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Alice Returns to Class

When Alice woke up on the first day of class, she literally had to drag herself out of bed. She wished she was still on vacation, but on the other hand, the idea of going back to school thrilled her. As soon as she entered the campus, allowing the familiar surroundings to slowly work their magic, her spirits soared.

From the day she had attended Professor Holmes' last lecture, and visited his laboratory, she had looked forward to coming back. She had diligently brushed up on her biology while on vacation, and was impressed by how many advances had been made. She was going to learn about the mysterious microscopic world within the realm of molecular biology, a realm quite different from macroscopic biology. This echoed a very different facet of *biology*. Studying living creatures and their behavior is just one aspect of what biology is all about. But underlying all these phenomena, a huge number of inconspicuous activities are taking place. The realm of atoms and molecules is not readily seen, but the combined effects of their activities create the phenomena that we witness with our naked eyes.

The relationship between the microscopic and the macroscopic worlds tickled Alice's imagination. She vividly recalled her experiences in the lab, and she knew how these worlds were so different, yet were only two sides, two facets, of the same phenomena.

While on vacation, she had been actively engaged in visualizing how things looked from the 'inside,' or from the microscopic point of view. In particular, she was looking forward to learning more about what was going on inside her own cells — something the professor had said was going to be part of the new term's lessons.

Aside from her eagerness to attend Professor Holmes' lessons and study molecular biology, Alice also greatly missed her forays into the 'inaccessible realms,' which only the professor's laboratory could have provided her. So vivid were her recollections of what she had seen and experienced in the 'shrinking machine' that it seemed to her that they had happened only yesterday. Although she now knew that the machine was not what she had originally been led to believe, she still found the illusion fascinating — and she was really looking forward to more adventures.

The stillness of the empty classroom didn't last long when Alice's classmates started trickling in. Girls giggled and shrieked as they talked about their summer escapades, video games whirred and bleeped, someone dribbled a ball around the classroom. But the deafening cacophony died down instantly when Professor Holmes entered from the back door. He greeted the class in his familiar booming voice: "Welcome back to my class!"

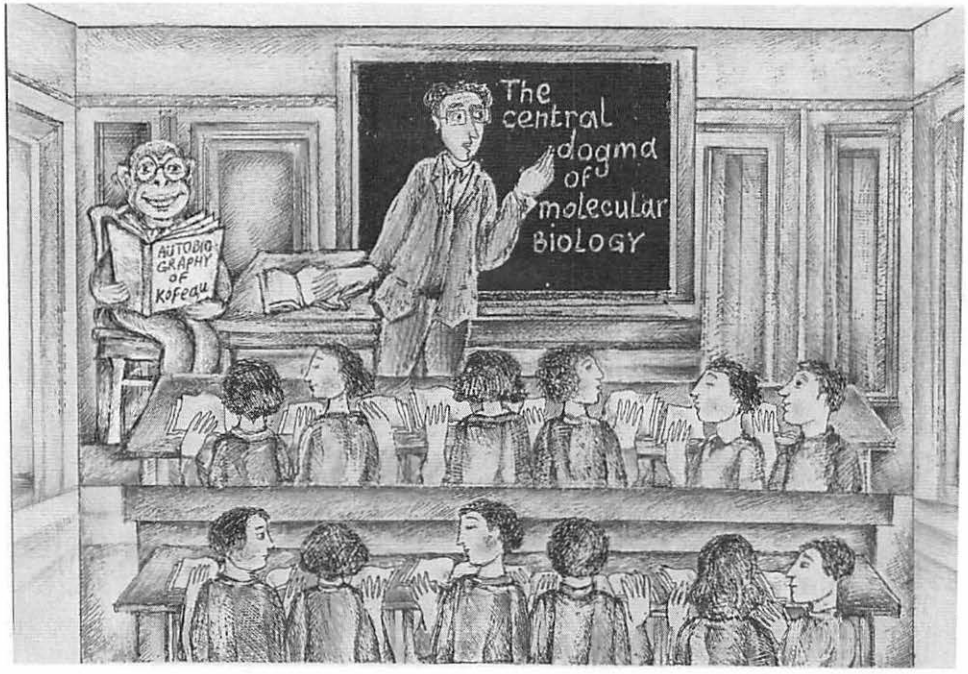

Fig. 1 Kofeau sitting in class.

But who — or rather what — followed the professor as he entered the classroom was unexpected. Some students could not control their laughter. A few others had raised eyebrows. Alice, like most of the class, was wide-eyed with amusement. A little monkey with big round eyes, dressed in a school uniform, with a mailman's bag slung diagonally across his hairy chest and a university ID loosely dangling around his neck, silently trailed the professor. Soon, the whole class was in stitches.

"Good morning! I see some familiar faces — Bob, Linda, and Alice, of course," said the professor with a knowing smile.

"Welcome to my molecular biology course. This semester we shall be learning about some very fundamental processes that go on in our bodies, or rather in the cells in each one of us — as well as in the cells of our friend here, Kofeau."

Upon hearing his name, the little monkey stood up and bowed to the class, and then sat down again without making a sound. Alice, thinking that bringing Kofeau to class had to be one of the professor's tricks, immediately started trying to figure out what he was up to.

"You must be surprised to see Kofeau in class, but there is really nothing unusual about it. This is all about biology, and our friend here is part of biology. You must have heard people say that a dog is a man's best friend, and that is perfectly all right because they are indeed our good and loyal friends. However, in some fundamental ways monkeys are much closer to us than dogs, not only in their appearance and in their behavior, but also in their 'book of life.' This book of life, stored in every cell of the human body, is more than 96% identical to that stored in Kofeau's cells. That is the reason I brought him to class, aside from him carrying my stuff," the professor said, grinning from ear to ear. "Kofeau is really the closest species to mankind."

