CE **Animation** Evolution **Seq** 1 Page# 1

Sc 1 **Panel** 1

Evolution

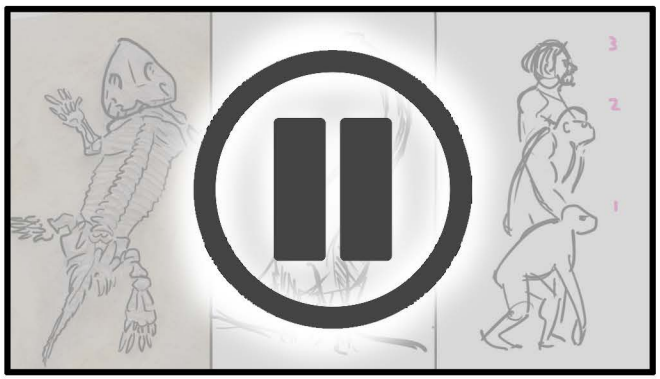
When you hear the word evolution, what comes to mind?

Sc 1 **Panel** 2

Maybe you picture fossils, dinosaurs, or that famous image of a chimp slowly standing up to become a human.

Panels reveal when described one by one;
the third one should be a rough animation
(3 or 6 drawings, per the famous illustration)

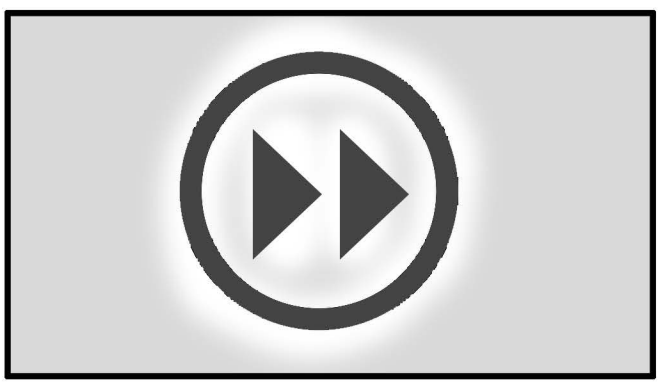
Sc 1 **Panel** 3



But evolution isn't just something that happened millions of years ago.

Add a glitchy, film grain, or flicker effect to make it feel like it's really pausing, and then another 'click' as the fast forward 'button' is hit next panel

Sc 1 **Panel** 4

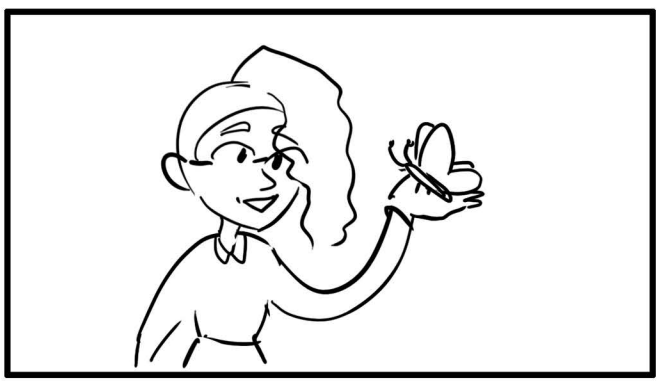


It's happening right now

Extreme fast forward montage, using clips from other projects to seem like we're zooming through human history

Sc 1 **Panel** 5

Sc 2 **Panel** 1



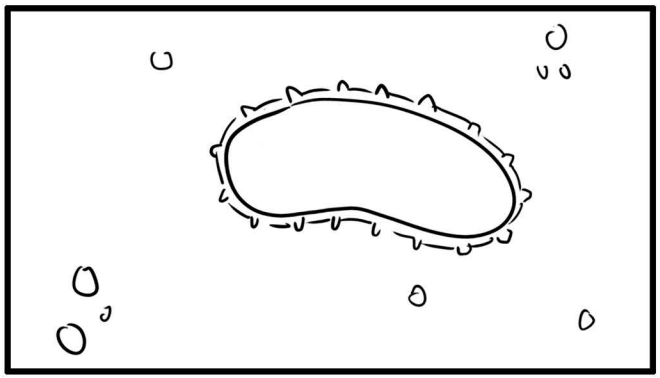
All around us.

Butterfly flaps and lands on her hand.
[Woman_Glasses AE character]

Story Artist AJ Ogden

CE **Animation** Evolution **Seq** 1 Page# 2

Sc 2 **Panel** 2

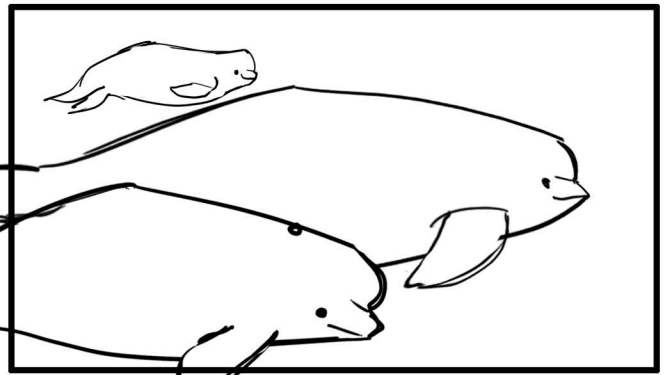


Bacteria are evolving resistance to antibiotics
Bacteria wiggling around

Sc 2 **Panel** 3

Insects are adapting to pesticides
(Colorado Potato Bug)
Antenna wiggling mayhaps, or leaf swaying

Sc 2 **Panel** 4

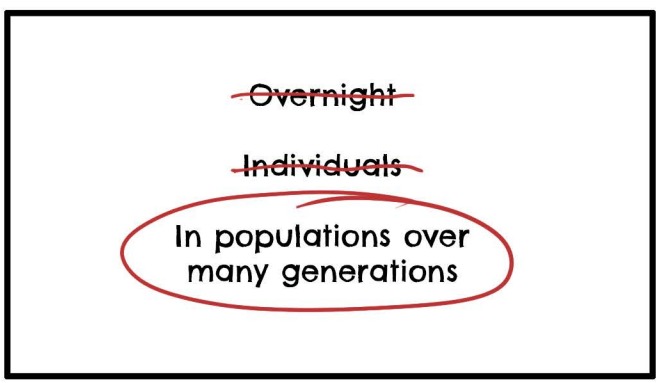


And even some animals are changing their breeding times or migration routes in response to climate change.
Whales drifting, maybe an ocean light effect. The adult beluga whales are white, the baby is a dark blue-gray.

