Extra-Ordinary

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Stories of Science in Everyday Life

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juggernaut

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To my Mamaji, the late Mr Vishwanathan Nair.
Hope this makes you smile :)

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Prologue

Unusual stories. Science. Magic and the mundane. How do we humans see the world and why do we put those two things – magic and science – in different buckets? What connects them? What do we learn and how do we feel when we change an artist's easel for the scientist's microscope?

Hello, dear reader. You don't know me, or maybe you do, but let's assume you don't (I do want strangers to read this book after all!).

This book is about some of the things that I find both beautiful in the scientific context and utterly magical when I wear my amateur artist's cap. Many of these are ordinary things, but indulge me as we walk into a realm where science and magic mix.

Actually, strike that, because it's not just the realm of imagination where these domains overlap. As the science-fiction writer and satellite-communication pioneer Arthur C. Clarke once said, 'Any sufficiently advanced technology is indistinguishable from magic.'

It's a reminder that magic and science aren't always as far apart in our reality as we think. Sometimes, all it takes is a shift in perspective for the ordinary to start feeling like magic.

For example, it would seem impossibly magical to somebody from a society without a written language if they saw us communicate across time and space by simply using these strange symbols we call letters. And yet, to us, that's ordinary, and therefore somehow, not magical.

Why isn't that magic? Is it any less magical just because we know how it works? I don't think so. To explain how I feel, let me share a quote from a famous scientist, Richard Feynman:

> I have a friend who's an artist and [he] has sometimes taken a view which I don't agree with very well. He'll hold up a flower and say, 'look how beautiful it is,' and I'll agree. Then he says, 'I as an artist can see how beautiful this is but you as a scientist take this all apart and it becomes a dull thing,' and I think that he's kind of nutty. First of all, the beauty that he sees is available to other people and to me too, I believe. Although I may not be quite as refined aesthetically as he is … I can appreciate the beauty of a flower. At the same time, I see much more about the flower than he sees. I could imagine the cells in there, the complicated actions inside, which also have a beauty. I mean it's not just beauty at this dimension, at one centimetre; there's also beauty at smaller dimensions, the inner structure, also the processes. The fact that the colours in the flower evolved in order to attract insects to pollinate it is interesting; it means that insects can see the colour. It adds a question: does this aesthetic sense also exist in the lower forms? Why is it aesthetic? All kinds of interesting questions which science knowledge

only adds to the excitement, the mystery and the awe of a flower. It only adds. I don't understand how it subtracts.

This is exactly how I feel, and it's one of the themes that runs through the book. I find the everyday world around me fascinating as I look at the magic hidden behind everything we dismiss as ordinary.

Since my world revolves around my daily routine, and my daily routine revolves around my dog Oreo, he is an integral part of these stories. Indeed, these stories all arose organically from the things Oreo and I do on Sundays and I've taken a little artistic licence in writing as though they all happened on a single ordinary yet magical Sunday.

It's time for you, dear reader, to meet the dashing Oreo Pupperwal, first of his name. He briefly considered being called Sir Oreo Pupperwal, but ultimately decided he didn't need the honorific. He self identifies as 'most important', and it has worked out great for him so far. Case in point, he is the only one who can boss around the strong, independent woman that I pretend to be.

Oreo is a four-year-old black-and-white dog who has the aloof yet demanding personality of a black cat – complete with judgmental stares and selective hearing. Yet, he howls like a husky, watches me like a sheepdog and has more than once been mistaken for an odd-shaped Dalmatian because of his spots. In short, he's a lot like his human – a mix of many things, yet totally unique.

We've been together since 2020, with him bossing his way into my heart from our very first encounter. This tiny puppy

ran to me and hid behind my legs, not because he wanted my attention but because I made a convenient human shield against other humans, two big dogs and one very judgy cat. I admired his priorities. And was secretly overjoyed with the quiet honour of being chosen as the safe human.

I sample much of the world around us in his company and share in his delight as we go through our daily routine of cuddles, walks and play. He reminds me to literally stop and smell the flowers, and I tell him about the hidden science behind things. I tell him things I've found hidden in obscure corners of the Internet and buried in books. And he listens to all of this patiently, even if it sounds like alien gibberish to him.

