ILDI VIBÓK

THE SUPERLADDER

What Is DNA?

ISBN 978-615-81820-8-9

Published by Pagony Kiadó in 2021.

www.pagony.hu

1114 Budapest, Bartók Béla út 15/a

ILDI VIBÓK

THE SUPERLADDER

What Is DNA?

Illustrated by Tamás Mayer

[illustration includes the word] Sleeping Beauty

DAY ONE

When it turns out that at the very least you need to have golden hair and a porcelain complexion to be beautiful, but not how to get it

Emma irritably tossed aside the masterpiece *1001 Tips for Troubled Princesses* that her grandma had given her for her birthday. She had been interested to find out what the book would say about her problems, but that, it turned out, was nothing.

These particular troubles had begun the night before with the story Queen Sara had told to lull her restless offspring into a deep and soothing sleep. But the story, which was about a princess, had really stirred Emma up. There had been a *Sleeping Beauty*, who had not been much bothered about anything since she slept through the whole story; however, there was just one thing in her favour, this interminably dull creature had an alabaster complexion, sky-blue eyes, and masses of curly golden locks cascading down her back. As any famously fair and beautiful princess would. Until the previous evening, it had never even occurred to Emma that she ought to be stunningly beautiful, but now she wanted nothing else. At this moment, she stood in front of the mirror, staring mournfully at her ugly carrot-top curls, the insolent freckles that were ganging up around her pimply nose, and succumbed to the feeling that these were insurmountable obstacles to her becoming a world-famous beauty. And the *1001 Tips* had not had one single line about how she might acquire golden curls or alabaster skin, preferably within the next 24 hours.

With her chin wobbling, she stepped over to her dressing table and pulled her favourite baggy tasselled beanie hat out of the drawer and pulled it down over her head—aargh! These outrageously awful, not even strawberry blonde curls! She headed for the kitchen. If she didn't have golden locks, at least there would be plenty of frothy hot chocolate, right?

The sweet, sultry scent of cocoa lingered over Emma's polka-dotted mug on the kitchen table. Queen Sara had just filled it. Indignantly, Emma noticed for the first time ever that Queen Sara's golden curls glistened alluringly—despite being caught in a prim little bun rather than cascading down over her shoulders.

'Mummy, you are blonde!' she said, staring sternly at the queen.

'And a good morning to you too, Emma,' Queen Sara responded, a little startled. 'Of course, I am!'

'Give me the spell!'

'Which spell?'

'The one for golden locks and a freckle-free face! I need it to become a world-famous beauty.' Emma explained.

Queen Sara looked thoughtfully at her child and the striped hat.

'I think I cast all the spells for earthly beauty before you were born.'

'What do you mean?' demanded Emma, swigging from her hot chocolate.

'Exactly what I said. Incidentally, as far as I know, the foremost expert around here on spells of that sort is Doc, so you'd better ask him.'

'But do leave the hat at home dear' she stepped up to the departing princess, 'In summer, you'd be better off with a polka-dot bandana or a straw hat,' she said firmly, tugging the stripey hat off the child's unruly locks.

Doc—or the Royal Paediatrician, to use his full title—was usually to be found at the Academy of Science from early morning until late at night and was therefore terrifically knowledgeable about all the mysteries of the world. Emma was astounded that he hadn’t occurred to her sooner as a potential saviour. So, she loaded up her ladybird rucksack—with some cheese scones and two bottles of tea—and set off. As she was leaving, she shouted back from the kitchen doorway:

‘Mummy, the password is: frothy chocolate! You know, in case you don't recognize me with flowing golden hair and a freckle-free face.’ And with that she was gone.

In under fifteen minutes, she was peeping in through the big glass doors of the Academy of Sciences, trying to reach the Doc's bell button. The one under which was hand-written in neatly formed letters:

[illustration includes the word:] LABORATORY

Then, as soon as the door opened, she set off to make herself beautiful, preferably before lunch.

Doc was fiddling around behind his desk, and from there he glanced up at the princess as she rushed in.

‘Hi, Emma, what's up?’
‘Hi, Doc! Listen, I've been longing to be a world-famous beauty since yesterday, but I can't do it alone. I need your help.’ Emma took off her backpack. ‘I brought a few scones and some tea. In case it takes a while…’
'I see,’ nodded the court scholar gravely. 'And how do you propose to make this transformation?’
‘Simple! I want golden hair instead of this,' Emma gripped a lock of her thick red hair. ‘Mummy says she can't help me. She thinks that she's already done everything she can to make me beautiful, but I doubt that very much, because she has golden hair and not a single freckle. I can’t imagine how I came to be covered in them!’ Emma stamped her foot in frustration, but then looked up hopefully and said, ‘you can help, can’t you?’
‘Why don’t we look into the matter a little…’ Doc lifted his giant magic book down from the shelf and picked up the remote control. ‘For instance, we could find out where the ginger hair came from. And then we'll see what else we can do. How does that sound?’
‘Well, if there's nothing else …’
‘Actually, it's been quite a while since people first noticed that children tend to look like their parents.’ Doc pressed the remote control, and Emma could see Ebony, the farm cat, cleaning her new-born kittens. Three of them were pitch black like their mother, but two were quite different. The princess sighed.

[illustration]

‘And sometimes they don't look anything like each other,’ he muttered.
‘In any case, the question of what decides similarity and how certain traits are passed from parents to children was a subject of interest to many scientists for a long time. They soon discovered that gametes were the key, so the question remained as to how?’
‘What on earth are ‘gametes’?’
‘I thought you might ask that. For the moment it’s enough to know that a lot of creatures use gametes for reproduction. Both female and male organisms produce these cells, and when they meet, they become the *zygote*, which is the tiny little organism that eventually becomes their offspring.

[illustration]

‘The female gametes are often called *oocytes*, and boys produce male gametes. Usually, the oocyte cells are bigger. An egg, for example,’ said Doc, pushing his glasses up, ‘is just a giant cell with a well-armoured shell. Unless, that is, the hen met a rooster early on, of course, if she did, then the egg is already a prospective chick…’

‘One that looks like its mum or dad?’

‘Well, yes. At least it'll be a hen or a rooster when it grows up, and certainly not a horse.’

Emma laughed.

‘Good thing too! How surprised would its mum be when it came out! But actually, why can't it be a trotting horse? Or at least, say, a dove?’

‘Well, scientists and animal breeders puzzled over that question too, and they discovered that tiny particles from each of the parent's organs migrate into the gametes, where the right ones get mixed together, the traits get averaged out and then passed on.’

‘What does averaging mean?’

‘If something very big and something very small come together and become a medium-sized something, that's the average. For example, if Cinderella falls in love with Bigfoot, she won’t have to worry that the size of her baby daughter's feet will be out of all proportion to her body. She might not be able to wear glass slippers, but her feet won't be either too small or too big. The scientists of old even gave this theory a name. They called it **mixed inheritance**.

