

Every piece of matter in this world consists of a multitude of processes, molecules, particles, and much more that we sometimes do not even think about. Every action we take, every thought we have, is the movement of a multitude of particles in our bodies. Moreover, it is these unusual and hidden processes that quantum biology studies. Scientists in this field often study complex and hard matter that is difficult for many people to comprehend. Hence, applied alongside quantum physics differs greatly from classical physics and sometimes even contradicts the laws that we are used to studying in school. This creates cognitive dissonance for scientists. Even Einstein, one of the smartest people in history and an expert in physics, denied the influence and existence of quantum physics. For many people, quantum effects are often the most difficult to understand. Moreover, there are tons of examples of quantum effects - one of the most common and frequently discussed being superposition. Superposition is a state of a particle in which it can be in different places at the same time. This happens because particles can sometimes take the form of waves, which allows them to explore a larger radius of reach. In one experiment called the observer experiment, light was first passed through a single slit, where, as expected, only one stripe was reflected on the wall. Then the light was passed through two slits, but the result surprised the scientists. Not one, not two, and not even three lines were reflected on the wall. There were many lines on the wall, which were darker as they moved away from the center. Scientists tried to release one photon of light at a time because they assumed that this was the result of particle collisions, but the result remained unchanged. After that, the scientists placed an observer to check whether the particle would go through a specific slit or whether it would pass through two at once. As a result, two lines appeared on the wall. This caused confusion and mass shock among scientists, because it was strange and contradicted all the laws of classical physics. That was called a superposition. From that moment on, the active study of quantum mechanics began. How much does our world depend on it? To what extent do these phenomena affect our world and ourselves, especially? This question is not about quantum mechanics, but about how its principles affect living organisms and biological processes in general. Living systems do not simply tolerate the laws of quantum physics; through evolution, they have learned to coexist with these laws and have learned to apply and control them in the necessary directions. Evolution has adapted to use even such features as quantum coherence, thereby achieving phenomenal super-efficiency and super-sensitivity. Quantum coherence happens when a particle can be a wave to be in different locations at the same time, which leads to greater efficiency. Imagine that you are in a maze, and you become a wave to check all the passages of the maze at the same time, and when you find the right exit, the wave immediately disappears. Biological processes actively use and control coherence to create the necessary conditions and resources, which occur in all processes of living organisms, and show how quantum life can be. But what if it is not “perfect”? Although coherence has its advantages, it can sometimes be excessive and even disruptive, which is why there is a quantum effect known as decoherence. Decoherence is a process in which quantum effects are unable to manifest themselves and influence important processes within the system due to the influence of the environment. Decoherence is actively present in cells, which must be in a stable state for the exchange of substances and information with the environment. Quantum effects such as superposition and entanglement (when two particles share a single combined quantum state) are preserved at low temperatures and in isolation, limiting interaction with the environment, because quantum effects are easily destroyed. The cell environment is opposite to it. Although cells are made up of quantum particles, they are always exchanging substances with the environment, and cells are usually warm and humid. Because of this, cells always remain in a stable state, and their location becomes predictable. Decoherence occurs in femtoseconds (1 femtosecond=10⁻¹⁵s), but this makes the cell stable, which is important for its functioning. This shows how biological processes, using the quantum particles they need, have adapted to control and ignore effects that interfere with their functioning, in order to accelerate or transform into useful products. That seems quite useful for us, too. People tend to create a “perfect plan” and try to escape any interferences or changes in the process, making it much harder and exhausting to control when everything falls apart. In the situations of perfect coherence, there is no place for stability, and in that case, it is worth acting based on the principles of natural systems. A cell creates a kind of chaos and noise, but it functions perfectly no matter what. So think about it, maybe sometimes we should put perfection on the back burner and try to combine the incompatible? And maybe then we will learn that imperfection is the key to our desired stability. The concept of efficiency that people use every day has been completely turned upside down. Photosynthesis is a good example of how efficiency takes place in nature and should be followed by humans. Photosynthesis is the process by which plants convert light energy, water, and carbon dioxide into glucose and oxygen. All of this is taught in school, and it would seem that there is no place for coherence there,