Sometimes I do feel like an alien with two hearts, one devoted to being an artist and the other delighted by dabbling in the sciences. I often find myself gravitating towards the stories that glue these two together.

So, I would love to share with you stories from the world of science, which, to me, are also stories from the world of art. Stories that make me love the fact that we exist on our little blue dot at a time when we can – to quote yet another great scientist – stand on the shoulders of giants and look at our world from a completely unique perspective. In my case, that also often involves looking at the world (and smelling it!) from a canine perspective.

I can't wait to share these stories with you. Stories that are part science, part daydreams, guided by curiosity, wonder and, occasionally, the wise instincts of a four-legged friend who knows that some of the most profound discoveries begin with simply stopping to notice the mundane.

1

The Immortal Eternal Apple

In the beginning, there was an apple tree. It had been standing there for centuries, and it was the first of its kind, and also the last of its kind. Or was it? The details are a bit fuzzy, so let's rewind!

In the beginning, there was the calm, cool morning of a peaceful day of rest. It was Sunday, the day when everyone's allowed to sleep in a little bit longer.

This, of course, is true only when you don't have a boss that insists you wake up early on a Sunday. In my case, that boss is a dog who doesn't get the concept of Sundays. So, seven days a week, my alarm clock is a well-loved and rather chewed up ball being pushed into my face to remind me that it is time for my dog Oreo's breakfast.

As I walk into the kitchen to prepare his breakfast, I am reminded of the fact that I have to make my own breakfast as well. I sigh, vaguely remembering that as a child I couldn't wait to grow up and eat whatever I want, whenever I want. I glance around, dreaming of something deliciously indulgent, but alas, my post-workout grocery shopping meant my choices

are limited to only 'healthy' options. My gaze wanders until it lands on something red – an apple. Now, as an adult I am burdened with the knowledge that all that freedom also means sometimes eating an apple.

As I hold this apple in my hand, my brain offers up a proverb, because of course.

It's the one that goes 'an apple a day keeps the doctor away'. This, in turn, leads to its own spiral with a series of interesting metaphysical questions. Given that I am a doctor (at least technically), am I currently being kept away from myself because of these apples? How does that even work? Am I just using this as an excuse to order something instead of eating the fruit in front of me? Ah. Questions.

As I stare at the apple, wondering whether I should cut it, grate it or eat it whole, I let myself slide further into thought. Whenever I look at any object, my brain has the habit of showing me all the interesting titbits it has collected over the years on the topic, like an eager friend who's been asked about something they know far too much about and simply can't stop talking about.

Come, let's talk about apples.

Apples are fascinating, delicious and quite abundant. There are so many varieties of them – there are the really small Kashmiri apples, the almost purple red Kinnaur apples, the bright red royal apples and even the almost yellow golden apples. These are just the varieties grown in Himachal Pradesh. If we look across the world, we have the deliciously sour Granny Smith apples, the extremely sweet honeycrisps or the pink lady apples that to me evoke the image of a cartoon woman in a pink ballgown handing out candied apples.

Apples are a huge part of our collective imagination, from the poisoned apple of Snow White to the Biblical apple of Eden from the Tree of Knowledge,[1] or the famed apple falling on Newton's head, causing him to discover gravity.[2]

For me personally, apples evoke memories of my childhood car rides through Himachal, where orchards lined the road – I can smell them even now. Whenever I remember walking in an apple orchard with trees laden with fruit, I understand why so many poems, stories and myths feature the fruit.

To delve further, let's enter the land of imagination. Here, the unexpected often happens, allowing us to see things we might not see in our everyday lives.

Come, let's walk through an apple orchard. I walk up to the nearest tree and wonder, 'Does this tree have a name?'

The tree turns to me and says, 'Hello. I'm Komal.' I'm startled until I remember that this is the land of imagination after all, where trees can talk. So I say hello to Komal the Tree, and walk over to the next tree.

'Hello, what's your name?' I ask.