Unfortunately, according to this theory, a black cat and a white cat can only have grey kittens, and a long-haired bunny and a short-haired bunny can only have medium-haired kits. And two brown-eyed people can never have blue-eyed babies. Only brown-eyed ones.’

‘But that's not true! Ebony, for example, had grey and black kittens last week! And my red hair couldn't have just appeared on my head out of nowhere, could it? Look at Mummy and Daddy!

[illustration]

‘Well, yes. I think you have hit the nail on the head!’ sighed the Doc. ‘And what a fashionable theory it was… People loved it! But there are some things it just couldn’t explain. Like Ebony’s kittens and your hair, and peas.’

‘Peas don't need explaining,’ Emma frowned, ‘they all look exactly the same.’

‘But they so do! They are very individual! And that is precisely what helped us to find out the truth. I know someone who is a real expert on the subject. He could tell you a lot about it, if you're really interested…’

‘I'm very interested!’ The princess's eyes lit up as Doc pressed the remote control again, and hey presto! Ebony’s kittens suddenly disappeared into thin air, and in their place slowly appeared a sign…

GREGOR AND THE PEAS

Then a mysterious looking monastery appeared under the letters, the door opened, and a monk in brown robes strode out.

‘Good morning, Doc! Long-time no see! I've been looking forward to a little chat. And who is this I have the pleasure of meeting, young lady?’ He turned to Emma.

‘I'm Emma, and unfortunately my hair is ginger.’ Emma pointed to her copper-coloured curls.’

'I see,' the monk scratched his head, 'or rather I don't. I'm not a barber!’

‘But Doc told me that you helped the peas…’ Emma was confused, but the court scholar rushed to her aid.

‘Emma, this is Gregor Mendel, the father of genetics. He was the first person to explain how heredity works. He didn't help the peas, they helped him.’

Emma stared at the monk.

‘Why? What did you do with those peas?’

'I grew them in the cloister garden, like this, you see,' Gregor pointed to the page. 'I planted a lot of purple-flowering peas in one bed, and white-flowering ones in another bed well away from the purple ones. Then I wondered what colour the new peas would be if I crossed them.

What do you do with them? ‘Emma asked.

'I cross them. I pollinate the white flowers with pollen from the purple flowers and the purple flowers with pollen from the white flowers.

[illustration]

‘You know, it's as if Gregor were a bee,’ Doc explained, ‘And with flowers, the pollinator is always the father and the fruitful one is always the mother.’

[illustration]

Emma nodded.
‘Then? what happened?’ she asked.
'I waited patiently for the pea seeds to grow, then planted them, and waited for the new plants to sprout and grow, and...’
‘It takes a lot of patience to do this science! So, what colour did the flowers of the baby peas turn out to be?’
‘See for yourself!’

[illustration]

‘All purple...’ the princess was amazed. ‘But what happened to the white ones?’

Gregor's eyes lit up.

‘Well, that's exactly what I asked! Because it didn't matter whether the purple flowers were stamens or pistils, whether they were fathers or mothers, the offspring of the peas were always purple. Without exception.’

‘That's not very fair to the poor white flowers, to make them disappear like that! They haven't disappeared completely, have they, Gregor?’

‘No, they haven’t. Because I pollinated these new purple-flowered peas as soon as they grew up, and then I planted the peas that grew on them, waited a while, and among them there were white ones, but only a quarter of them were white’.

‘Wow. So, the white flowers did come out again,’ Emma sighed with satisfaction. ‘But there were just more purple ones,’

Doc nodded.

‘That's true. Only about every fourth pea has the same white flower as its grandparents.’

‘Of course, it took me a while to guess the reason,’ Gregor continued, ‘so I started to observe the other characteristics of the peas in the same way.’

‘Why,’ Emma wondered, ‘do peas have other properties?’

‘Listen! There are:

wrinkled or smooth round peas

yellow or green peas

rough or smooth pea-pods

yellow or green pea-pods

and there are some that only produce flowers at the end of the stem, and some that produce flowers in the middle of the stem.'

'Wow, you really had to work your socks off then!'

'And there were so many peas too!' Gregor sighed. 'We ate pea soup for eight years. How many times did the others rub my nose in it, asking me why I didn't study chickens instead...!'

'But you stuck to peas, didn't you?'

'I most certainly did! I've never really got bored with them because no matter how many peas I planted, no matter how many traits I tested, I always ended up with the same thing:

- the first batch of baby peas always resonated with one of the parents. That is, if you can say that about peas.
- With the next batch of peas, the previously hidden trait appeared, but in every four peas only one had the characteristic. Regular as clockwork. So, it was time to move on

I also pollinated the flowers in the second batch of peas (you know, where about every fourth one was white). Of course, those were on their own, too. And look what I got: the white flowered peas always produced white flowered peas—sure as eggs is eggs. But the purple-flowered ones were not so boring! Among them both white and purple flowered plants grew among the offspring. Of course, as previously, the purple ones were much more numerous. And I just planted and pollinated, planted and counted, and suddenly, hooray, I had the solution! How obvious it was!'

'Do you think it's obvious, Doc?' Emma looked at the court scientist, perplexed, 'because I didn't come up with any explanation for it myself.'

‘No, and nor had anyone else before Gregor!’ Doc smiled.

'Look at that!' Gregor pointed to the page. It's all there! And it really is all in the gametes!’

In the beginning, purple-flowered peas have only purple flowers and white-flowered peas have white gametes. That's pretty much how it is:

[illustration]

And the colour of the new batch of pea flowers…’

Emma sighed ‘Purple….’

‘Of course! But they still carry the white characteristic in them, do you see? But the purple is stronger and overpowers the white.

[illustration]

But then, in the second round, the white can appear in any plant that doesn't have the dominant purple one next to it. Look at that! You can see it clearly here, where the purple is absent, the white does make its presence felt, but only there, in about one in four flowers.’

[illustration]

So that's the secret!
‘Traits are transferred from parents to children by tiny particles. Some traits are always visible, others are hidden, but sometimes they can reappear. If they're not overwhelmed by the stronger one. That's what I discovered. Incidentally, I named it: **the theory of particle inheritance**.’
‘I think I begin to understand,’ Emma looked at Doc with satisfaction.
‘Super. Then it's time for our pea puzzle!’ winked the court scholar at Gregor.
‘Well…’ The princess suddenly looked a little uncertain, and Doc continued.

‘Here's this pea,’ Gregor pointed to the card next to him, ‘Is it a full-blooded purple flower? Or does it also carry the white colour?’

‘Easy peasy!’ said Emma. ‘Let’s pollinate it with a white-flowered pea and draw out the white particles. If it has any. And then if it doesn’t, it'll have all purple babies.’

‘By heavens you’ve got it! By the way, the particles that carry the property are called ***genes***. And usually, we have two of the same trait: one from our father and one from our mother. They are ***alleles***, or **variants of a gene**.’