Sc 3 **Panel** 1

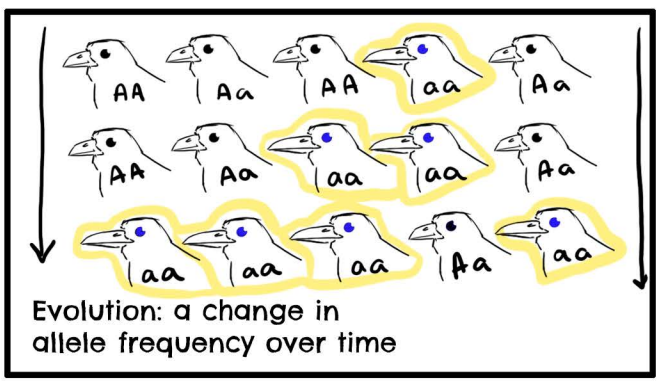
So how does this happen?

Sc 3 **Panel** 2



Evolution doesn't happen overnight and it doesn't happen in individuals. It happens in populations over many generations.
Via mask, make the strikethroughs and circle appear like they're being drawn in real time

Sc 3 **Panel** 3



When scientists talk about evolution, they are talking about a change in allele frequency over time, or in other words, how common or uncommon different versions of genes become in a population from one generation to the next.
The "aa" group has blue eyes and larger beaks

Story Artist AJ Ogden

CE **Animation** Evolution **Seq** 1 Page# 3

Sc 3 **Panel** 4

Four Main Mechanisms of Evolution

1. Natural (and Artificial) Selection
2. Genetic Drift
3. Gene Flow
4. Mutations

These changes in allele frequency occur through four main mechanisms of evolution. The first one...
...and sometimes even form new species.

Sc **Panel**

Sc **Panel**

Sc **Panel**

Sc **Panel**

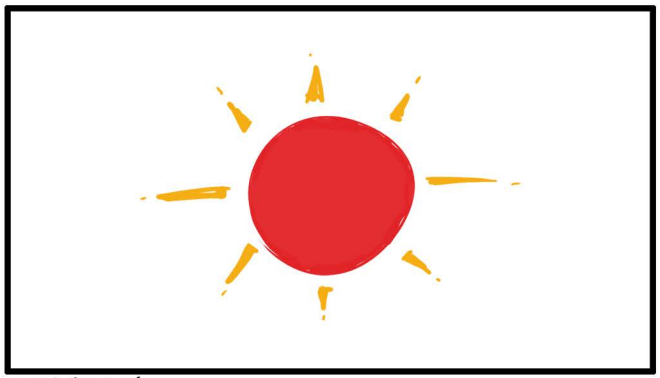
Sc **Panel**

Sc **Panel**

Story Artist AJ Ogden

CE Animation Cell 120 18- Evolution Seq 2 Page# 1

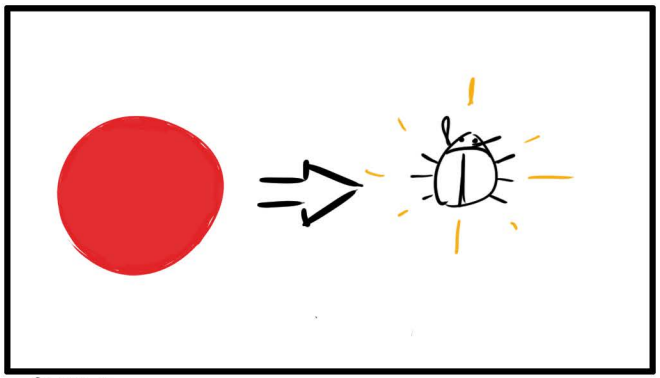
Sc 1 Panel 1



00:01:16

To make this easier, we are going to demonstrate each of these mechanisms using M&Ms.

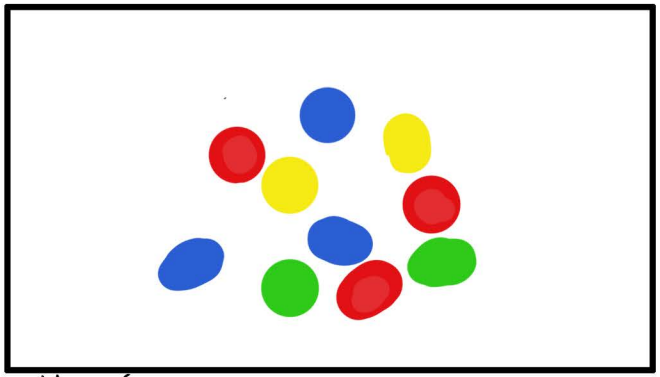
Sc 1 Panel 2



01:22

Imagine each M&M represents an organism in a population.

Sc 1 Panel 3

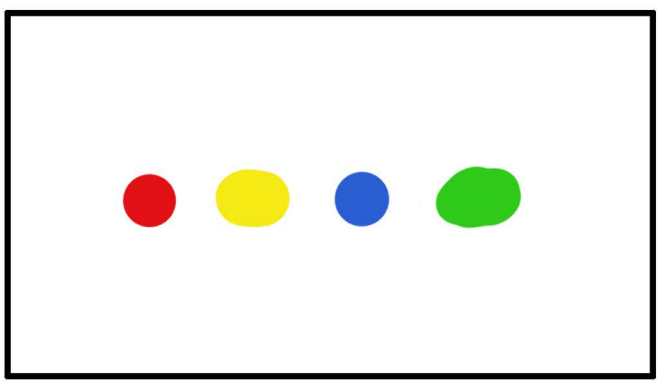


01:26

bugs are scattered across the screen, then turn into MnMs

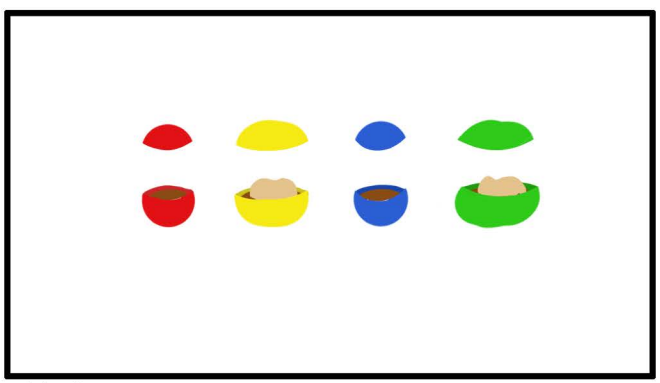
They are all of the same species, M&Ms, but there are different colors or characteristics representing different alleles or versions of the genes.

