[1: Who, What] Good morning. My name is Dmitriy Fedoriaka, I am the third-year student at MIPT. I will tell you about animals' magnetic sense.

[***JUMP START,*** Why] At school we were told that human can't feel electromagnetic field, so we need use special devices to detect and measure them. But recent research showed that some animals are able to feel magnetic field of Earth. It sounds unbelievable and scientific community for long time didn't believed that fact. But nowadays there are reliable evidence that animals have magnetic sense.

[2: How, Plan] My presentation will last about 7 minutes and will contain of two parts. First, I will tell you how scientists noticed that animals can feel magnetic field and use it for navigation. Then I will make an overview of two hypotheses, how technically animals can do it: using small magnetic particles, and using quantum effects in molecules of certain pigment.

[3] Now, let's talk about birds. Some of them migrate each year, going to South at winter and returning back to North at summer. People noticed that caged European robins at autumn escaped toward the south even if they had not visual cues to where south was. So, researches carried on a row of experiments.

First, in 1960s, they demonstrated that electromagnetic coils wrapped around birds' cage could trick them into trying to flee in wrong direction.

Another experiments showed that if birds are putted into 'wrong' magnetic field and let away at night, they will lead in wrong direction, but on sunset they will reset their compass and correct their way.

Also there was showed that radio waves can mislead the birds.

[4] After all, there were a lot of evidence that birds (and also other animals, such as sea turtles, some fishes and even mammals) can feel magnetic field and scientists started to look for special organs responsible for magnetic perception.

Their search was successful. They found special cells in rainbow trout. These cells contain small ferromagnetic particles, which tends to orientate themselves along magnetic field. When the fish turns, the particle turns relatively to cell's membrane and open pores (*see picture*). Ions goes through these pores and appears electric signal, which can be interpreted by brain. Researches experimentally proved that these cells send signal to brain in response to outer magnetic field. Results of this research were published in 2002.

[5] Now let's consider another, more complex mechanism of magnetic sense, which is based on quantum effects. There is a pigment protein **cryptochrome** in bird's eye. When a photon hits its molecule, it kicks one electron from its orbit forming free radical. Then there are two ways: electron will return to its orbit returning molecule to stable state, or chemical reaction will occur. But, according to Pauli's principle, electron can return back only if it and the second electron at the orbit have antiparallel spins. So, reaction goes only when spins are parallel. But, as we know, spin interacts with magnetic field. So, intensity of chemical reaction is implicitly connected with bird's orientation relatively to magnetic field.

This mechanism explains, why birds can reset their 'compass' only in day time – because it needs photons to work.

[6: Summary] I am nearing the end of my talk. Let me recall what I was talking about. Dozens of animal species have well-documented abilities to detect the geomagnetic field and use it for orientation and navigation. Now researchers have located the organs for this magnetic sense. Some animals may use microscopic magnetic particles to detect magnetic fields; others might use quantum effects on certain pigment in the eye.

[Conclusion] To sum up, scientists really discovered and proved a new sense, but now it's not studied completely.

Thank you for your attention. I am ready to answer your questions.