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[1] Sadly for the apple, it is very unfortunately associated today with that story, when in reality, the word 'apple' just meant any fruit in Middle English. Up till the seventeenth century, 'apple' was a generic term for all fruit apart from berries, and even included nuts. Dates were finger apples, and bananas were called 'ye appel of paradis'. This also shows the influence art can have on collective memory, as most of the early illustrations of the Garden of Eden depict an apple, burning that image into the collective psyche.

[2] Of course, this is just a story. Newton did not discover gravity just because an apple fell on his head. Yet it is a story we like telling and retelling, because it sounds so good.

The tree looks at me and replies, 'Hello. I'm Komal!'

Bewildered, I ask another tree, and it also says, 'Hello. I'm Komal.'

Confused?

Well, so would I be – if I didn't know that these are apple trees. Which means that all of these trees are, in fact, clones!

So, what does it mean that all these trees are clones? Is this a sci-fi story set in the distant future where we have for some reason cloned … apples?

Not really! It is a story about clones, but it's set very much in our time and, indeed, part of our history as a species that evolved from being hunter-gatherers and became farmers. These trees – and in fact all trees that bear a certain variety of apple – are clones of a single ancestral tree that initially grew that kind of apple. The same tree has been grown and regrown over and over again for centuries, clones producing the exact same fruit!

Indeed, in the beginning, there was an apple tree, and it seems it is still here!

This brings us to even more questions. Why are all these trees clones? What does it mean when we say a plant is a clone? Can we not just grow apples out of seeds? As I think of all these things, I discover I'm not actually eating the apple in front of me.

Well, since I'm not eating it anyway, let me fully commit. Come, sit with me under the shade of this lovely apple tree of our imagination as I tell you all about apples, and much more. This is a story about how humans should not have been able to domesticate apples, and how – spoiler alert – we did it anyway.

I know we were talking about clones and apples, so how is it a story about domestication? And what even is domestication? It rings a bell as it is a moderately well-known word – many people may have heard of the concept, but not everyone is familiar with how it actually works, so let's talk about it.

'Domestication' is a complex word; when I first read it as a tiny human, I couldn't pronounce it correctly. However, my mother taught me a trick to tackle such big words instead of being scared of them. She told me, 'If you encounter a big word that you don't know the meaning of, or are intimidated by, just break it down, sound it out, and if you still don't understand it, use the dictionary or ask someone who knows how to pronounce it. Slowly but steadily, you will learn so much more about it.'

Well, this trick works with concepts, ideas and scientific details as well as words. It's all about breaking something we don't understand down into chunks that we can understand and looking for things we don't know.

So, let's break it down.

Dom-est-ica-tion comes from the mediaeval Latin word *domesticare*, which loosely translates to 'to tame' or 'to dwell in the house'. When it comes to animals like dogs – yes! – domestication refers to them living in close quarters with humans, while with plants, it often refers to our ability to grow them in large quantities via agriculture.

Let us talk about domestication in plants. The way domestication in plants usually works is simple. We take a tree that grows the fruit we like and collect the seeds from the tastiest fruits. We then plant these seeds to grow the

next generation of trees. If all goes well, in a few generations, we get trees that mostly grow the delicious fruits that we like.

That, however, is a very simplified view of what really happens.

In reality, very few things are truly that simple. Whether we get delicious fruits from the seeds of delicious fruits depends on several things. One of them is heritability. Heritability is a measure of the chance that any desirable feature that you want – also known as a 'trait' – gets passed along to the next generation from the parent.

Let's say that every time you plant a seed from a delicious fruit, you always get a tree that also grows those delicious fruits. That means this trait that we like, has a 100 per cent heritability. However, if the chances of getting a delicious fruit from this seed are lower – say, only one in 10 trees grows such fruits – then the heritability is down to 10 per cent. As the chances get lower and lower, the uncertainty increases manifold. Imagine being a farmer, trying to grow fruit to sell, and never knowing whether the tree you planted will yield edible fruit or not.

All this is not to say that it is not possible to domesticate plants. That, in essence, is what we have done for many crops that we farm. If you sow wheat or barley seeds, you are guaranteed to get wheat or barley that is very similar to the seeds that were planted, almost 100 per cent of the time.