Sc 1 Panel 4



For example, the different colors represent ifferent alleles or versions of the color gene.

Sc 1 Panel 5



01:40

The presence of peanuts or chocolate on the inside represent the inner filling gene.

MnMs open up

This mix of colors and inner fillings

Sc 1 Panel 6

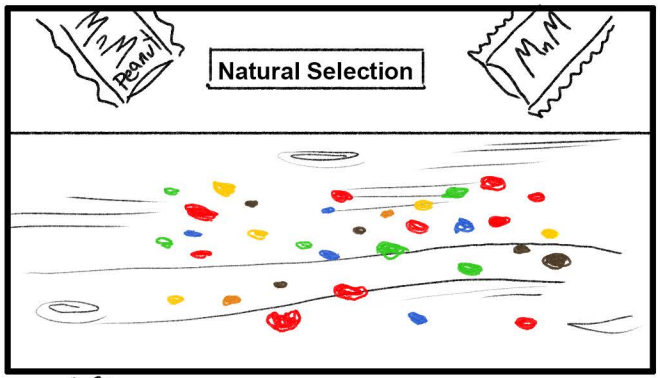
01:48

represents genetic variation, just like in a real population where individuals have different traits. It is this variation that evolution acts upon. So now we will explore the different mechanisms of evolution and how they can change our M&M population over time.

Story Artist Isaac Pitcher + Logan M. Shelley

CE **Animation** Cell 120 — 18- Evolution — **Seq** 2 — Page# 2

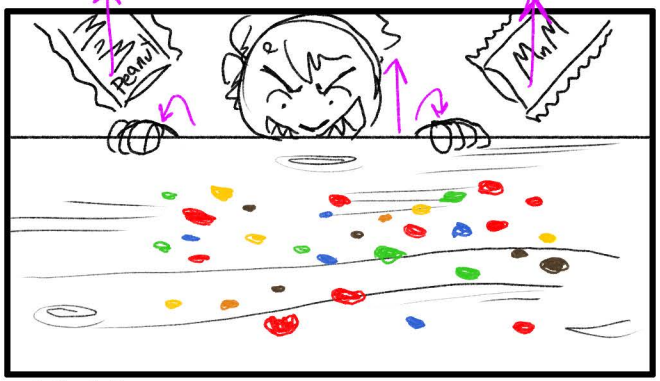
Sc 2 — Panel 1



02:06

Let's start with natural selection.
We have a bunch of regular and peanut M&Ms
poured out on a surface.
Title 'Natural Selection' pops up first, followed by the
scene, then fades out

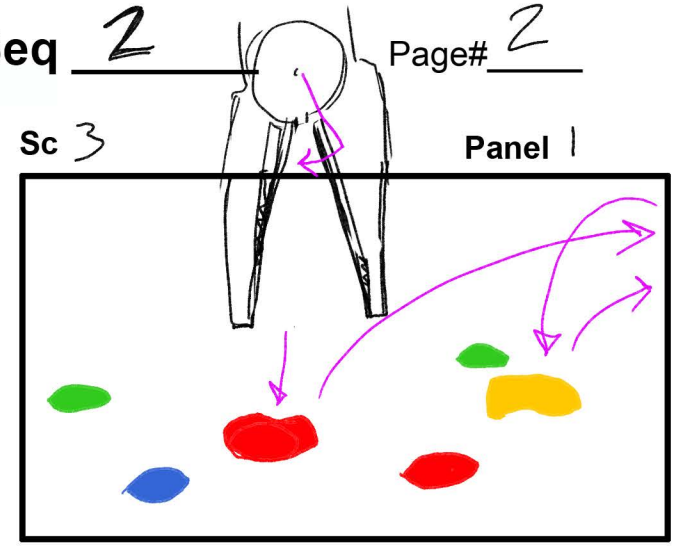
Sc 2 — Panel 2



02:12

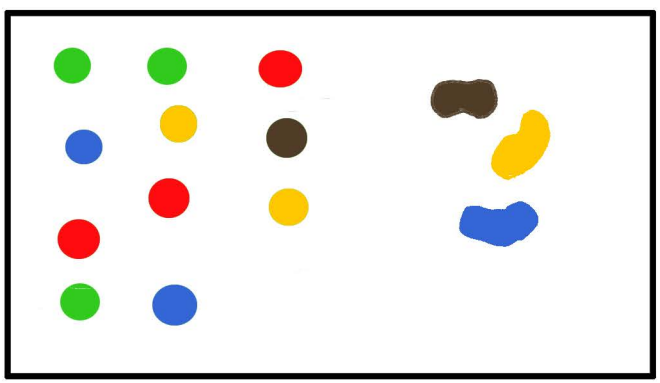
Now imagine a predator, that's you,
comes along to eat the M&Ms.
MnM bags go up offscreen, hands appear from under
the table and then the head appears

Sc 3 — Panel 1



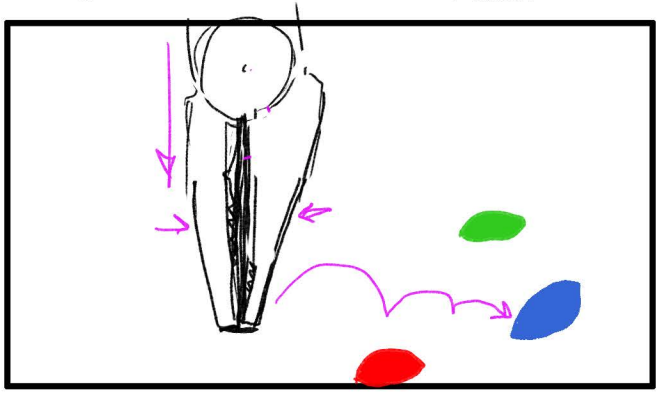
You can only pick them up with tweezers,
and you have 20 seconds to grab as many as you can.
Animation of tweezers picking up peanut MnMs

