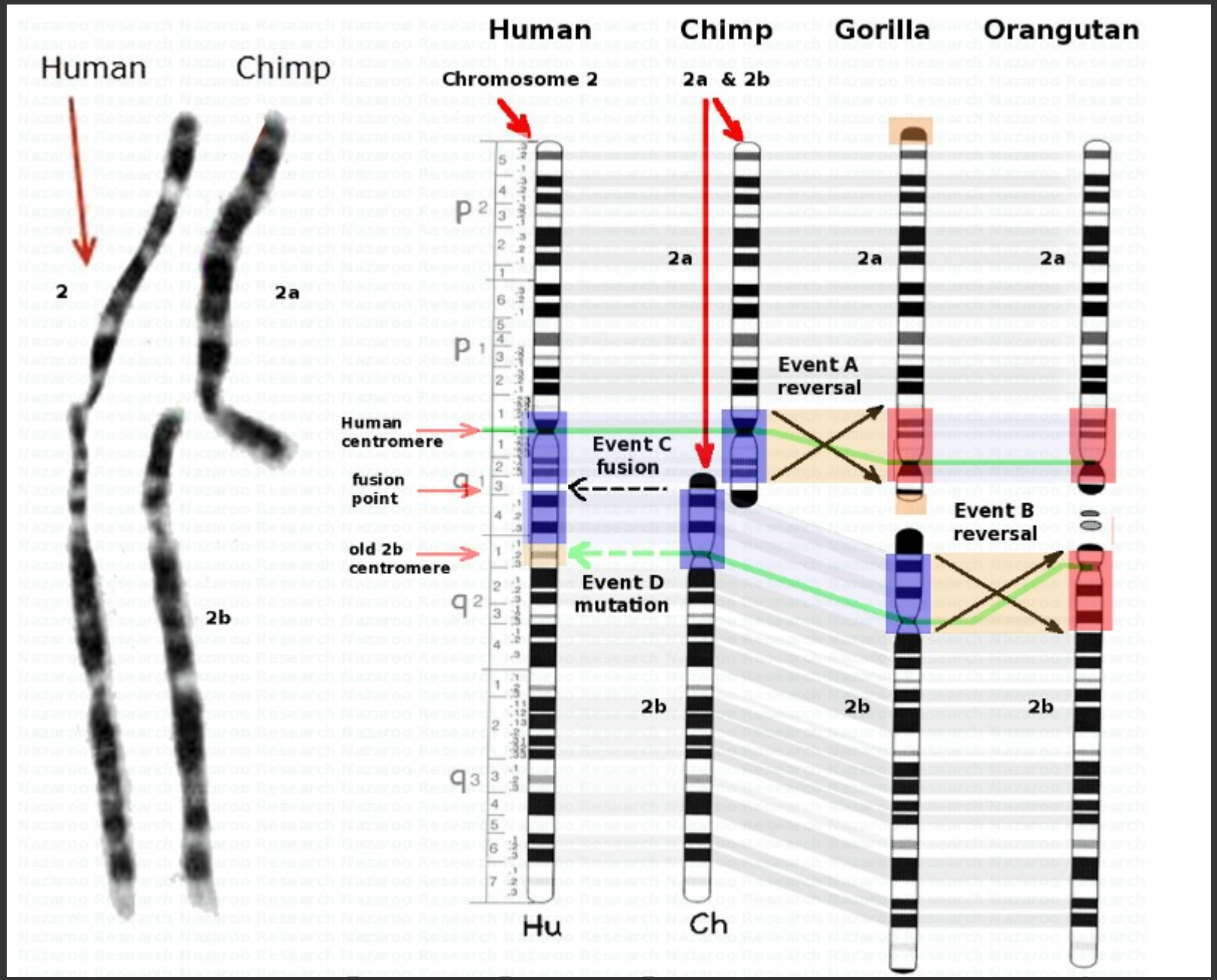


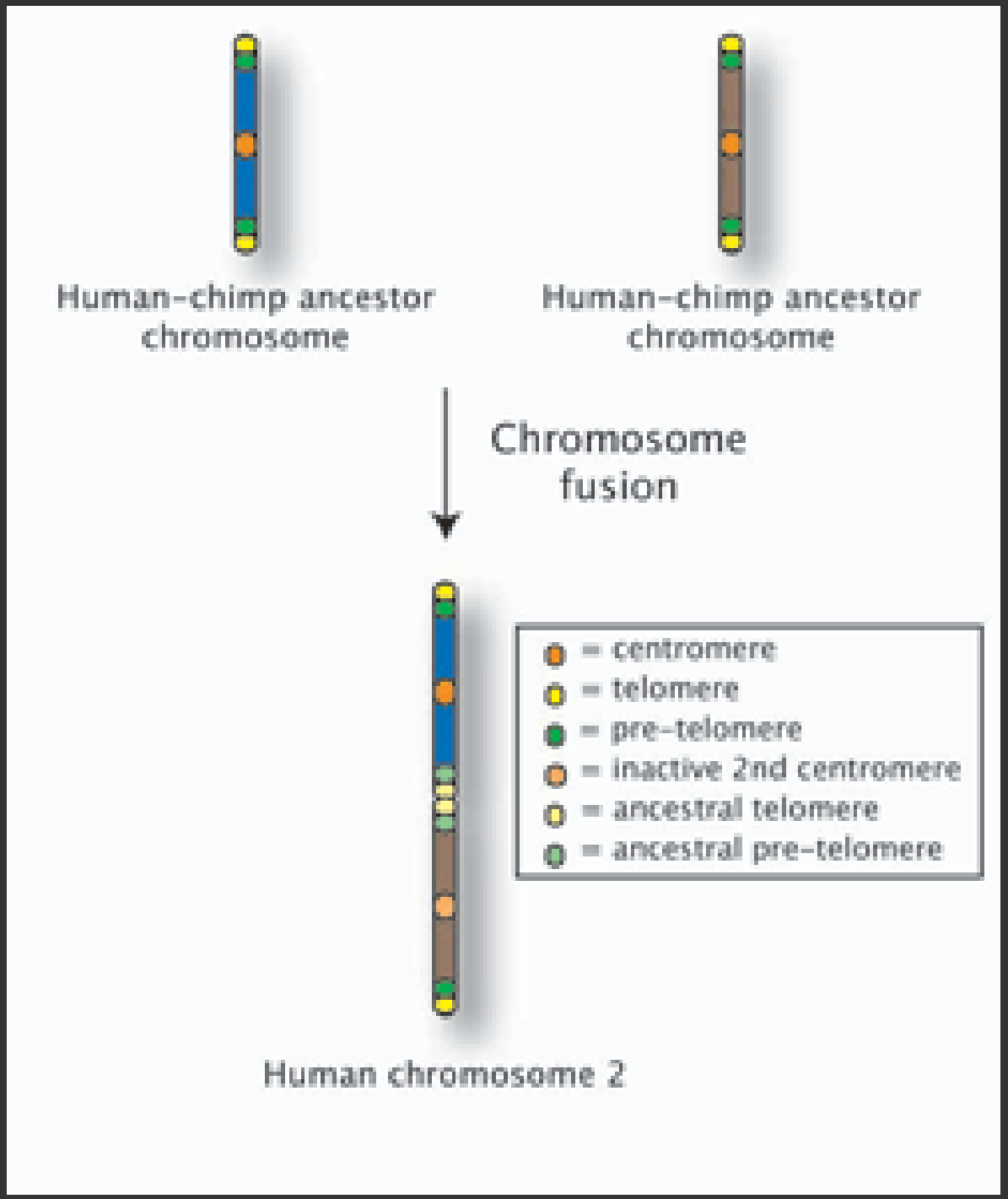
Testable? Falsifiable?

How would you test this hypothesis?

Sequence these entire chromosomes..... compare.




Human
Chimp
2
2a
2b
Human
Chimp
Gorilla
Orangutan
Chromosome 2
2a & 2b
p2
p1
q1
q2
q3
2a
2b
Human centromere
fusion point
old 2b centromere
Event C fusion
Event D mutation
Event A reversal
Event B reversal
Hu
Ch



Centromere and telomeres are exactly what hypothesis predicts

What about the actual genes?