‘So, the colour of a pea flower can be passed on by white and purple alleles. But it's not just hidden and furtive alleles! For example, there's the *Miriblis jalapa* or Marvel of Peru…’

‘That sounds magical, is it?’ The princess's eyes widened.

‘Almost!’ nodded Gregor. ‘There are red and white ones. I used to get some seeds and plant them in the garden, and when they sprouted, they grew and bloomed…’

‘So, you were playing at being a bee again?’ Emma asked.

‘Well, sort of! I paired the red ones with the white ones and the white ones with the red ones, and when they produced seeds, I planted them. You wouldn't believe the flowers that grew from the

seeds!’

‘All red?’

‘No!’

‘Then all white!’

‘No, no!’
‘I give in,’ said Emma, and the page was suddenly covered with a huge pile of pink flowers.

‘You got pink flowers? It's a bit like that thing with Cinderella's feet, don't you think?’

‘The mixed inheritance? Well, yes. It does seem similar at first. But only at first. Because when I pollinated all those pink Marvels of Peru with my own, then all of a sudden it was like this:

illustration

‘But with the blending, all I'd get would be pink flowers, right?’

‘Yes. How on earth did this happen?’
‘Because alleles can be more than just self-promoters and hideaway-Harrys. They're also the kind that stick together. They're collaborators. Now, if our miracle cone gets the allele responsible for the colour red from both mum and dad, it will be red, if it gets the allele responsible for the colour white, it will be white. But if one allele is red and the other is white, then the flowers…’ Gregor smiled at Emma.

‘They will be pink, that’s obvious,’ said Emma, ‘so I will have things from both Mummy and Daddy that you can’t see on them, and so I got what I got, and that’s just the way it is, isn’t it?’

‘It might just be…’ nodded Doc, ‘don’t you think Gregor?’

‘So, it would seem! Just like in the pink Marvels of Peru, where despite both the mum and dad being pink, the offspring might not only be pink, but also red and white. And this proves that alleles don't mix like a cocktail. Even if one of them is not getting a say because another is suppressing it, or the two of them are developing some very new trait side by side, they are still there separately in the cell.’

Emma sighed heavily.

‘So, mummy really doesn't have any magic, it's just the particles, or genes that I inherited from her and daddy. Thanks anyway, Gregor.’

‘You're welcome. But don't look so gloomy. I think your hair-do looks very pretty. Now, I'd better be off. I'm studying bees these days. I must say, they're a terrifically interesting bunch. And honey is even tastier than peas. Good day to both of you, Emma, Doc.’

'Goodbye' Emma murmured thoughtfully, then suddenly turned to Doc. ‘But where are these particles of qualities in me? Just in case I want to change them…’

Doc scratched the top of his head.

[illustration]

‘Well, everywhere. More precisely, in every single cell of you, from the top of your head to the tips of your toes.’

‘You mean there are particles for red hair and flipping freckles all over me?’

‘I do.’

‘Then there really is no hope…' sighed the hopeless princess. ‘I don’t think I'll ever be beautiful! But if I can't have golden hair, then what's the point of all this heredity stuff? And how do I fit all these qualities into all my tiny cells? And what does the colour of my hair have to do with the toes on my feet? Oh my! Doc! I do hope I won’t get hairy

toes!’

Doc smiled.

'I think we should try the Queen's super cheese scones now and try to solve the rest of the mysteries tomorrow, what do you think? But I can promise you this, you will never need a hairbrush for your toes.’

Emma pulled the bag of scones out of her backpack. ‘Let's gobble them all up. All this science has given me an appetite!

[illustration]

DAY TWO

When we find out a lot of things about hereditary particles, for example, that sometimes they also get things wrong

The next morning, Emma ran into Doc, armed with another batch of cheese scones and some tea, and a sheet of paper covered in writing.

‘Hi, Doc! I've been thinking about it,’ and as she said this, she dropped her rucksack on the floor and slapped the paper down in front of the astonished royal tutor, ‘because I'm not quite clear on this inheritance business. Neither are mummy and daddy, so here are some questions.’

‘Let's hear them!’ Doc adjusted his glasses.

‘Well, first of all, you said yesterday that my hereditary particles, which somehow have all my traits in them, even the freckles, are in all of my cells. I think you are wrong about that! Because on the one hand my cells are terribly small, because I'm not very big, and on the other hand I have an awful lot of characteristics! How could they possibly all fit into one little Emma cell? And you’re telling me they're just scattered all over the place? How do they know where I want to develop which trait? That I want to have hair on my head, toes and toenails on my feet, teeth in my mouth, and that I don't need a moustache like my dad's, for example? So, I'd like to know precisely what you mean by that!’

‘Let’s take look into all of those things right now.’ Doc lifted the huge book off the shelf and opened it.

This time there was no sign of the monastery in the book, nor of Gregor. Instead, there was Emma and her best friend, Paul, flying a kite at the edge of a forest. Then there was Ebony the cat and Doris the dachshund, and there were some pots of green peas, two or three Marvels of Peru and so on.

‘How did that picture get into your book? And how did Ebony and Doris the dachshund get into it at the same time? I don't think they're very good friends…’

‘You may be right,’ said Doc, pushing his specs up his nose, ‘but there are some things in which they are very similar. And you, too, for that matter, because you and Paul and Ebony and Doris and the peas and the Marvels of Peru and even me, we’re all made up of cells. I'll show you in a moment,’ he said, and suddenly the page was full of tiny cells. ‘This is an Emma-ear cell, this one is from Paul’s little finger, this came from Ebony's tongue, this is from a moth's antennae, this is from a leaf from a walnut tree. There are so many cells from all over the place. Of course, there are differences between them, but they all have a part—here it is—that we call a *nucleus*.

illustration

‘It looks like a blob,‘ Emma narrowed her eyes, ‘are you saying there are blobs in all my cells?

‘Almost all of them. Not in the red blood cells that float up and down in your blood, carrying oxygen and carbon dioxide, but that is why we don't call them cells.’

‘So, what does this blob do?’

‘The nucleus? Lots of things. For example, it stores hereditary 'stuff'. That is, the blueprints for your traits. And Ebony’s nucleus holds her blueprints.’

‘You mean mine has what makes me a kid and Ebony’s has what makes her a cat?’

‘Well, sort of. And you don't have all those genes wandering around in your cells, they're all packed

into the nucleus. And they're not just clumped together in bulk.

‘I see.’ Emma looked at the Doctor.

Doc pressed a button on the remote control, and the cells started to grow, and then all you could see were the nuclei and a bunch of little things inside them.

‘Are all those weird little dots hereditary material?

‘Yes. We call them *chromosomes*. Well, these chromosomes are where the genes sit. Of course, they're usually wrapped up in some kind of protective casing to keep them from getting hurt. And then when they're needed, the body releases them, and when they're used, they're released.

Emma looked at the picture carefully.