Sc 4 — Panel 1



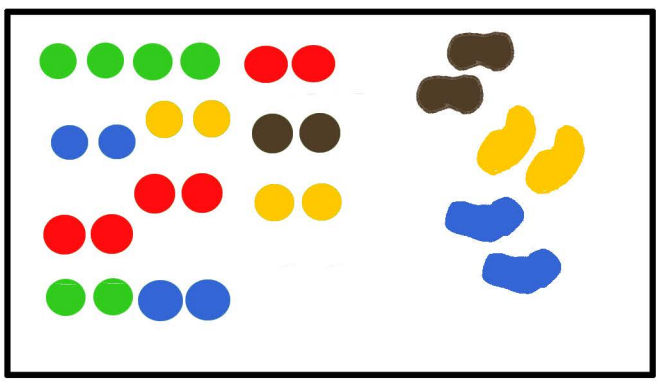
After the 20 seconds, we will collect the survivors, and

Sc 5 — Panel 1



note that more regular M&Ms remain than peanut M&Ms
because the regular were smaller and harder to grab.
tweezers come down and close around an MnM but
it bounces out

Sc 6 — Panel 1

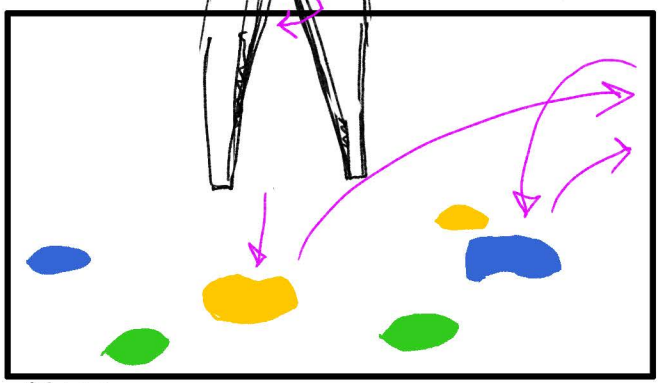


Those survivors reproduce, so we double
the survivors to represent their offspring.
Each MnM doubles by shooting out
right and left of the original
Now the population has more regular M&Ms than before because
regular made-up the greater portion of the population that
survived and was able to reproduce.

Story Artist Isaac Pitcher
+ Logan M. Shelley

CE **Animation** Cell 120 **18- Evolution** **Seq** 2 Page# 3

Sc 7 Panel 1

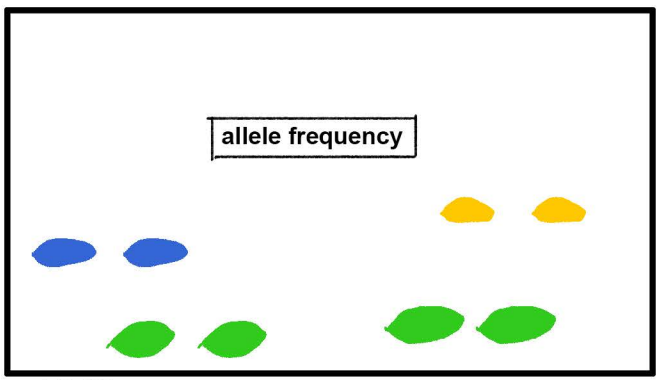


02:49

This is an example of natural selection, when certain inherited traits help individuals survive and reproduce better than others.

Repeat Scene 3 w/ different colors

Sc 7 Panel 2

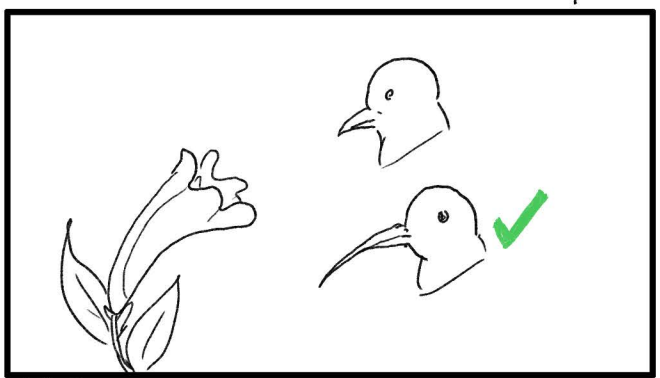


02:57

These traits, or the allele frequency, will become more common over time.

MnMs duplicate after tweezers leave

Sc 8 Panel 1



03.03

birds appear

It is not random.

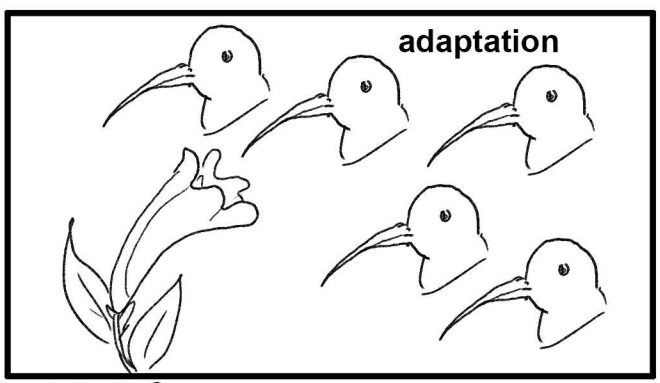
flower appears

The environment selects which traits are favorable or not favorable.

Short beak bird dissappears

(the long beak bird is the green hermit hummingbird see ref)

Sc 8 Panel 2

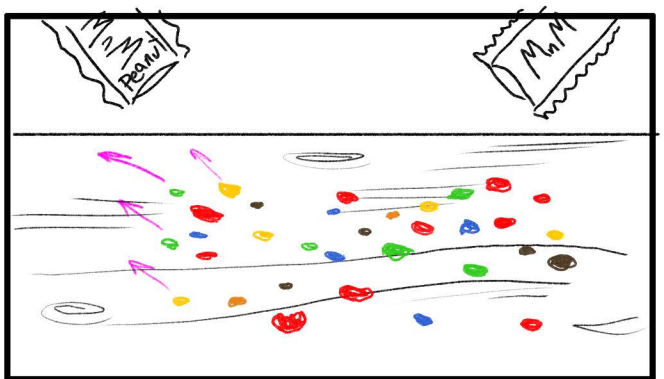


03:08

More long beak birds pop up

Over many generations, This leads to adaptation, populations becoming better suited to survive their environment.