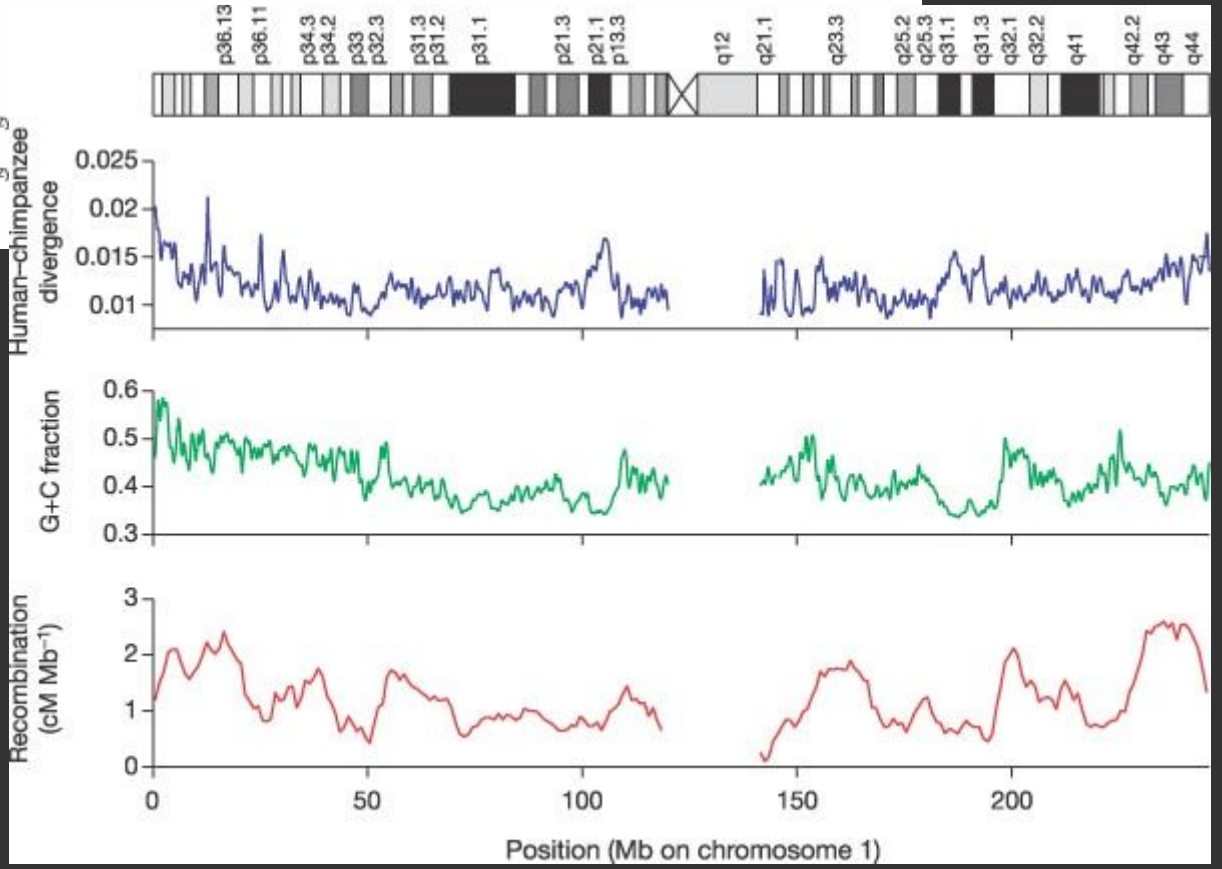
p-arm [edit]

Partial list of the genes located on p-arm (short arm) of human chromosome 2:

- ACTR2: encoding protein Actin-related protein 2
- ADI1: encoding enzyme 1,2-dihydroxy-3-keto-5-methylthiopentene dioxygenase
- AFF3: encoding protein AF4/FMR2 family member 3
- AFTPH: encoding protein Aftiphilin
- ALMS1
- ABCG5 and ABCG8: ATP-binding cassette, subfamily A, members 5 and 8
- C2orf18: encoding protein Transmembrane protein C2orf18
- C2orf28: encoding protein Apoptosis-related protein 3
- CAPG: capping acting protein
- CCDC142: Coiled-Coil Domain Containing 142
- CTLA4: cytotoxic T-Lymphocyte Antigen 4
- DHX57: DExH-box helicase 57
- DPYSL5: Dihydropyrimidinase like 5
- ERLEC1: Endoplasmic reticulum lectin 1
- EVA1A: encoding protein Eva-1 homolog A (C. elegans)
- FAM49A: Family with sequence similarity 49 member A
- FAM98A: Family with sequence similarity 98 member A
- FAM136A: Family with sequence similarity 136 member A
- FBXO11: F-box protein 11
- GEN1 encoding protein GEN1, Holliday junction 5' flap endonuclease
- GFPT1: glutamine—fructose-6-phosphate transaminase 1
- GKN1: gastrokine 1
- GPATCH11: G-patch domain containing protein 11
- GTF2A1L: General transcription factor IIA subunit 1 like
- HADHA: hydroxyacyl-Coenzyme A dehydrogenase/3-ketoacyl-Coenzyme A thiolase/enoyl-Coenzy hydratase (trifunctional protein), alpha subunit
- HADHB: hydroxyacyl-Coenzyme A dehydrogenase/3-ketoacyl-Coenzyme A thiolase/enoyl-Coenzy hydratase (trifunctional protein), beta subunit
- HSPC159: Galectin-related protein