[illustration]

‘I think, Doc, your book is broken,’ he muttered, ‘Ebony has fewer chromosomes than Paul and I do…
‘Because Ebony is not a human, she's a cat, and cats have 38 chromosomes, and we humans have 46. More precisely…’

‘More precisely what?’

‘More precisely, Ebony has 19 pairs of chromosomes, and you have 23. Because she has two of each chromosome in her nucleus. Do you remember? Your daddy and your mommy both gave you a whole set of genetic material in a gamete.’

Emma remembered and Doc continued.

‘By the way, the set of chromosomes has a name. It's called a **genome**. That means you have two complete genomes in almost every cell. And because scientists like to name everything, your chromosomes have names too. But they didn't overcomplicate the naming. First, they put them in order of size—the biggest was at the top—and then they counted them, and finally they named them by number. The biggest was number one, and the smallest was number twenty-two…’

‘Not twenty-three?’

‘Good question, but no. Because there is a very special pair, which in girls is two very similar chromosomes, and their names: X. They got one from their mother…’

‘And the other one from their daddy. I already know that. And what else?’

‘It's that this is only true for girls. You, your mum and Ebony the cat. It's different for boys. Because they, that's us, like Paul, your dad and I, have only one X chromosome per cell, which we got from our mum. The one next to it is quite chunky, and it’s called a Y chromosome. We got it from our dads.’

‘It's really quite dinky.’

‘Yes, but it's very important. It's got the gene that makes us boys and you and Ebony are girls because you don't have that gene.’

‘I see’. Emma thought that Paul might be surprised if she told him that. Then she suddenly remembered something. She looked at Doc.

‘And what else is on the Y besides being a boy? A quality that only you boys have?’

Doc grinned.

‘If you have the hairy-ear gene, it's on your Y chromosome. So, if you or your mum want to have hairy ears for the carnival, you're just have to wait for it to develop. But there's also a very important gene on the X chromosome that, if it's working properly, will make sure that any damage heals quickly, but if that gene goes wrong, it's a much bigger problem than the hairy-ear gene would be. Of

course, usually, if a girl has a bad allele, that is, a faulty variant, right along next to it is the healthy one, which gets her out of trouble. You know, on the other X chromosome. In boys, on the other hand, if they have the defective gene on the one X that their mother gave them, even a small injury can cause a lot of trouble, because the wound will bleed and bleed and it's not going to heal.

Emma looked sternly at the picture of the tiny Y chromosome, which instead of helping in recovery from a disease as dangerous as this, shrugs it all off with a hairy ear… Then her eyes wandered to the Ebony cell, and her freckled face brightened

illustration

‘By the way, I assumed that I would have more chromosomes than Ebony because I have so many characteristics…’

‘But it doesn't really matter that Ebony has fewer chromosomes than you, just as it doesn't matter that Doris dachshund, like all puppies, has many more. 78 to be exact. That's 39 pairs. And butterflies have many, many more. Almost 400.’

Emma pondered for a moment.

‘But they are so small! So why do they need so many?’

‘Because it's not the number of chromosomes that matters.’

‘What does then?’

‘It’s the secret codes that are written inside them.’

‘Secret codes? Wow! I have secret codes written in me?’

‘Absolutely! You know, genes. They hold the secret recipe for all your special qualities.’

‘Even the one about for chocolate ice cream being my favourite?’

‘‘That's not exactly what I meant. To unravel the mysteries of chromosomes and genes, it's best to unravel a chromosome first.’

Doc pressed another button on the remote control, and a blob appeared on the page with a sign that read:

[illustration] THE NUCLEUS

THE WORLD OF CHROMOSOMES

And through the crack underneath the sign, a sprightly, slightly stick-like creature was peeping out.

[illustration to the top right]

‘Hello!’ he waved to the people outside. ‘Hi, Doc! What's up?’

‘Hi, Sherlock! Emma, this is one of your number eight chromosomes.’ Doc looked at his grinning guest and continued, ‘Sherlock, this is Emma, and she's been very curious about you. I mean all of you, chromosomes.’

‘Hello, Emma! I can well imagine. If you only knew how long scientists have been studying us! They don't even know the first thing about a lot of our traits. Are you interested in anything in particular?’

‘Everything!’

‘Hmm.’ Sherlock wondered, ‘and what is your first impression of me?’

‘You look like all sort of bundled up. And you're quite small, which is fine because so am I. But I'll grow up one day, and you'll never get any bigger, will you?’

Sherlock looked her up and down.
‘That’s right, I'll stay this size. Unless you get hurt somehow. And I while I do look a bit knobbly to you now, I'm actually very neatly rolled up. And the point is, I'm tiny, but I'm terribly thin, so I can be very long. Which means I have room for everything I need.’

‘But I can't see anything on you at all!’

‘Well, look closer! I'm going to enlarge my tummy. Come on Doc, give me a hand?’

‘Okay, okay!’ Doc pressed the magnifying glass and Emma's eyes grew wide.

‘Crikey… Now you look like a ladder!’

‘Yes. This part of me is what scientists call DNA. And it really does connect the two strands like a ladder. A SUPER LADDER!’

‘Well, your DNA is a bit twirly…’

‘I’m sure it is,’ said Sherlock, pulling himself up straight, ‘but believe me, it's just perfect! One thread has the codes to you, the other completes it and makes the whole thing super-strong. So, I take care of the code, and make sure it doesn't get damaged easily. You know, two strands are much harder to break than one. And if it does break, it's easier to fix.’

‘And which thread is the secret code on?’ Emma leaned up close to the paper.

‘One on one side and one on the other. The point is that when they break, the organization can build another thread just like the original one. You have two identical pieces of DNA.

‘You seem very complicated…’ the princess was sizing up Sherlock.

‘I’m really not, just simply wonderful! My DNA strand is made up of four building blocks, and they're all there. Something like this:

[illustration]

They are the **bases**.’

‘And what do the bases do?’

‘Cryptography!’ Sherlock whispered mysteriously. ‘The neighbouring bases get together and together they write what kind of bricks you need to put in your protein chain code.
‘What chain?’ Emma's eyes lit up. She loved chains.
‘In your protein chain,’ Doc interjected, ‘Which is not a necklace, but a small part of what makes up you. The different proteins are all very important because everything that lives is made of them.’
‘Even me?’
‘Yes! Your auburn curls, your nails, your bones, your muscles, you yourself from the top of your head to the tips of your toes are largely made up of proteins, or if something in you is not actually protein, it is made up of proteins.’
‘That's right! Just take a look at my lovely cape, it protects my DNA!’ Sherlock interjected, ‘because that's protein too!’
‘Exactly,’ Doc nodded. ‘And all proteins are made with the recipe for the gene inside.’
‘Wow! It's really complicated.’
Sherlock looked at Emma, who was clearly puzzled, then scratched the top of his head.
Hey Doc, call the Courier please, we need him now.
Doc nodded and pressed the button on the radio control. On the page a figure appeared who was even spindlier than Sherlock.
[illustration, figure has an acronym in two places--on his hat and on his bag--that should say RNA]
‘Hello Sherlock, what’s the score?’
‘Hi, Messenger! This is Emma, and she's curious about you for some reason…’
‘Courier, Sherlock. My name is Courier. Not Messenger. Hi, Emma. I bring you the latest news.
‘What news?
‘You know, chromosomes are an idle bunch. They sit around in the nucleus, acting all mysterious. They hang on to the recipes for your all parts.’
‘Yes, Sherlock has already told me that.