Sc 9 Panel 1



03:16

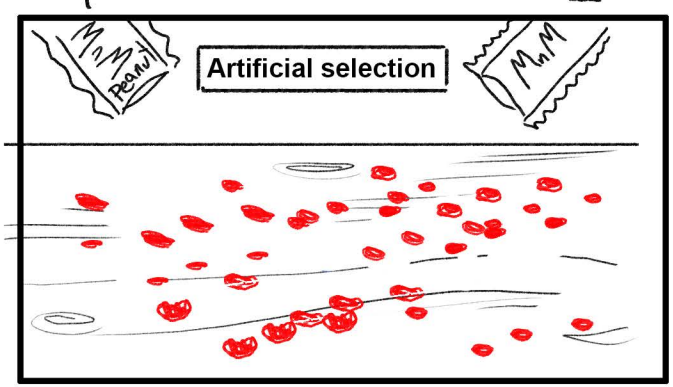
Sometimes the selector isn't nature though, it is us.

Artificial selection is when humans intentionally breed or select organisms with desired traits.

As if we picked out all the red M&Ms to create our new future population.

all the non-red MnMs fly off left, then the remaining red MnMs duplicate, leaving a table full of red

Sc 9 Panel 2



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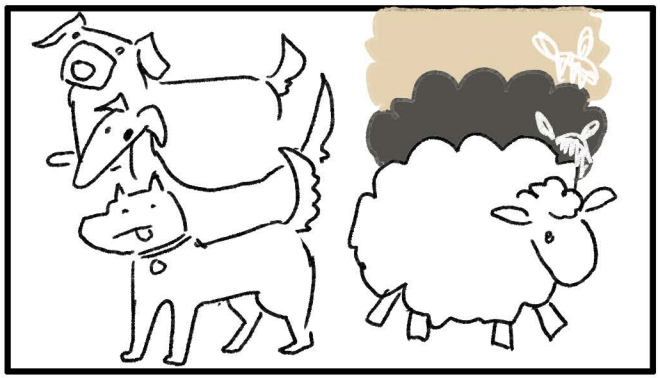
CE **Animation** Cell 120 18- Evolution **Seq** 2 Page# 4

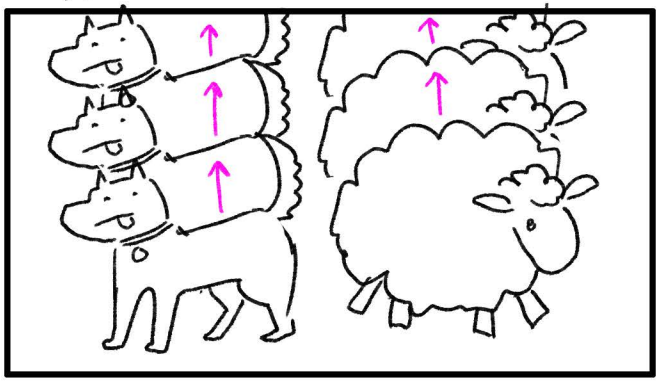
Sc 10 Panel 1



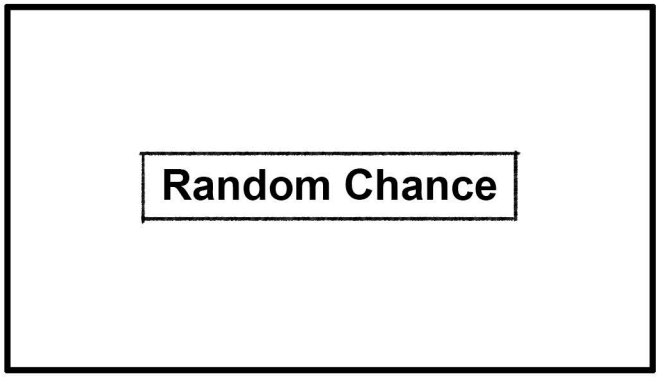
03:31

This is commonly seen in dog breeds and farming.
the bottom dog and sheep duplicate upwards, replacing all the other variations

Sc 10 Panel 2



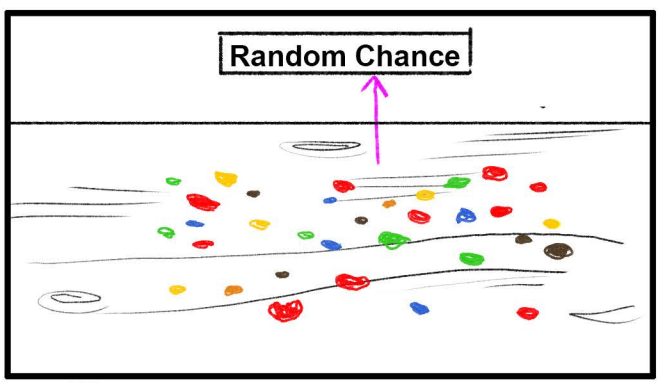
Sc 11 Panel 1



03:34

Now, not every evolutionary change happens because of a genetic advantage. Sometimes, random chance plays a main role in deciding who survives or reproduces.

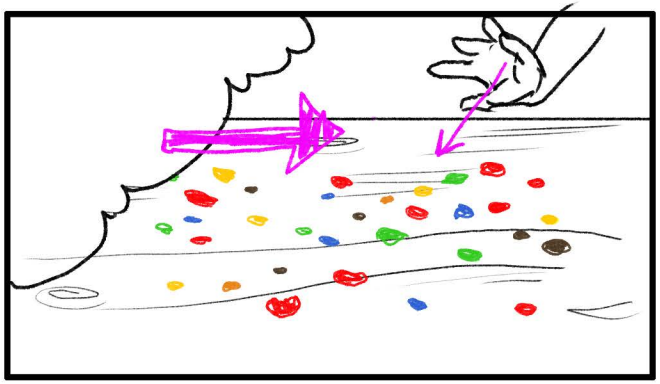
Sc 11 Panel 2



03:45

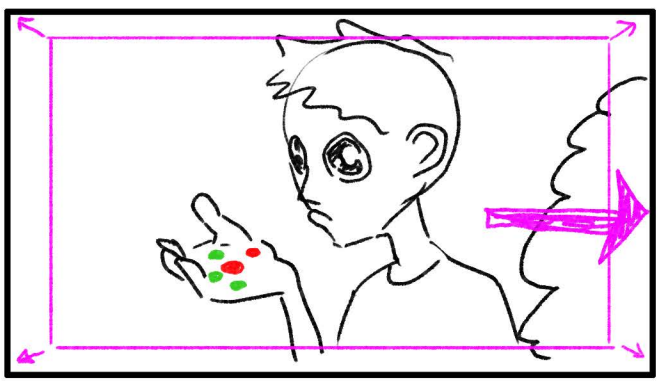
We will begin again with our M&M population.