Looking at the monkey, the professor said, "Oh, I forgot to tell you that I named him 'Kofeau' because it's a combination of 'kof' and 'eau'; *kof* is 'monkey' in Hebrew and *eau* is 'water' in French — together *Kofeau*, pronounced 'Kofo.'"

When he heard his name mentioned again, the little monkey stood to attention and looked back at Professor Holmes. He seemed to be waiting for

Fig. 2 Kofeau water content.

instructions from the professor, but when nothing came, he sank back into his chair, and nonchalantly continued his earlier preoccupation — rolling his eyes and searching every nook and cranny of the room.

Professor Holmes continued, "For the time being, I will not explain further why I chose this particular name for our friend. For now, bear in mind that our bodies, as well as Kofeau's, contain about 70% water. But that is not all there is to the name. We shall also see how Kofeau can help us understand the role of water in some fundamental processes that occur in our cells, as well as in Kofeau's."

Professor Holmes paused briefly and threw a quick glance at Kofeau, who was sitting comfortably and quietly in the corner. However, upon seeing the students reach for their notepads, he lifted the flap of his bag, dug deep into it, and produced his own notepad — so large that it dwarfed his tiny face. Fishing inside the bag again, he produced a big, fat pencil, which was longer than his own hands. Not done yet, he opened the bag, almost tearing it apart, looking intensely for something, and with a sigh of relief found what he was looking for — oversized eyeglasses, which he quickly put on. His hilarious antics brought the house down. Even the professor couldn't suppress a chuckle. When the laughter in the room died down, he continued.

"Don't confuse what I just called the 'book of life,'" he said, "with a book that narrates the story of one's life, which we call an autobiography. The latter is a real book, as you know." When he heard the word 'autobiography,' Kofeau frantically searched inside the bag and produced yet another huge book bearing his own name on the cover, and with the book's boldly written title: *Autobiography*. He held the book up for everyone to see.

Fig. 3 Kofeau with biography.

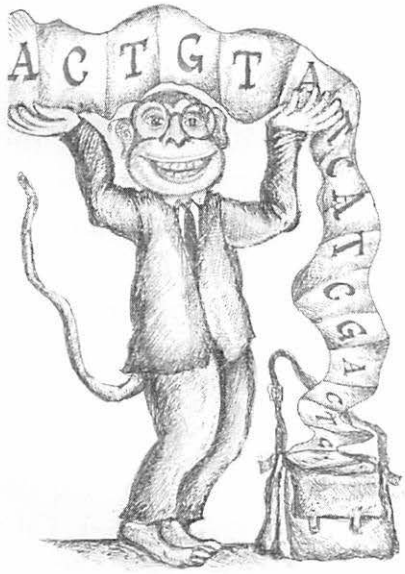

Fig. 4 Kofeau with string of letters.

Without turning to Kofeau, the professor went on: "The 'book of life' is very different from the book your little classmate is showing you. The 'book of life' is like a long — very long in fact — sequence of letters that we cannot read. It does not tell the story of any specific person's life." Setting the autobiography aside, Kofeau's scrawny fingers plunged into the bag yet again, fishing out an immensely long ribbon. It was so long that it seemed as if would take him forever to find the other end. The class applauded thunderously, and the little monkey seemed pleased with his audience's reaction. Kofeau's ribbon revealed a sequence of letters; Alice wondered what they stood for.

"As you can see," said the professor, "what I referred to as the 'book of life' is not a book at all, and it tells no story. In fact, what you are looking at is merely a metaphor for what I referred to as the 'book of life.' This book does not tell you anything about life. It only contains information relevant to the construction of everyone's bodies, including Kofeau's. OK, show time's over." Kofeau patiently gathered both ends of the ribbon and tucked it inside the bag, and then sat quietly again.

"Let us now discuss what is meant by the 'book of life.' Of course, there is no such book stored in our cells, but there is some kind of *information* that is stored in a very long molecule called DNA. This molecule is very long in

molecular terms, and it's tightly packed in the nucleus of our cells. We shall learn about the meaning of this information, the language in which this information is written, and how it is translated into instructions to make our entire bodies. As you can see, many of our features are similar to those of the primates. The similarity stems from the similarity between the DNA of our species and those of the primates. There is another branch of biology that studies the evolution of the various species. This theory will not be discussed in this course. We shall focus on the central dogma of molecular biology."

Without wasting time, Professor Holmes flashed a slide on the screen, the very same one that he showed on the first day of class last semester:

THE CENTRAL DOGMA OF MOLECULAR BIOLOGY

"This semester we shall learn about the central dogma of molecular biology and perhaps a little beyond that. There are essentially three molecules involved in the central dogma: the DNA, the RNA, and proteins. At this stage, we do not need to know the exact molecular structure of any of these molecules; remembering the initials will be sufficient for now. Briefly, the DNA is a molecule that carries all the information that is essential in building up the entire cell, or the entire body of a living creature. This is the reason we can refer to these molecules as the 'book of life.' Technically, this book is called the *genome*; our particular 'book of life' is referred to as the *human genome.*

"The RNA, on the other hand, is an auxiliary molecule, which is actually a family of molecules that help to *translate* the information from the language of the DNA to the language of proteins. Proteins are the final products of the central dogma. These molecules perform so many functions that it would take more than a whole semester to describe all of them. Some of them are the building blocks of many tissues, while others perform a host of different functions, acting like little molecular robots. These robots carry out many processes in our cells such as aiding in food digestion, transporting oxygen from our lungs to the tissues, and transporting waste materials away from the tissues to be expelled from the body. They help to accelerate certain chemical reactions while decelerating or inhibiting others. They are part of the 'motor'