‘Yeah, but what good is a recipe that nobody makes anything from? Because there are no ingredients here in the nucleus… So, when the time comes, the chromosome unwinds, the recipe appears, and we Couriers quickly copy it. Because we are, in fact, the working copy. You can see how similar we are to Sherlock's DNA. But we are always much shorter because we only copy part of it. Plus, we only have one strand, not two. And our name is RNA. When we're ready, we pop out of the nucleus, rush over to the protein library, and there, according to the plan, we're ready to start making stuff…’
Emma was stumped.
‘I know you make proteins, I just don't understand what this protein thing is yet…’
Sherlock scratched his head.
‘You know what? Imagine that the protein chains that you are made up of are like reels of slide film. We chromosomes decide what the slide film is about. More specifically,’ Sherlock raised his index finger, ‘the bases of our DNA chain. Three adjacent bases arrange a film frame. Each chromosome has a lot of fairy tale code on it. Since we are usually in pairs, those in the same pair have the same story plans, neatly in sequence, just not in precisely same way, of course. Like a story told by your mom is then told by your dad. Does that make sense so far?’
‘I think so’.
'Good,' nodded Sherlock. ‘And here's the thing, because all the stories that can be rewritten about your chromosomes are about you! It's all about your personal characteristics.’
[illustration with two signs] NUCLEUS

PROTEIN FACTORY
‘Do you mean my ginger hair and freckles?’
‘That and that you have two hands and five fingers on each hand, that you have two ears and a nose, that you have blue eyes, and that no matter how many salami sandwiches you eat, you will never, ever be two and a half metres tall.’
‘I should hope not. I'm not a giraffe!’
‘Exactly. But the point is, we have all your traits mapped out for you. Even the ones you don't know about.’
'I don't think there are any that I don't know about,' scoffed the princess.
‘Of course, there are! Or perhaps you already know how big your feet will be when you grow up, or exactly what your blood group is, or how grey your hair will be when you grow old?’
Emma shook her head and Sherlock continued.
‘Well, you see, we do know! But I won't tell you now and spoil the surprises!’
‘And how did you get into my cells?’
Sherlock pondered a moment.
'It all started about seven years ago, when your daddy gave one gamete and your mummy gave one too, a full set, each with chromosomes, and then the two gametes merged.’
‘In my zygote.’
‘Yes,’ nodded Sherlock. ‘Then you started to grow, your cells multiplied, the new cells became very different after a while, but they were similar in one thing: the two sets of hereditary material had all your characteristics.’
‘Doc said that once before, but I still don't get it because if I have the same hair code in all my cells, how come, for example, I have hair on my head and not on my toes? And my bones are hard, but my skin is soft, my lips are red, but my eyes are not, and I'm not at all the same everywhere…’
‘Not only are all your traits encoded in us, but each plan has an instruction that tells you which cell to turn on and when.’
‘Is that important?’
‘Of course, it is! For example, that's why Paul doesn't have a moustache yet, but Papa does, even though they're both boys. Or it is why Ebony produces milk when she has kittens and not otherwise. These are very important things.’
Doc pressed the button on the remote control.

[illustration labels in sequence]
END PROTEIN RECIPE START DIRECTION TO GO IN
'This is a gene,' he said, and there it was on the page, the gene, 'This section here tells you what part of your body it can work on, this one turns it on, this section is the recipe for the protein chain itself, and this one at the end tells you when it's done its job and should stop copying. By the way, the start sequence is just like a lock that only opens when the organism lifts the latch, because the gene is in the right place at the right time to work. That's when the copying can start.
'That's when it's our turn' said the Courier, pulling himself straight. We rush down to the factory with the plan.'
Emma looked at Sherlock.
'Lucky you never miss all this stuff.'
'Well...' the little number eight chromosome looked down at his feet, 'we do occasionally get things wrong, too. Those blooming mutations, you know!'
'What are they?'
'The mutations.' Sherlock jumped on Doc's hand. 'Hey, Doc! You understand this better than I. Or... tell you what, call Brains. If he's free...'
'Okay...' Doc fiddled with the remote control in confusion. 'I can give it a try... just, he's always so busy. Let's see!'
Suddenly something like a workshop appeared on the page. Above the door, there was a sign:
[illustration contains the following 4 lines, top to bottom]
OPEN

ALL KINDS OF GENE ERRORS
REPAIRED WHILE YOU WAIT
(or at least we'll have a go)

[illustration top right]
Doc nervously pressed another button on the remote control, and almost at once a small, disgruntled figure appeared.
'What the blazes is it now? And in the middle of my lunch break?' The newcomer glanced up and looked at his companion with disdain. 'Hello Doc, is your tap broken? Need something fixed?'
'Very funny!' Sherlock looked at Emma. 'I Don't think he knows anything about taps! All he does is fix chromosomes. He's like a sort of hyperactive genetic enhancer, but with such a mouth on him!'
Brains grinned.
'What would you do without me, Sherlock? You and your friends! If it weren't for us, you might not have Emma's story encoded in you, but that of a dung-scraping troglodyte monkey. Or something even worse...'
Emma laughed, and Brains sighed.
'I'm not really joking, little lady. Do you know how many typos and tears we correct while you're having breakfast, or reading, or toasting yourself on the beach?'
'How many?'
'Well, loads.'
'And what are mutations?'
Brains scratched his head.
'All the copying errors and all the changes that happen in this poseurs paradise that we professionals can't fix.'
'He's only joking about the poseur's paradise,' Sherlock sniggered. 'We're all the best of friends really. So, what's a mutation? You remember how your cells keep multiplying, don't you? They divide in two. And we don't have to be in every cell.'
'The two sets of genomes,' Doc muttered.
'Yes. So, every time a cell divides, we have to change. Now, have you ever copied anything in your life? A picture? A task? A letter? Anything?'

Emma nodded.
‘And was it always perfect?’
The princess thought back to her homework the previous week and shook her head.
‘If you realise you have messed up, what do you do? Did you leave it like that?’
‘No way, that’s just what I needed! I erased the mistake and wrote it down correctly.’
‘‘Now imagine that you have to copy something thousands of times over, and that you have to do it in a flash.’ Or even faster than that.’
‘Lightning fast?’
‘Yes. Of course, there'll be plenty of mistakes! But these mistakes are not in your homework, but in your organisation. Most of the mistakes are corrected by us professionals, but every now and again there is something we don't notice, and some of them we don't even correct properly. Sometimes we mess things up too.’
‘Well, this is not good news! I mean, I love my properties, and I don't want any others! Especially not defective ones… Okay, the freckles can stay. Doc’ the redheaded girl looked at the court scientist, ‘will you please stop this mutation thing?’