Sc 11 Panel 3



Let's say a storm comes in and wipes out most of the M&Ms, or you randomly grab a handful to eat, leaving only a few survivors.
Storm passes over the table blocking view hand reaches towards MnMs

Sc 11 Panel 4

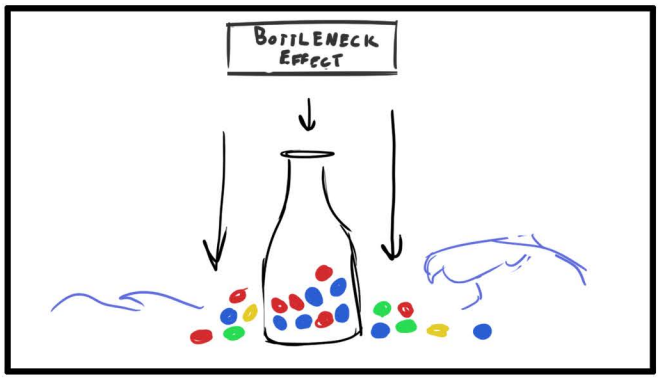


Maybe we are left with three green M&Ms and two red ones. Not because they had a trait that made them more fit or favorable to survive, but just by random chance. Now again, the red and green ones will reproduce, but they can only create more red and green M&Ms in future populations. This is genetic drift, random changes in allele frequency.
storm passes and reveals sad person. Slow push in

Story Artist Isaac Pitcher
+ Logan M. Shelley

CE Animation Cell 120 18- Evolution Seq 2 Page# 5

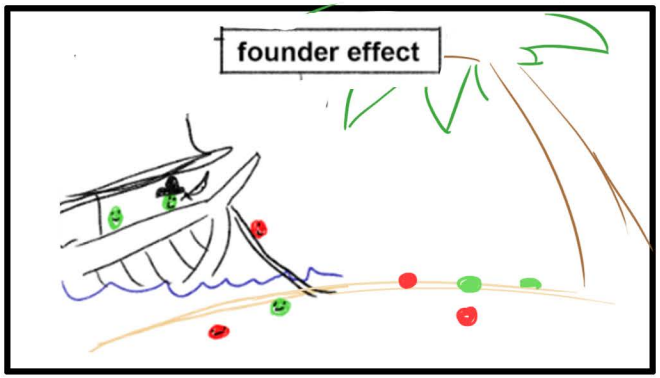
Sc 12 Panel 1



There are two common examples of genetic drift.
the bottleneck effect, where a large population is suddenly reduced by a disaster, leaving a random few
A pile of M&Ms fall onto an open bottle. Only red and blues go inside
Then, a wave washes away the loose M&Ms

04:20

Sc 13 Panel 1



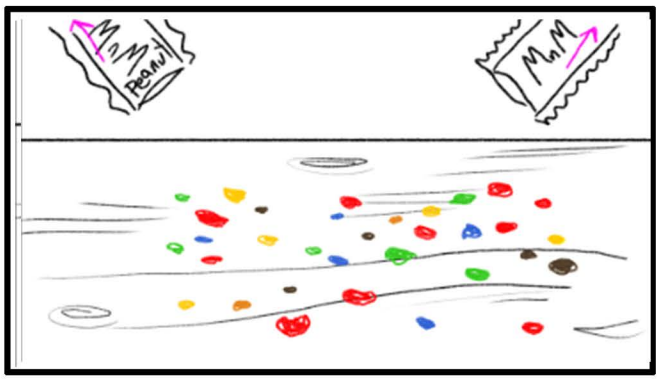
Or the founder effect, where a few individuals start a new population somewhere else

In both cases, chance, not fitness, determines which alleles survive

MnMs arriving at new lands on a boat

04:23

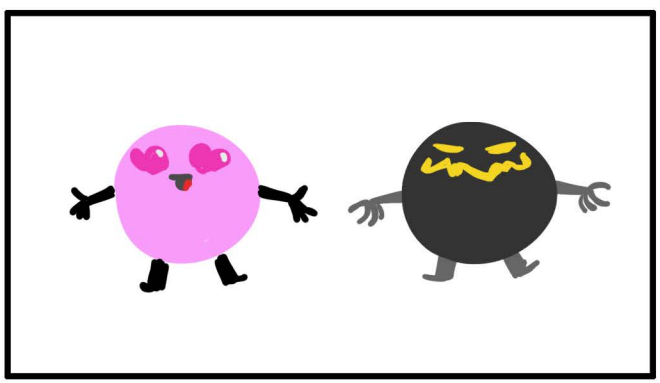
Sc 14 Panel 1



Now let's mix things up, literally, and look at our third mechanism. Our M&M population has all the standard colors, orange, green, red, blue, and so on.

04:40

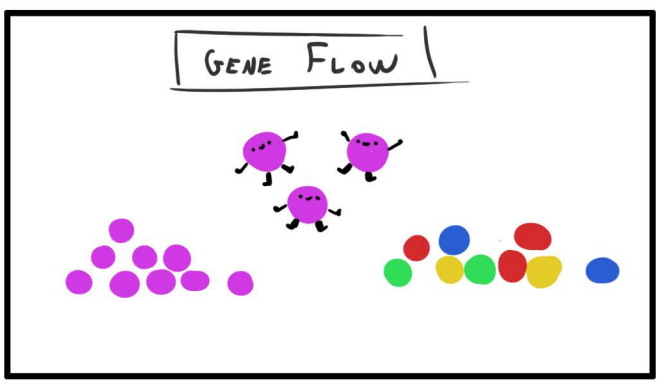
Sc 15 Panel 1



But on holidays, new populations appear.
Valentine's Day M&Ms with pink ones, or Halloween M&Ms with black ones.