Which brings us to the golden question: What are the chances of getting a golden apple if we plant a golden apple

seed?[3] The answer, actually, is virtually none. Apple seeds have a really low degree of inherent heritability. This means that the chances of getting similar traits to the parents are overall lower. A tree grown from the seed of an apple can yield edible but very different fruits, or fruits that taste absolutely horrible. If your livelihood depends on getting tasty fruits, apple seeds are probably the worst of the lot to bet on.

Now comes the second problem. 'Deliciousness' is not really a single trait. It is a combination of traits.

Why does that matter? Well, let me give you an example from our everyday life.

Every time we follow a recipe, it involves adding several different ingredients. All of these ingredients need to be added in a specific ratio and often in a specific order. In addition to that, the ingredients need to be chopped a certain way, cooked for a specific amount of time, mixed with specific spices and served hot or cold. All of these factors affect the taste of the final product.

To take a simple example, a dosa is definitely not the same as a dish made of rice, dals and other ingredients put together anyhow. In fact, even using the same batter, the dosa will be crispy when the batter is spread thin, fluffy when poured as a set dosa and taste completely different based on the amount

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[3] Three 'goldens' in one sentence deserves some bonus trivia, so here you go. In Greek mythology, the Apple of Discord was a golden apple thrown by Eris, the goddess of strife, during the wedding of Peleus and Thetis. This act sparked a vanity-fuelled rivalry among the goddesses Hera, Athena and Aphrodite, which eventually culminated in the Trojan War.

of butter or ghee used. So, the 'taste' of the final product is greater than the sum of its parts, with every individual element having a considerable influence on the final product.

Similarly, for the apple to be delicious, we need a combination of sweetness, texture, smell, shape and several other factors. This means that for apples from a tree to pass our criteria of 'deliciousness', they have to inherit all those traits at a relatively high rate, and the lack of any single one of these traits may lead to an apple that doesn't quite make the cut.

Since we already know that apples have a low heritability for most traits, and you add the number of traits required for deliciousness, it becomes apparent that growing an edible apple out of a seed is a really big challenge.

Moreover, apple flowers do not self-pollinate. For any fruit to grow out of a flower, the flower needs to be fertilized by combining the male gamete (known as pollen) with the female gamete (known as the ovule). This process is called pollination.

For apples, the plants need an external source of pollen, which usually comes from nearby crab apple trees, or from another apple variety planted nearby. This means that while the fruit looks like the parent tree, the DNA inside is from two different sources. This process further increases the inherent variability that we find in apples in every generation, thus leading to the fruits being dissimilar to the parent.

So what would happen if we took a lot of seeds and kept growing them until we found seeds that grow trees with the traits we want to breed for? Well, a group of German scientists did this experiment, starting with 52,000 seeds from different types of apples, trying to grow apple seedlings that were

scab resistant. After 26 years of growing seedlings, screening them in the lab and then grafting them onto rootstocks and evaluating them in the field, do you want to guess how many varieties of apple fit their criteria? Three! Out of these, how many healthy cultivars were suitable for cultivation? Just one! Like I said earlier, growing apples from seeds isn't a gamble for the feeble-hearted.

So, as I mentioned, we should not have been able to domesticate apples.

But we did. How did we manage it? You could say that humans that domesticated apples did not know that they shouldn't have been able to grow them, just like the bumblebee that didn't know that it shouldn't be able to fly because of aerodynamics. They imagined a universe where they could harvest apples and made that a reality.

Indeed, many inventions have resulted from the fact that humans are very persistent. It is this same persistence that fuels all of science, with us looking for ways to travel to the stars, and also to look at the tiny particles within an atom. If we want something, as a species we keep trying to find ways to get it. So how did we manage to get crops of apples? And why are they 'clones'?

It's because we used grafting, or something called 'clonal propagation'. This is the process that made all the Komals clones.