Doc smiled.
‘That wouldn't do. Mutations aren't always bad. In fact! Some of them are quite useful. They make sure that we don't all look the same, that we develop new traits. If, for example, our environment changes, we living things should be able to adapt. Of course, they can also cause illnesses, but most of the time we don't even notice them.
Emma was thinking about what she had just heard for a suspiciously long time, so Sherlock came to her aid.
‘Listen! Do you remember when I recommended that you imagine us chromosomes to be like pictures in a slide show? But the truth is, not all the descriptions we have are for meaningful stories.’
‘No?‘ the princess was astonished. Sherlock scratched his head.
‘‘There are a lot of advertisements in the film projects. Although nobody knows what they're for. And now I'll show you something!’ Sherlock led the way, and suddenly the sign on the page flashed up:

MUTATIONS

‘First of all, the bugs may be mutations that the specialists have not corrected. Brains and his friends are not

[illustration top left containing 2 words]

Advert

shampoo

the sharpest knives in knives in the drawer ‘Sherlock winked at the master. ‘They don't care how much trouble one slip-up causes. If they catch it, they fix it.’

‘That's our job,' grumbled Brains.
‘And sometimes a mistake might go unnoticed. For example, if it fell in the advertising section, it might never be discovered. It could be a bigger problem if the copy is wrong on an important part of an important film. Say, a frame might be incomprehensible or disappear altogether, but there's still a chance that you'll understand the story by the end. But a really major problem can be when it isn’t a whole frame that disappears, but only part of it, because the frames then shift and cut into the story in a different place. And after a mistake like that, the whole film can become an opaque unwatchable mess. Of course, the film might not be an important one, but what if it is? Translated into the language of proteins, it could be that an important feature is destroyed, and its absence causes a

disease. And then there are the little jumpers, the jumping genes…'
'What? Genes jump around?'

[illustration on the top right] PUSS IN BOOT Sleeping Beauty ADVERT

'Not all of them, of course, but some do,' Doc immediately pointed out, 'And the jumpers tend to bounce near, and sometimes right into, the working genes, which of course destroys everything, at least until they move on. You think you're in for the tale of the Puss in Boots, and then Sleeping Beauty jumps into place.

Emma chewed on the matter for a while, then spat it out. 'You know, Sherlock, what I don't understand is that if you're everywhere, and there's a lot of you, what difference does it make if one of you in one of my cells breaks down a little bit? Say, a cell in my toe in my left foot gets my eye colour gene? Especially since my toe won't use it anyway. Right?'
Doc cleared his throat.
'That's a very good question, Emma, because it usually doesn't matter. But sometimes it can cause disease. Say, when jumping genes land behind the start sequence of a gene that's working, and not only do they mess up that gene, but they start to copy. And they just copy, and copy, and copy, and the faulty cell starts dividing like crazy, just multiplying, and multiplying, and suddenly there's nothing to stop it in the organism. That's when tumours can form. They're very dangerous characters.'
'Ahem… ahem,' Brains cleared his throat, 'but we're there to keep an eye on the what-ifs, for sure. We patrol non-stop, day and night, and if we come across any crazy parasites, we give them a right going over.'
'But how?'
'He he… We plug the closing sequence into the opening one, which he's using without permission, and shut it down. That way the virus can't keep copying.'
''Then there's the gametes,' Doc interjected. 'Erm, they have one of each chromosome, so it's especially important that any dangerous errors are corrected in time for the offspring to be healthy.'
'Yep! And we also have to be terribly vigilant in the early stages of the baby period, when babies are still in their mothers' wombs, because if there is a defect in the genes when there are so few cells, so at the beginning of life…'
'That's going to be in a whole lot of cells later on' Emma nodded. 'So that's why mums have to take such good care of themselves.

'Yes!' agreed Brains enthusiastically. 'We've got enough to do as it is, because these people' he pointed reproachfully at Sherlock, 'are always getting into trouble.

'Really?'

'Yeah, yeah. Take, for example, when chromosomes move into the gametes.

[illustration]

'Before they separate, the chromosomes, say goodbye, embrace their mates, swap alleles, that sort of thing… And if they're not careful, sometimes they break off a piece…'
'Yes, that does sometimes happen,' Sherlock admitted sadly.
'What if you just waved to each other from now on?' Emma wanted very much to help, but Sherlock just nodded.
'I can't do that. Hugging and exchanging alleles are very important! Right, Doc?'
'It most certainly is! That's when the father and mother genes mix.'
'Exactly,' Sherlock agreed, and Brains continued unperturbed. 'It also happens that after a tearful

goodbye, one of the unreliable chromosomes will cross over into the same cell as its mate. None of them will be transferred to the other gamete. And then the zygote will not have two similar chromosomes or, if not, three or only one.'
'Is it a problem if there are more?'
'Yes. For most chromosomes that would be fatal. But not always. For example, take one of my friends, number 21. If just a piece, or if three of his chromosomes somehow get into the zygote instead of the required two, he'll be a Down's syndrome baby who needs more care and attention. And not just from his parents, but from his friends too. And from everyone else.'
'I'm happy to help any baby.' Emma glanced at Sherlock, who just carried on.
'But the most exciting thing is when the zygote splits completely in two at the first division and two babies start to grow out of it at the same time. Because they have the same genetic material...'
'At least at first...' Brains muttered.
'They're identical twins,' Doc interjected.
'Like Paul and Peter!' shouted Emma. 'They're not exactly the same! Paul is a thousand times nicer... Okay, Doc, it explains an awful lot about heredity, but can we actually use it for anything?'
'There are plenty of things we use it for already, and many people are increasingly using that knowledge every day. But today I think we've covered quite a lot of new things. Let's leave that one for tomorrow!'
'Then we'll be on our way,' said Brains, looking at Sherlock and Courier. 'Courier will be asleep soon, and my lunch break is long over.'
'Keep up the good work, you two!' Doc picked up the remote control.

'Bye! And thanks,' Emma waved and slowly closed the book. ''Now for the scones,'

she looked at Doc and emptied the contents of the ladybird rucksack onto the table.