04:50

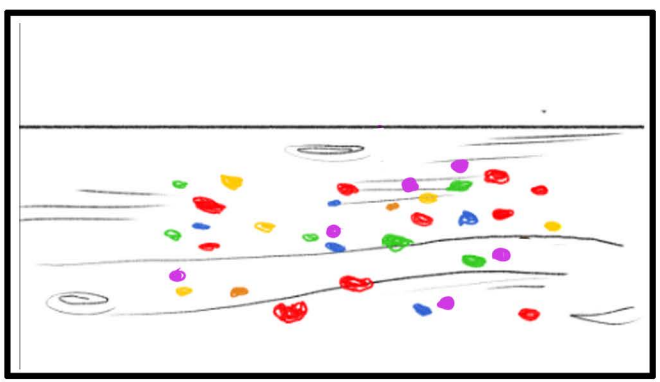
Sc 16 Panel 1



A few of those holiday M&Ms, like these purple ones, join our regular population. New color alleles have now entered into our gene pool. This is called gene flow, or also known as migration. This occurs when individuals from one population move into another population, bringing their alleles with them.

05:00

Sc 17 Panel 1



Gene flow tends to increase genetic diversity and helps connect populations so that they don't evolve completely separately .

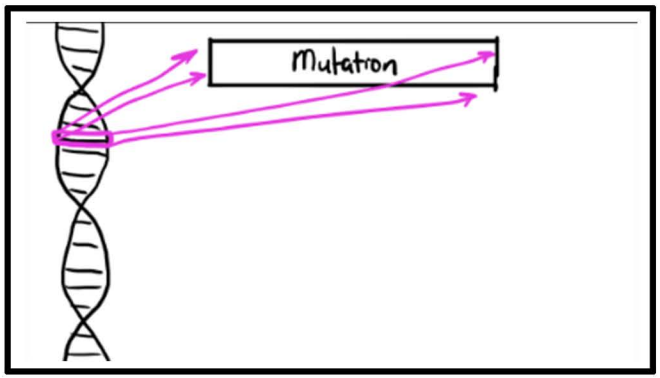
Purple M&Ms appear amongst the others

05:21

Story Artist Isaac Pitcher
+ Logan M. Shelley

CE Animation Cell 120 18- Evolution Seq 2 Page# 6

Sc 18 Panel 1

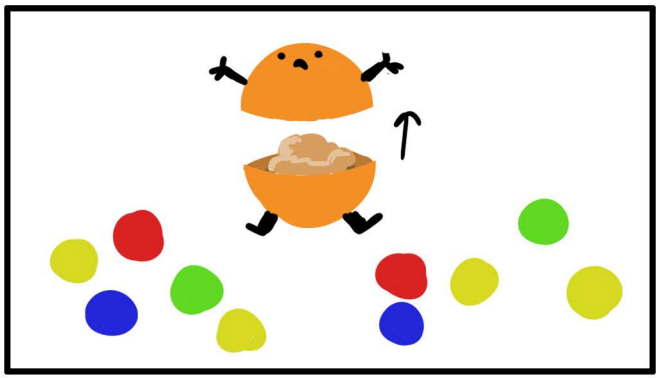


Our final mechanism is mutation, the original source of all genetic variation

A DNA helix appears and one of the bars emerges from the DNA with "Mutation" on it which becomes the title card for the next section

05:30

Sc 19 Panel 1

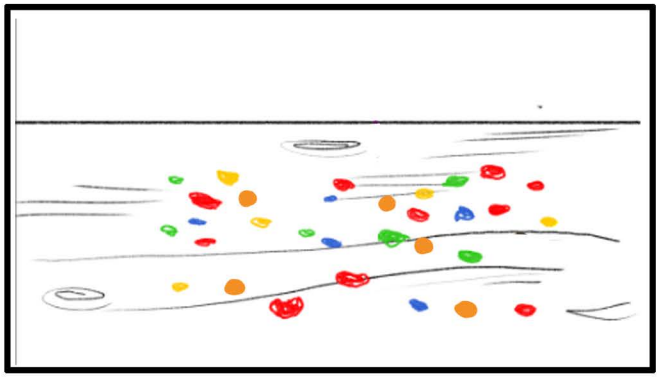


In our M&M population of regular and peanut M&Ms, randomly a new type appears, a peanut butter M&M. A mutation, or a random change in the DNA, creates a new version of the gene.

Orange M&M appears and opens up to show peanut butter

05:36

Sc 20 Panel 1

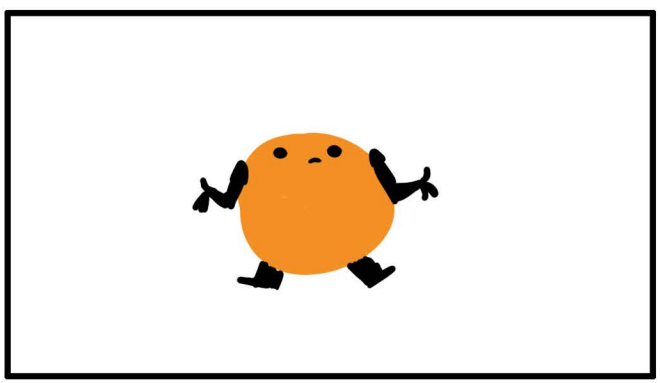


Through reproduction, this allele can be passed on, and more and more peanut butter M&Ms will be found in the population

Orange M&Ms appear amongst the others

05:50

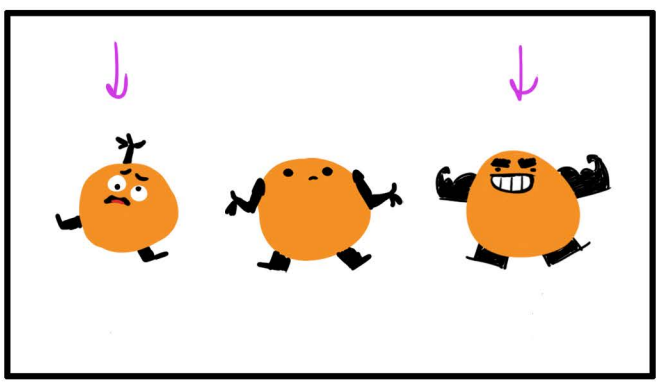
Sc 21 Panel 1



Most mutations don't make a noticeable difference.