Grafting is like something out of a sci-fi movie – if we didn't already know it was a thing, we'd probably assume aliens came up with it. Picture this: From a branch from one plant, you can get a brand new tree that can grow leaves, flowers and even fruits! If humans could pull off something like that, you'd

be walking down the street, see a stray arm or leg growing into a full-on person, and just say, 'Oh, cool, they're grafting.' Sounds bizarre, right? Well, plants have a secret superpower that makes it all possible: pluripotency.

Certain – but not all – plant cells have the ability to become almost any type of cell the plant needs. In grafting, it is this ability that is harnessed. A part of the desired plant we want – often the stem – is joined together to the root system of another tree. This part is vital, and it is where farmers with a lot of skill combine the cambium – the part of the plant that rapidly divides – of the two trees together by creating complementary cuts and interlacing them. As time passes, the site of the cut starts healing, creating a seamless connection. Before we know it, we have a whole new tree growing from the small section of the stem, which retains all the features of its parent plant, while being nourished by the roots of the plant it was grafted on.

A tree grown like this is a clone of its parent tree. This process bypasses most of the problems of heritability I mentioned above. As long as you pollinate it with the same kind of trees that the original was pollinated with, you are guaranteed a fruit that is very similar to the parent. In addition, grafts usually grow much faster than a tree grown from the seed stage, and this gives farmers the ability to speed through the process of getting a fruit-bearing tree. Now that's something I would like, if my livelihood depended on selling delicious fruit.

So that's how we did it. We took a plant that we shouldn't have been able to domesticate, and we did it anyway. Often when looking at impossible problems, we look at nature for

guidance because if we look long enough, we find that an apparently impossible thing like the one we're interested in already exists, and then we can start asking 'how'. There are theories that suggest that early grafting may have been inspired by the extremely rare natural grafts that occur in some plants.

By now, grafting has become quite a commonplace procedure. It's how we grow roses, plums and cherries. But here's where it gets even more mind-blowing – people have mastered grafting to the point where they can grow different varieties of fruit on the *same* tree. By painstakingly grafting multiple varieties on the same tree over many years, people have been able to create Frankenstein-esque trees that have over 250 different varieties of apples! If you want a mental workout, just scour the Internet for an explanation of '250 varieties of apples on a single tree'.

In fact, grafting – also known as vegetative propagation – also known as clonal propagation – is something that humans have been using for a long time around the world, from monks in Europe to farmers in Asia. It's used to cultivate many types of plants, not just trees with low heritability like apples, which we can't easily breed for the characteristics we want. By some estimates, over 75 per cent of all types of perennial[4] fruits that humans grow commercially involve some form of grafting. Talk about hacking nature!

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[4] 'Perennial' comes from the Latin perennis, which means 'lasting through the year'. For plants, it refers to any plants that grow for longer than two years. Fruit trees like apples, once planted, can last for several years and are thus called perennials, as opposed to plants like wheat which need to be grown every year and harvested, thus called annuals.

It is also how we grow seedless varieties of plants like the Cavendish banana – named after William George Spencer Cavendish. Just like apples, Cavendish bananas are all grown from clones of a single seedless plant variety, first grown in Britain in 1834. The same is true for seedless navel oranges and many wine-producing varieties of grapes. So in this specific case, you can actually compare apples to oranges, or even grapes!

Of course, as with any plant, environmental factors like soil conditions, humidity and water source can have a huge impact on the taste of the fruit. Think of it like this: You may be following the exact same recipe as one you've made before, but if the quality of individual ingredients is poor, the resulting food will still taste very different. It is similar in plants, as they use the nutrients from the soil to create the fruit every fruiting season. This means that everything else being the same, there will still be a difference in how the fruits taste every year if the environmental conditions change. This is also why certain wines from specific years cost a lot more than others, as the inherent quality of the grapes changes from year to year, due to minute differences in soil, weather and other environmental conditions. (There are some who believe that wine pricing is all an elaborate scam and even experts can't really tell the difference, but that is a different subject for another time.)