[illustration]

Day three

When it turns out that not only can chromosomes heal, but they are also the ultimate scientific detectives

The next morning, Doc—who had arrived at the Academy of Science at the crack of dawn as usual—glanced at his favourite cuckoo clock on the wall at eight o'clock sharp.
‘Why,’ he muttered half aloud to the cuckoo, ‘where can that child have got to?
But Emma was nowhere to be seen. Not at eight, nor at 8:30, nor at 9:30. Finally, at precisely seven minutes past ten, the bell rang, and Doc elbowed the door-opener with a sigh of relief.
‘Hi, Doc! Guess what, someone kidnapped my bunny, Carrot Cake, and all his chromosomes! Thankfully he was returned. I found this in his cage, see!’ Emma was recounting the morning's events as she raced through the lab, dumped her backpack and finally shoved an envelope under Doc's nose.
‘I thought something must have gone very wrong…' the court scientist grumbled as he peered into the envelope. He had been about to say: ‘But it's completely empty!’ when he suddenly noticed a thin brown hair lying at the bottom of the envelope.
‘So, I won’t have time today, Doc. I'm going to check this hair against everybody’s head one by one. Grandpa is the only person I know who is bald enough to skip it!’
‘Well, we can do way better than that!’ Doc grabbed a pair of tweezers, carefully lifted the hair out of the envelope, and plopped it on a slide. ‘How did your rabbit cope with its adventure?’
‘Carrot Cake is a real hero,’ the princess said proudly. ‘But just to be on the safe side I left him a comforting carrot to help him get over his fright. Have you thought of a simpler solution? Do you have a super-secure, super-secret, super-scientific thief-catching technique?’
Doc nodded, he was already lifting the book off the shelf.
‘Let's see what our detective can do with a great, big trail like that…’
‘Do you mean the hair?’
‘Yes! You do remember that we have chromosomes in almost every cell in our bodies. I mean…’
‘So, does the hair have the rabbit-napper’s chromosomes?
‘Indeed, it does! Right here, at the hair follicle…’
‘But how do we know which chromosomes are which? After all, we can't ask them, can we? They won't tell us who they belong to, will they?’
‘Oh, but they will… you just need to know their secret language…’
By this time, Sherlock had already popped up on the white page.
‘Hello, Emma, hello, Doc! How are you today?’
‘Hi, Sherlock. We're investigating. Somebody kidnapped my bunny this morning, but they left a hair behind, so we have a hot lead.’
‘Oh, boy! So, your bunny's in danger?’
‘Not anymore. Luckily, the villain brought it back, but it'd be nice to know who it was. I'd better catch them before it's too late. I mean, I can't guard Carrot Cake all day long, can I?’
‘Right,’ nodded chromosome eight. ‘We will find out who is responsible for this outrage by the time the day is out, or my name is not Sherlock… What did you say your bunny's name was?’
‘Carrot Cake.’
‘I see. So, Carrot Cake.’
‘Can you track him down?
‘Of course!’ said Sherlock. ‘That's how I got my name. I named myself after Sherlock Holmes, the great detective. You’d never believe what they called me before!’
‘What did they call you?’
Sherlock suddenly scowled and started to fidget uncomfortably, then looked at Emma and

sighed heavily. ‘All right, I'll tell you, since it was me that brought it up. So, well, sort of… junk chromosome.’
‘But why?’ cried the princess, ‘You are the sweetest, cleverest, nicest little chromosome in all the world.’
Sherlock blushed and coughed and cleared his throat in his embarrassment.
‘Thank you for saying that. That's very kind of you. But the thing is, we have genes on chromosomes…’
‘I know, the ones that are written down as protein recipes for our characteristics.’
‘That’s right. But when scientists deciphered us, it turned out that considering how long we are, we really only have a very few useful genes.’
‘Really? How few?’
‘Well, very few. Around 30,000.’
‘30,000! Not many you say?’ the princess was astonished, for she had guessed from the beginning that she had a lot of characteristics, but she was obviously not prepared for thirty thousand of them.

[Illustration to the left containing the following text, top to bottom]

ADVERT
SAMPOO
SALE
ADVERT
New flavour!
CHOCOLATE
SALE
SHAMPOO
ADVERT

She decided to write them all down when she got home. Or at least half of them. But there was not much time to think about it, because Sherlock was continuing.
‘Okay, not so few, but besides the genes, we've got about thirty times as many that are just rubbish! Long stretches that just take up space but don’t encode anything. Sort of useless, you know, jokes and junk.’
‘Joke junk?’
‘Yes. It's like your TV films, after an hour of the Golden Hair story, they run commercials for a day and a half…’
‘There are some really cute commercials though. Like that one for shampoo with the golden-haired lambs,’ Emma tried to console the disgruntled number eight chromosome, but he just snorted derisively.
‘Oh, come on! Leave it out! I know perfectly well that the bigger part of me is even less useful than adverts. The same piece of fluff just repeated over and over again. CATCATCATCATCATCATCAT 'CATCATCAT. It's all just like one long hiccup, and that's that.’
‘And why is that in you?’
‘I don't know. Nor does anyone, really. Some parts of it are packed with stray viruses that have been in us since the dawn of time. They've been there ever since we began, and we just keep on copying them. They're genome parasites. Parasites that reproduce in us, and we perpetuate them, and it costs them nothing. Isn’t that right, Doc?’
‘Something like that. We've got almost half as many of these viruses passing from cell division to cell division as we have genes. And, of course, we give them to our children. Fortunately, these viruses or virus fragments are usually very calm, peaceful creatures. They are content to be reproduced by our bodies from time to time.’
‘And some are not content?’
‘Of course, but most of them are harmless.’
‘We chromosome eights have a lot of these ancient quirks in us,’ nodded Sherlock. ‘Hence my old name.’
‘So why did you become Sherlock? Anyway, I think it's a much better name than Junk…’
‘Of course, it is! That's why I gave it to myself. Because it turns out that not everything in me is junk! Some of them are quite useful. For example, for investigation. Because these tiny, repetitive bits, if scientists can tease them out, they can form a pattern. A kind of bar code. This pattern is different in each individual. Like a fingerprint. That is, everyone has their own DNA barcode, which is inherited, so relatives are very similar to one another. I've got these repetitive stretches in me, too, as do other chromosomes, but I have an awful lot of them.

If Doc can conjure up the DNA of the bunny snatcher from the mystery hair and the barcode of the perpetrator, then…'
'Then?
'Then we can find out who the hair belongs to, or who they are related to. The entire royal court is in your personal family tree,' Doc muttered, 'and we have the barcode of the bunny thief,' he held up a strip of tiny paper, 'so we have the Great Court Family Tree, which, if we look closely, we can see that…'
'Louisa is the culprit!' snorted the princess. 'But why did she kidnap Carrot Cake? It really is such a good bunny! She would have happily played with her in any case!'
'Couldn't that be what happened?' Sherlock scratched his head. 'That the culprit, or rather this Louisa, had just taken the furry creature out to play and meant no harm? But then got so scared by all the commotion that she didn't just bring the long-eared thing back but smuggled it back in a sneaky way.'
'She really should have asked for it,' Emma puffed, but her face had brightened. 'It's great that you're so clever!'
'And we know so much more! For example, how to cure people of their illnesses.'
'Aren't those things for the immune system to fight? 'Asked Emma, who thought she knew everything about diseases.

