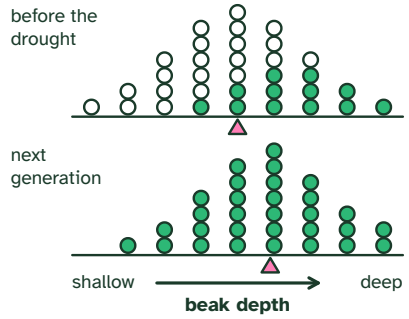
# Who leaves the most *offspring*?

What to know, what to draw and what to say. Nothing else.

**THE ONE IDEA**

**Individuals vary, and some variation is heritable. Those whose traits suit the environment leave more offspring, so the population changes over generations.**




**A drought on one island.** Green birds survived; white ones died. The pink mark is the mean.

**7.1.A** START HERE

## More offspring than can *survive*

- Populations produce **more offspring than the environment can support**. Food, water, space and mates are limited, so individuals **compete**.
- Survival is not random: individuals with **more favorable phenotypes** are more likely to live and reproduce. This is **differential survival and reproduction**, and their offspring inherit the traits.
- Natural selection is **one major mechanism** of evolution (Darwin and Wallace, 1858 and 1859). Drift, gene flow and mutation come in the next guide.

WHAT SELECTION NEEDS — *Very Important Parents*

| | | |
|---|---|---|
| **V** Variation: individuals differ in a trait | **I** Inheritance: the differences are heritable | **P** Production: some leave more offspring, because of the trait |

**7.1.A** NOT INDIVIDUALS

## Populations *evolve*

- **Evolution** is a change in the **heritable traits of a population** over generations.
- **Individuals are selected; populations evolve.** A finch keeps its beak for life.
- A change gained in life (a lifter's muscle, a chipped beak) is in body cells, not in the DNA of the **gametes**, so it is **not inherited**.

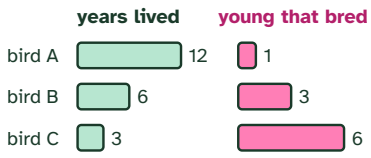
**Lamarck** rejected
A giraffe stretches and its calf is born with a longer neck.

**Darwin** supported
Necks already vary; longer necks reach more food and leave more calves.

**7.1.B** NOT STRENGTH

## Fitness is *offspring*

- **Evolutionary fitness** is measured by **reproductive success**: offspring that survive and reproduce in their turn.
- Surviving counts only as a step toward offspring. A healthy, sterile mule has a fitness of zero.
- Fitness belongs to a phenotype **in a particular environment**. The alleles of the fittest become more common.




**7.2.A** WHERE VARIATION COMES FROM

## *Heritable* variation

- Selection acts on **phenotypes**, but offspring receive **alleles**: variation caused by the environment alone is not passed on.
- Selection **never makes** a variation: it sorts what is there.

NEW ALLELES
**Mutation**
Random with respect to need.

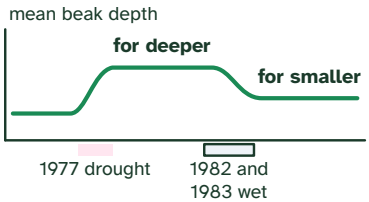
NEW MIXES
**Meiosis**
Crossing over, independent assortment.

NEW PAIRS
**Fertilization**
Gametes join at random.

**7.2.A 7.1.B**

## When the environment changes, so does *selection*

- A **selective pressure** is any feature of the environment that makes some phenotypes do better: **abiotic** (rainfall, temperature, a chemical) or **biotic** (predators, parasites, competitors, food).
- Environments are **stable or fluctuating**, so the **direction and rate of evolution** can change, and different variations can be selected in different generations.
- **Daphne Major, Galápagos:** the 1977 drought killed over 4 in 5 medium ground finches and left only large, hard seeds, so deeper beaks survived and their offspring had deeper beaks. After the wet years of 1982 and 1983 left small, soft seeds, selection favored smaller birds.
- **Field mustard** grown from seed collected after a run of dry years in California **flowered earlier** than seed from before it (about 2 and 9 days at two sites).




A sketch of the pattern, not measured values.

# One trait, two places, and selection by *people*

7.2.A DDT AND MOSQUITOES

## Helpful here, *harmful* there

- A variation can **raise or lower the fitness** of an organism **in a particular environment**. No allele is good everywhere.
- **DDT** was sprayed against malaria mosquitoes from the 1940s. Resistance alleles arose by **chance mutation**; DDT killed the susceptible ones, so the resistant ones left the offspring.
- In *Anopheles funestus* one allele changes one amino acid in the enzyme GSTe2, which then breaks DDT down. With no DDT the allele often **costs** something, so it becomes rarer.
- The human case is the **sickle cell allele**, which helps where malaria is common (next guide).




Illustrative fitness values.

7.2.B MOLECULES VARY TOO

## Variation *inside* the cell

- Individuals and populations vary in the **number and types of molecules** in their cells, not only in traits you can see.
- That variation gives a population a **greater ability to survive and reproduce** in different environments.

NUMBER
**More gene copies**
Some resistant mosquitoes carry many copies of an esterase gene: more enzyme to break the insecticide down.

TYPE
**Membrane fatty acids**
Kinked unsaturated tails keep a membrane fluid; cold-water fish have more.

VERSION
**Hemoglobin**
Mountain deer mice carry alleles for hemoglobin that binds oxygen more tightly.

7.3.A

## Artificial selection: a *person* chooses

- In **artificial selection** humans choose which individuals reproduce, so **humans are the selective pressure**. The mechanism is the same: heritable variation, unequal reproduction, change over generations.
- **Wild cabbage** (*Brassica oleracea*) of European sea cliffs gave six vegetables, each selected for a different part. All six are still **one species**.
- **Maize** was bred from teosinte, a wild grass, from about 9,000 years ago in southern Mexico. In Illinois, maize has been selected for high and low oil every year since 1896.
- Breeders choose only among **variation that already exists**, and a breed or crop from a few chosen parents often has **lower genetic variation**: more inherited disorders, or a crop open to one disease.

| PART SELECTED | VEGETABLE |
|---|---|
| **Leaves** | Kale |
| **Terminal bud** | Cabbage |
| **Side buds** | Brussels sprouts |
| **Stem** | Kohlrabi |
| **Flower heads** | Broccoli, cauliflower |

**Natural** the environment selects
People add an antibiotic, but no one picks which bacteria live.

**Artificial** a person selects
The breeder picks who reproduces: the biggest cobs.

WATCH OUT

## Five mistakes that *cost points*

- ✕ **Organisms do not change because they need to.** Variation arises first, by chance; selection sorts it.
- ✕ **An individual never evolves.** Individuals are selected; the population changes over generations.
- ✕ **DDT did not cause the mutations.** The alleles were already there; DDT changed who survived to reproduce.
- ✕ **Fittest does not mean strongest.** Write "reproductive success" or "offspring" every time you write fitness.
- ✕ **Selection, natural or artificial, never makes new alleles.** Only mutation does.

COVER THE SHEET

## Can you *answer these?*

1. Describe the steps of natural selection in a drought.
2. Explain why a trait gained in life is not inherited.
3. Identify how evolutionary fitness is measured.
4. Predict the next generation if beak depth were not heritable.
5. Explain how a fluctuating environment changes selection.
6. Predict the resistance allele's frequency once DDT stops.
7. Describe two ways molecules in cells vary.
8. Explain why a crop breed can lose genetic variation.

IN THE EXAM

**Write the chain in full:** heritable variation, a named selective pressure, differential survival and reproduction, a change in the population over generations. Never "the finches adapted because they needed to".

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.