Grafting is also the method that allows us to bring back ghosts! I don't mean bringing back the dead, but something scientists refer to as ghosts. More specifically, fruits like the avocado are called 'ghosts of the evolutionary past'. That's because the natural process through which avocado seeds

turned into trees involved some really large mammals like the mammoth or the mastodon. These massive creatures would eat the fruit whole, and the large avocado seeds would pass through their digestive systems, only to be deposited miles away in their droppings – a perfect way for the tree to spread and germinate.

Unfortunately for avocados, those giant mammals disappeared about 10,000 years ago – so, you'd think the avocado would have gone extinct, too. After all, its huge seeds weren't suited for smaller animals to spread. Yet the avocado survived, which brings us to the following question: How does a plant survive if it has a seed that requires it be passed through the guts of the extinct mastodon to germinate?

Well, one reason it survives is because avocado trees naturally have a long lifespan, which allowed them to survive for a very long time even though the natural dispersers of their fruit were no longer around. Even if no new trees were growing, the older ones that remained kept growing and quietly producing fruit year after year. In modern times, it has survived because of humans who painstakingly grew it. Unlike the apple, we didn't initially grow avocado trees using grafting, but from seeds – a tricky, highly variable process that likely took a lot of trial, error and patience. To mimic what once happened in the guts of those extinct animals, people had to soften or remove the outer seed coat, and sometimes even score or pierce the seeds to help them germinate. Even today, if you Google how to grow an avocado plant, the first step would be to pierce the seed with toothpicks or score it with a knife.

Why did humans do it? The answer is unclear. Maybe

because it is an excellent source of healthy fats. Maybe because it became a part of the diets and cultural norms of several Central American civilizations. The ancient Aztecs, for example, apparently considered the fruit an aphrodisiac and something that boosted fertility.[5] Or maybe – just maybe – humans really like eating guacamole, and thus learnt to grow the fruit that gives it its characteristic taste. Whatever the reason, the truth remains: The avocado exists today because humans decided it was too delicious to lose.

Here's where grafting enters the picture though. Today, most commercial avocado varieties, especially the popular Hass avocado, are propagated through grafting. This ensures that each tree produces fruit with the same taste, texture and quality. Every Hass avocado you eat essentially comes from clones of a tree that was discovered in the 1920s by a California postman named Rudolph Hass. By grafting branches from this original tree, growers have been preserving the ghosts of the avocado past for future generations to enjoy.

So, the next time you take a bite of an apple, I hope you smile at the thought of how every Granny Smith apple comes from clones of a tree found in 1868, growing as a chance seedling in a compost pile in the orchard of farmer Maria Ann 'Granny' Smith in Ryde, New South Wales. I also hope that it makes you marvel at the sheer power of the human mind and

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[5] The word 'avocado' comes from the Spanish aguacate, which derives from the Nahuatl (Mexican) word āhuacatl, both of which anecdotally refer to a certain part of a bull's anatomy (yes, that part!) that the fruits resemble. No wonder, then, that the ancient Aztecs considered these fruits a symbol of fertility.

our imagination – our striking ability to tell ourselves stories in which we can imagine the impossible being possible and then figure out a way to do it in real life.

For instance, if you thought growing plants without seeds was impressive, wait till I tell you that we figured out how to grow plants without any soil, and from a very small number of cells. This incredible feat is achieved through a technique known as tissue culture. In this process, we can take just a few cells from a plant – sometimes as small as a microscopic piece of tissue – and use them to grow part of a, or even an entire, new plant. What makes this possible is that very same power of pluripotency. To remind you, pluripotency refers to the ability that some plant cells have the potential to regenerate into an entire plant, given the right conditions. This is why tissue culture works – it taps into the natural flexibility of plant cells to grow into whatever is needed.

This ability is a game changer for agriculture, conservation and even plant research. Through tissue culture, we can create clones of plants with desirable traits like disease resistance or improved growth rates, or rescue endangered species that are difficult to propagate naturally. It allows us to mass-produce plants that are genetically identical, ensuring consistency in crops or helping preserve rare species that are threatened in the wild. Anecdotally, one of the key factors that led to the development of the art and science of tissue culture was a desperate need during World War II. The British and Japanese nurses who were treating soldiers in the war apparently used coconut water for infusions, as sterile saline – which is what is typically used – was in very short supply. Since coconut water is naturally sterile and contains most of the vitamins and

nutrients required for cells to grow, it was a useful alternative in the time of war. That said, it was only used in times of emergency, and then too as a very temporary alternative.