05:57

Sc 21 Panel 2

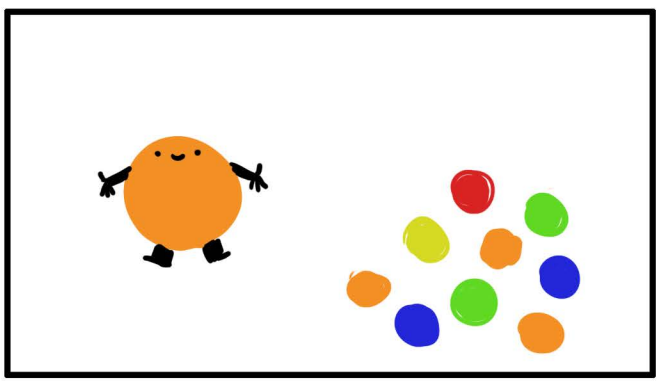


Some are neutral, some are harmful, but once in a while, one creates a beneficial trait that natural selection can act on. Without mutations, there would be no new alleles, and the evolution would eventually stop

Good and bad mutaion M&Ms drop down as they are mentioned

06:00

Sc 22 Panel 1



So as a review, evolution is a change in allele frequency over time that begins in an individual and spreads to a population.

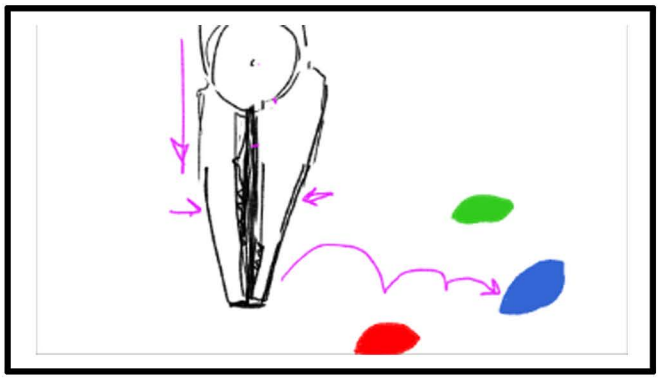
Orange M&Ms appear in a pile of red, green, blue and yellows.

06:13

Story Artist Isaac Pitcher + Logan M. Shelley

CE **Animation** Cell 120 **18- Evolution** **Seq** 2 Page# 7

Sc 23 **Panel** 1

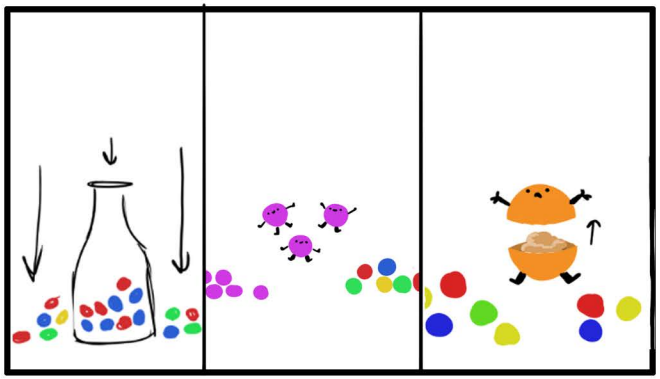


Natural selection and artificial selection help certain traits become more common because they increase survival or reproduction.

Show tweezer footage from earlier

06:22

Sc 24 **Panel** 1

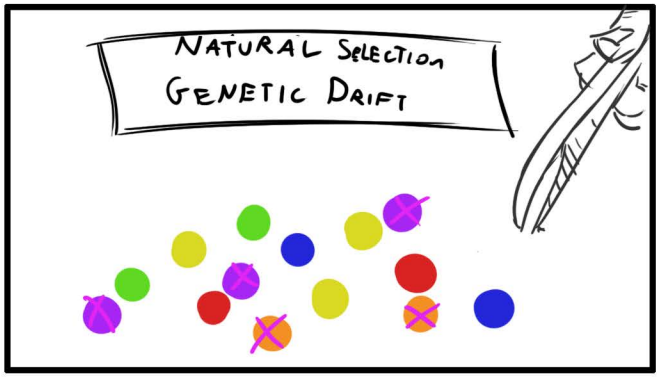


Genetic drift changes allele frequency by random chance, gene flow moves an allele from one population to another, and mutation introduces new alleles into the gene pool.

Splitscreen of earlier footage that demonstrates the subjects

06:31

Sc 25 **Panel** 1

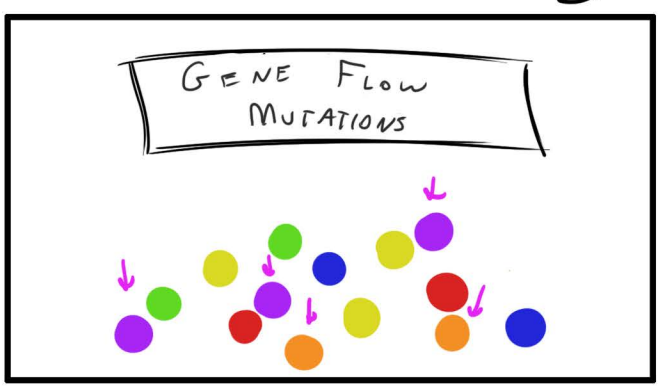


While natural selection and genetic drift often decrease variation,

Orange and purple m&ms are removed by tweezers

06:42

Sc 25 **Panel** 2

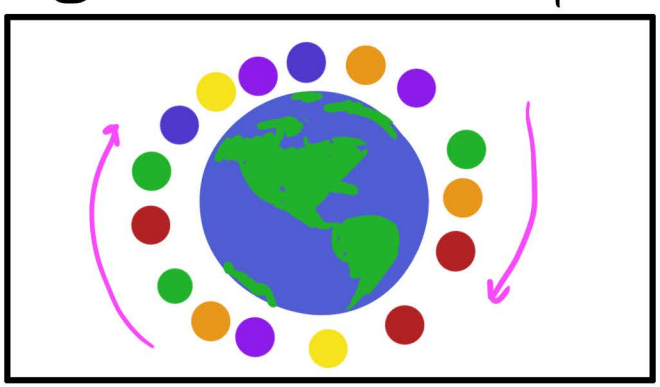


gene flow and mutations tend to increase it.

Orange and purple m&ms drop back in

06:42

Sc 26 **Panel** 1



These mechanisms constantly interact, shaping populations and driving the incredible diversity of life on Earth.

M&Ms of all colors circle the earth

06:50

Sc **Panel**

Story Artist Isaac Pitcher + Logan M. Shelley