vestigial centromere

- LEPQTL1: Leptin, serum levels of
- MEMO1: Mediator of cell motility 1
- MPHOSPH10: M-phase phosphoprotein 10
- MSH2: mutS homolog 2, colon cancer, nonpolyposis type 1 (*E. coli*)
- MSH6: mutS homolog 6 (*E. coli*)
- MTHFD2: Bifunctional methylenetetrahydrofolate dehydrogenase/cyclohydrolase, mitochondrial
- MTIF2: mitochondrial translational initiation factor 2
- NRBP1: Nuclear receptor-binding protein 1
- ODC1: Ornithine decarboxylase
- OTOF: otoferlin
- PARK3 encoding protein Parkinson disease 3 (autosomal dominant, Lewy body)
- PCYOX1: prenylcysteine oxidase 1
- PELI1: Ubiquitin ligase
- PLGLB2: Plasminogen-related protein B
- POLR1A: DNA-directed RNA polymerase I subunit RPA1
- PREPL: Prolyl endopeptidase-like
- PXDN: Peroxidasin homolog
- QPCT: Glutaminyl-peptide cyclotransferase
- RETSAT: All-trans-retinol 13,14-reductase
- SH3YL1: SH3 and SYLF domain-containing 1

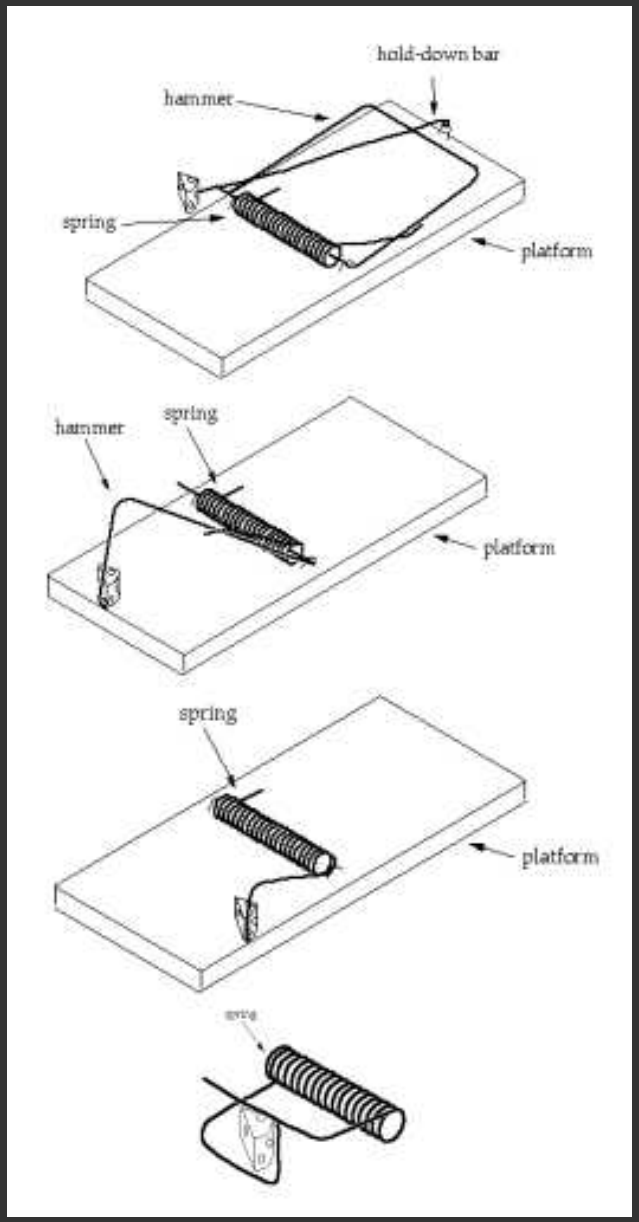


Same genes, in reverse order on human 2 vs chimp 2a

This generates new predictions

Natural selection is limited by historical constraints

Irreducibly complex mousetrap



Irreducible complexity?

Quiz – Week 3

1. If nucleotide variability of a locus equals 0%, what is the gene variability and number of alleles at that locus?

2. What is artificial selection?

3. Mammalian forelimbs are examples of _____ structures.

4. The bottleneck effect is a special case of ____?

5. What is the main source of genetic variability between human individuals?

Quiz – Week 3

1. If nucleotide variability of a locus equals 0%, what is the gene variability and number of alleles at that locus?

2. What is this an example of?

3. Bird and bat wings are examples of _____ structures.

4. The founder effect is a special case of ____?

5. What is the main source of genetic variability between human individuals?