''Some diseases,' Doc began, 'are not caused by germs or viruses that get sneezed onto us, but by the way our genes work…'
'Or don't work,' Sherlock sighed.
'Yes, that's true. One of these diseases, which has caused children a lot of suffering and scientists a lot of puzzlement, is a very small change in a gene on chromosome 20…'
'ADA 'Sherlock sighed an even more deeply. 'We're doing a good job of 'reminding' him. He's a very hard-working, dedicated little gene who produces protein for the immune system. Only if he's healthy, of course.'
'Quite right. But all it takes is one tiny change and he stops producing ADA, and then you are left without a functioning immune system. Little kids who don't have this gene working in them used to have to live in isolation, in a super-clean, bacteria and virus-free tent, because anything else was a death sentence, all those pathogens that we healthy people are immune to.'
'Even the slightest sniffle.

‘And how did they manage to help them?
‘Nowadays, geneticists—the scientists who work on genes—can tailor and sew together genes like seamstresses tailor cloth. Remember the viruses that can jump into the genome? Well, with ADA, they've called in viruses just like that. They packed a bunch of flawless and super-functioning ADA genes onto their backs and injected them into the sick child’s bodies. And as soon as the viruses popped into the right place on the chromosomes, the newly introduced flawless ADA gene at once kicked in. It manufactured the good protein.’
‘And the babies were cured?
‘At least their immune systems started working. Of course, the doctors are still helping, but with ADA, this thing called gene therapy definitely works. And it's worked for a lot of other diseases, too.
‘Spot on!’ Sherlock quipped. ’Now, I must be off. I have a date with the other chromosome eight. Emma, Doc, have yourselves a lovely day.’
‘You, too,’ the princess waved to Sherlock, then turning suddenly to Doc ‘so, Doc, are all of our characteristics Sherlock's directed by Sherlock?’
‘Not exactly!’ Doc scratched his head. ‘For example, the way in which we behave, the things we do every day. Well, we inherit, some of that, so it's in our genetic code, and some of it we learn from our environment. And then there is also instinctive behaviour, for example, how we talk, because learning to speak is coded into us. Babies have almost no need to be taught. They learn from their environment. But the words themselves, that is something else! You have to learn them, for example, from friends and so on.’
‘And what else do you have to learn?’
‘Reading and writing! That's not learned instinctively.’
‘Pity!’ sighed Emma, suddenly remembering the spelling test that she had promised Queen Sara she would do. And she had promised something else, too…’
‘Guess what, Doc,' she began, 'I was explaining about chromosomes and traits and jumping genes at home, and Daddy asked if you could get him glow-in-the-dark bait worms for night fishing; and Mummy would like a golden-egg-laying hen. I should mention here that I was quick to say that we can't interfere in the private lives of chromosomes unless we want to cure someone. That’s right, isn’t it?
‘Of course, scientists have been tampering with genes and chromosomes for a long time now, developing new technologies, and sometimes new methods have to be accompanied by new laws.’
‘What do you mean?’
‘Simple. Things can usually be used for both good and bad purposes. Because if you have a sewing needle, you can use to sew on a new button, that is good; but if you then put the needle in someone's room so they can prick themselves on it when they walk in, that's bad, wouldn’t you agree?

‘Of course!’
‘Well, so it is with the private life of genes. For example, there's cloning…’
‘What is cloning?’
‘It's when a living thing is copied exactly.’
‘You mean, like, painting a picture of it?’
‘No. I mean, making another identical version of the same thing in a lab. Or more than one.’
‘Is that possible?’
‘Yeah. Nature can do that, too, by the way. Think about it…’
‘I know! Paul and Peter!
‘Yes. Identical twins. Who have the same genetic makeup.’
‘And scientists can do that?’
‘Yes, they can. They've done a lot of work on it, and the result of all the experiments was this,' said Doc, and pressed the button on the remote control. ‘Emma, meet the wonder of the genetic world, Dolly!’
Emma stared in shock at the sheep grazing peacefully on the page.
‘But it's a sheep!’
‘But what a sheep! She is the world's first laboratory-cloned lamb. In fact, the first cloned mammal!’
‘And what is *cloning*?’
‘Oh yes! I'll start by saying that Dolly the lamb had three mums. The nucleus was taken from one of her first mother's cells by the scientists.’
‘With all her chromosomes?’
‘Exactly! Both genomes. Then they took the nucleus from the egg of mother number two. Remember, in each gamete, there is only one set of chromosomes, so it could not have produced offspring on its own. Then they put in the double genomic nucleus, took the zygote and implanted it in the womb of a third sheep, who then gave birth to Dolly.
‘Wow! So, Dolly was just like her first mum's lamb! But how could cloning cure anyone of anything?’
‘There are diseases that destroy parts of the human body. Take for example, when someone's kidney gets sick and doesn't work properly, or it doesn't work at all. Then if scientists, could grow a kidney from the person’s own cells and swap it for the bad kidney, their immune system wouldn't object to it. Because the brand new kidney would have exactly the same chromosomes as all the other cells in his body. And so, it would heal more quickly and easily.’
‘True,’ Emma nodded, ‘but a hen laying a golden egg and a glow-in-the-dark baitfish isn't going to cure anyone.’

‘No, I don’t think so either.’
‘Never mind! It would take hours to make soft-boiled eggs from golden eggs in the morning, anyway, wouldn't it?’
Emma leaned over the big open book, and you could see that she was thinking about something.
‘So, it is possible to change our own characteristics then after all?’
‘Well, up to a point, yes. But it's a very difficult thing to do. And it costs a heck of a lot of money. And now we both know that it's generally used to cure very serious and dangerous diseases, not to remove freckles and conjure up curly golden locks.’
‘Except I don't want that kind of golden 'hair' anymore. Emma opened her rucksack, but this time it wasn't the usual scones, but an old photo in a clear plastic file.

[illustration]

‘Mummy gave me this last night,’ she held it out to Doc, ‘This is Scarlet, my great-great-grandmother, who was awfully pretty. A world famous beauty in fact.’
Doc carefully took the case in his hand. The photograph showed a beautiful young girl smiling at him. Her long, red hair framed a tiny face full of mischievous freckles.
‘So that's it. I meant to shown it to you earlier, but I forgot about it because of the business with Carrot Cake. My mum said it didn't matter what colour my hair was or however many freckles I had, or even if I was a beautiful woman at all, but it was really so good to meet Sherlock, Gregor, Brains and learn about the whole chromosome thing. And now that I've found out that Louisa likes to play with Carrot Cake, I think I'll have a bunny party for Carrot Cake’s birthday and invite her over for it. While she's there, I'll tell her about chromosomes. And I think tomorrow I'll open my very own Royal Scientific Detective Agency. Of course, I'll let you in on it, Doc. Now, I think it’s seriously time we scoffed some scones.’
‘Good idea, the detective agency.’ Doc began gorging on a delicious pumpkin seed scone as he spoke, ‘especially when the clues always lead us to between mission scones!

Contents

[illustration on the right hand side]