Hello. I’m Dr Alex Lathbridge and this is Bitesize Biology.

This is the sixth episode of a seven-part series on Inheritance, Variation and Evolution.

In this episode we’re going to talk about two methods where humans deliberately change animals and plants to give them desired traits: selective breeding and genetic engineering.

In episode four of this series we talked about natural selection, where genes for beneficial traits become more common within a population. It's important that you understand natural selection, before jumping into this, because today we’re going to be talking about another kind of selection.

And to do so, we’re going to talk about my favourite animals: dogs.

Humans first co-existed with wolves tens of thousands of years ago and the eventual domestication led to what we know today as dogs.

In the wild, animals like wolves would adapt to the environments that they’re in. For instance, the Arctic Wolf has long, white fur because it lives in the frozen reaches of the arctic circle. Whereas, the Arabian Wolf is smaller and adapted to living in the changing weather found in the desert.

These are traits that they have due to natural selection. That’s just a couple of different of wolves, but dogs have over 400 different breeds and that seems like a lot more variation. Why?

Because humans bred different dogs for different uses. And so selected different desired traits.

What does that mean?

Well, want to hunt an animal? You pick the dogs with the best sight and speed and breed them together.

Need a guard? Breed the ones that are the most protective.

Need some dogs to herd your sheep? You breed the most trainable ones.

Want a companion? Breed the dogs that show the least aggression and so on and so forth, all across the world, eventually resulting in different breeds.

This is an example of selective breeding, where humans deliberately animals (or plants) for selected characteristics that we decide are useful or desired.

As you can guess, selective breeding happens over generations. It takes a while to successfully select for certain traits.

Apart from dogs, examples of selective breeding are:

Farmers breeding cows for lots of meat, or large volumes of milk.

Or farmers breeding plants to create crops that are resistant to disease or that grow large flowers.

Okay back to dogs now.

So imagine you're responsible for breeding your ideal dog.

There are four stages of selective breeding you'll need to remember so grab a pen and write this down:

1. What are you breeding for? You've got to decide which characteristic is important and what you want to select for future generations.

2. Find the parents in the stock that best show this characteristic. You then breed them together.

3. From the offspring of these two parents, you then find the best offspring with the desired characteristics to be the parents of the next generation.

4. Repeat the process again and again continuously over many generations, until all the offspring show the desired characteristics.

Basically, you keep breeding the best parents to get the best offspring with the useful characteristic.

It's like natural selection, but it's not happening naturally in nature. Its artificial selection.

We've been doing this stuff for thousands of years with plants and animals, so why? What are the benefits?

Advantage one: new varieties. Selective breeding can lead to new varieties of crops or animals, that produce more or better-quality food. Corn, for instance, was selectively bred over thousands of years from an ancestor that was ten times smaller than it is today and wasn't yellow.

Advantage two: gentler animals. Selective breeding can create animals that do not cause harm, for example cattle without horns.

If you're thinking that this sounds a little bit dodgy, you're right. Because plants and animals aren't choosing this, humans are the ones artificially selecting desired and useful traits, it has to be done correctly.

Like a wise person once said, "with great power there must also come, great responsibility."

This is because when desired traits are deliberately and selectively bred over time, future generations of the animals and plants will share lots of the same genes, reducing the genetic variation.

Unfortunately, some dog breeds are perfect examples of reduced genetic variation.

Because certain dogs are desired for looking a specific way, rather than having a specific purpose.

There are irresponsible breeders who will use one dog to father many litters of puppies.

When dogs from these litters come to be mated, some will be paired with dogs that share the same father from other litters. Over generations, more and more dogs across a particular breed are related to one another and the chances of relatives mating increase.

Why is this bad? Because the animals will be very closely related genetically, and this is known as inbreeding.

Why is inbreeding bad?

Risk one: disease. Reduced genetic variation can lead to animals or crops being more susceptible to a new disease. If one of them is killed by the new disease, it’s likely that many of them will be affected.

For instance, Cavalier King Charles Spaniels have a higher risk of heart disease. Bulldogs risk painful bacterial infections if their face folds aren’t cleaned regularly.

Risk two: health problems. Reduced variation and inbreeding unfortunately means there’s more chance of plants or animals inheriting harmful genetic defects.

A high percentage of Dalmation dogs are deaf in one or both ears. And do not get me started on the ethics of intentionally breeding dogs that can’t physically give birth naturally because their bodies aren’t large enough to push out their puppies' large heads.

But it’s the 21st century, surely there’s got to be another way that humans can change an organism to give it desired traits?

Yes - genetic engineering.

This involves modifying the genes of an organism by transferring a gene from one organism to another, resulting in it having a desired characteristic.

Genetic engineering has four stages:

1. Select the desired characteristic.

2. The useful gene is removed from one organism using enzymes and is inserted into a vector.

3. The vector is a small circle of DNA made of plasmids (if you don’t know what plasmids are listen back to our Cell Structure episode if you need a refresher)

That small circle of DNA made of plasmids is transferred to the organism that you want to develop the characteristic.

4. You then replicate the modified organism with the gene for the desired characteristic.

Let's think about some real-world examples where genetic engineering is used:

1. Diabetes. Diabetes is a health condition where the body doesn't regulate its blood sugar levels, so glucose in the blood is too low or too high. Insulin is a hormone that regulates blood sugar. Genetic engineering can be used to genetically modify bacterial cells that make human insulin, which is then taken by people with diabetes.

2. Crops. Genetically engineered crops have been modified to be resistant to diseases or insects, or to make bigger fruits.

Like selective breeding there are advantages and disadvantages to genetic engineering:

Advantage one – improving yields. Yield means the amount of something made. Genetic Engineering can improve crop yields or crop quality, which can reduce hunger in developing nations.

Advantage two – improving nutrients. Crops can be genetically engineered to contain a specific nutrient.

An example of this is a type of rice called "Golden Rice" which is genetically modified to include beta-carotene. A deficiency in beta-carotene can cause blindness so beta-carotene is pretty important.

But there are risks to genetic engineering:

Risk one – causing harm to humans. Some people think genetically engineered crops aren't ethical or safe for humans. Because we don't know the long-term effects of genetically modified food. For example, humans could develop allergies to them.

Risk two – transfer to the rest of nature. What benefits one plant, may harm other plants or animals. For example, pollen taken from genetically modified plants could harm insects that carry it between plants.

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