but research by scientists has proven the opposite and made a breakthrough. Scientists have discovered that when a light photon enters a chloroplast, an exciton is formed (a kind of transport for energy in the process of photosynthesis). In order to transport energy, the exciton must pass through many paths and find the best one for transfer to the photosynthetic reaction center, where most of the resource conversion process takes place. However, this takes a long time and is not very efficient. Therefore, plants have learned to control both coherence and decoherence to achieve it. Entering a state of superposition, the exciton can quickly and easily pass through several paths at supernatural speed. Thanks to simultaneous movement along several paths, transportation takes less time, which helps the plant make photosynthesis more efficient. However, what about decoherence? Of course, it is present in the process of photosynthesis, but it does not interfere with the exciton being in superposition; on the contrary, it helps. Thanks to the vibrations of the surrounding protein framework, the quantum state does not “get stuck” in a local minimum, and the system, remaining coherent, improves the search for a suitable path. This makes photosynthesis stable and efficient, while also minimizing the consumption of solar energy along the way, maintaining a happy medium between coherence and decoherence. This shows that efficiency is not about getting as much as possible. Efficiency is about minimizing losses as much as possible. Sometimes, in their efforts to keep up with everything at once, people do not notice the large costs and losses that lead to disruption of the entire system. Consequently, they fail to achieve the main goal. How are we supposed to achieve more when we do not basically understand what efficiency is? And it is not the only thing that the quantum world can show and teach us. Surprisingly, intuition and quantum physics are connected more closely than they seem to be. The theory that birds’ eyes contain a quantum pair mechanism clearly demonstrates both the use of quantum physics and trust in one’s intuition, although the bird’s future life depends on migration. The quantum pair mechanism is closely related to quantum entanglement. It implies that two or more particles can be connected to each other regardless of distance. Even at great distances, particles can transmit information and share states. This is similar to the relationship between people at great distances. No matter what, people have a connection with their loved ones. They can share emotions, feel each other’s state, and the same thing happens with these particles. They remain inseparable no matter what. It is believed that a similar mechanism is found in the eyes of migratory birds and is used for navigation. With this mechanism, they can sense the Earth’s magnetic field and thus use it for spatial orientation. According to the theory, when light energy hits the cryptochrome proteins in the retina of a bird’s eye, quantum-entangled pairs of radicals are created that are sensitive to the Earth’s magnetic field. The state of these pairs depends on the direction of the Earth’s magnetic field, which allows the bird to see lines. This can be called a kind of natural compass that birds use during migration. This is evidenced by studies that have shown that during migration seasons, the level of cryptochrome-4a protein increases and changes its state for maximum sensitivity to the Earth’s magnetic field. Birds move according to the magnetic field, as humans sometimes do with a compass. During hiking, people use a compass and certain factors encountered along the way to determine their route. For example, which way the moss is facing, how the stars are aligned, and much more. Birds do the same thing, only instead of a compass, they use their intuition. Imagine if you only had your sense of the magnetic field when traveling. Would you trust your senses? Many people doubt their feelings and decisions. Some even worry about insignificant things. Migratory birds are a good example of why people shouldn’t be afraid of their intuition and should follow it often. Even when making decisions, there is a place for an inner compass that leads and protects, besides just bold logic and facts. For example, when choosing a profession, people tend not to listen to their feelings and hunches and choose based on profit and efficiency. This can lead to consequences such as burnout and unwillingness to work in this position, as everything inside screams: “It is not for me”. It would be better for us to learn from birds how to trust ourselves. Even these small creatures can teach us how to follow our own path in life. Quantum physics is not just laws, but an integral part of our lives and a kind of tool that increases work efficiency and sensitivity. Organisms and systems have managed to evolve and adapt to quantum effects. They have even been able to use a feature such as decoherence to their advantage to increase efficiency, as shown by cells that consist of quantum particles but use decoherence to remain stable. We do not need a perfect plan to achieve our goals. On the example of photosynthesis, it is seen in combining decoherence and coherence for efficiency by minimizing energy loss. Photosynthesis showed that efficiency is not about how much we get, but about how much we minimize losses. We should not chase maximum results; we should monitor losses, and this is laid down in the simple fundamentals of energy and heat transfer. We also knew that we needed to trust our feelings, as birds do. Birds can sense the Earth’s magnetic field and use it as a compass, so why shouldn’t we use our senses as a

compass on the path to our dreams? All three of these examples not only show how evolution has turned quantum physics into its weapon, but also how we can apply these simple principles in our own lives. So, in times of uncertainty, to find the right answer, try to look literally “inside” the situation and return to the basics of our quantum world. Perhaps the answer lies where you least expect it.