However, the story goes that this led scientists who were trying to grow plant cells to use coconut water as a medium, and that actually ended up working much better than any existing mediums![6] In fact, coconut water was used as the base for tissue culture for a long time, until artificial nutrient mediums were developed.

Coconut water is rich in vitamins, amino acids and sugars, making it an excellent natural medium for supporting plant cell growth and for rehydrating yourself on a warm day. While synthetic nutrient solutions have become more common, coconut water remains a valuable tool in certain applications due to its natural composition.

So far, I've told you all about the marvellous ingenuity of humans that has allowed us to do what once seemed almost impossible. But it's important to acknowledge that not everything is sunshine and rainbows. There are significant downsides to growing plants through grafting and cloning, particularly when it comes to reducing or even eliminating their natural diversity.

While apples in nature boast an impressive genetic diversity, apple trees grown as cultivars[7] often suffer from very

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[6] Again, while both parts of this story are independently true, we do not have any concrete proof that shows that one led to the other. Yet, like with Newton and the apple, this is another story that is both compelling and fun so we love to propagate it.

[7] Cultivar is just a fancy word for saying 'grown as a specific variety of apple'.

low genetic diversity. This lack of diversity can make them particularly vulnerable to a host of diseases and pests that could otherwise be mitigated by nature's built-in safeguards. It is akin to having the exact same password across many different websites. Once a hacker has access to one, they can wipe out your entire digital existence, since the password gives them access to everything else.

In the wild, the genetic diversity among different apple trees means that when a disease strikes, not all trees are affected equally. Some might show resistance while others succumb quickly, creating a balance that helps maintain the overall health of the ecosystem. However, in the world of clones, where genetically identical plants are grown side by side, a disease can sweep through an orchard like wildfire. Since all the trees share the same genetic makeup, any disease that targets one tree will likely affect all the others in the same way. This can lead to catastrophic losses in a single growing season, with entire orchards wiped out by a single disease outbreak. The consequences can be devastating, not just for farmers but for food supply as well.

This isn't just the case for apples. As I mentioned before, the Cavendish banana has a global presence in supermarkets, largely because of its ability to withstand shipping and its consistent taste. However, it being a clone means that it's genetically identical across the globe, leaving it as vulnerable as a lone tree in an orchard full of identical siblings.

A devastating fungal disease known as Tropical Race 4 (TR4) is now threatening Cavendish bananas, and if it spreads unchecked, we could face a banana apocalypse! What's more, this fungal disease is known to be resistant to most known

fungicides, which makes its effects all the more dreadful. Something like this can affect the global banana trade, which supports millions of farmers worldwide.[8] This has happened before, with bananas being devastated in the 1950s by a fungus that caused 'Panama disease', which is why the Cavendish, which was Panama-resistant, replaced the Gros Michel, which was not. Moreover, because most cloned plants are genetically identical, they can be particularly susceptible to diseases and pests, leading to the widespread use of fungicides and pesticides. These chemicals may help control outbreaks in the short term, but they can harm beneficial organisms in the soil, disrupt local ecosystems and even lead to pesticide-resistant pests, creating a cycle of dependency that can be tough to break. The environmental impact can be significant, especially when runoff from treated fields contaminates local waterways, affecting wildlife and drinking water quality.

Finally, the pressure to produce uniform crops can push farmers to prioritize short-term yields over long-term sustainability. In their quest for the perfect apple or the ideal banana, they might overlook the importance of maintaining a diverse range of plants that can adapt to changing conditions. While grafting and cloning can yield impressive results, over-reliance on these techniques can undermine the very resilience we need to navigate the challenges of climate change and biodiversity loss.

But wait! There's hope on the horizon! As we face these challenges, communities all over the world are beginning to revive wild varieties and harness their incredible genetic

[8] Not to mention the fictional but very important species of Minions!