Tiny dust is a quiet gift from the space

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You may think that fall of a meteorite is a huge, catastrophic disaster. However, a large proportion of mass coming to the Earth from space is occupied by submillimeter-sized dust, which I introduce in this article. Cosmic dust is a general term for celestial bodies smaller than about a millimeter. Most of them are pieces of asteroids or comets produced in collision or weathering of them and are very common in our solar system. Therefore, it is not unusual that it falls onto the Earth; the amount exceeds 40,000 tons[1]. Most cosmic dust. Of course, scientists pay such efforts because of the scientific importance of these cosmic matters.

We can gain knowledge about the history of the solar system from cosmic dust. That is why scientists actively investigate it. In the form of cosmic dust, celestial material reaches the Earth without alteration in atmospheric entry, so it keeps its original form as it is in the space. Because, thanks to its small size, dust slows down in a higher level of the atmosphere, where air molecules causing frictional heat are sparse, and therefore escapes intense heating and melting, unlike larger meteorites. These small astronomical objects have a bunch of early solar system materials. To understand why,

you need to know how the solar system came into being.

Stars, including the Sun, were born in a molecular cloud, where molecules such as H_2 gather densely. We can see them in the night sky as a nebula. In the first step of star formation, an especially denser region in the cloud attracts molecules by gravity. Then, at the center of the region, attracted molecules join together and become a star. Planets and other solar system members originate in the protoplanetary disk, a disk-shaped structure which gas and dust swung by the young Sun's gravity form. Over time, the dust grows in size by sticking to each other in a collision. Ones that have grown to some extents are called planetesimals. Some of them continue growing and extremely become a planet, while others stay small and become comets or asteroids. This is a crucial crossroads, because planets are so large that they have much radioactive nuclides and store heat produced by nuclear division, then finally melt. In the melted planet, such as the young Earth, heavier elements fall to deep underground and only one part of the elements is left around the surface. This is why samples from comets and asteroids are precious though the Earth itself is built from planetesimals just like them. Thus, cosmic dust has substances preserved from the childhood of the solar system.

One of the most primitive contents of cosmic dust is presolar grains. They are generated around a star other than the Sun and are identified by a large distinction in isotopic composition from solar system materials. The solar nebula (the nebula in which the Sun was born) had already included these grains before the birth of the Sun and presolar grains have survived up to the present. Since their isotopic composition reflects the characteristics of their parent star, they give us a hint what kind of stars were around the cradle of the Sun. A supernova explosion of the stars might have triggered the assembly of the materials of the Sun.

Since the early solar system materials keep their shape in cosmic dust, you can discuss in what condition they formed. The question is directly connected to forming process of the solar system. For example, such discussion is going on about GEMS (glass with embedded metal and sulfide), a major component of less altered IDPs (interplanetary dust particles: one kind of cosmic dust). It is known that there is glass also around stars, so if a relation between the two types of glass is revealed, then that lets us know how materials in solar nebula turn into solar system materials.

Cosmic dust, together with its parent bodies, has played important roles in building up today's Earth environment. It is believed that falling meteorites brought a large amount of water to the Earth after the rocky part of the planet had formed since the Earth is too near the Sun for water to condense into ice and there must have been some water carriers. Comets, parent bodies of cosmic dust, are examples of outer solar system bodies coming inner for some reason. Therefore, researching them helps us consider how outer solar system bodies change their orbit and eventually in what process in the history of the solar system water was brought to the Earth.

Molecules in living things may also come from meteorites or cosmic dust. Some cosmic dust is very rich in carbon and contains organic molecules, such as amino acids[2]. This means that primitive meteorites or cosmic dust delivered carbonic components of life from the outer solar system. Here restriction of the environment where comets are formed connects to the problem of the origin of life. If we know the condition from which our carbonic components, then we can investigate what kind of molecules may be ingredients of our body by reproducing the condition experimentally, for example. Cosmic dust is a member of the Earth's history, and revealing its origin leads to clarifying where we are from.

References

[1] Love, S. G. and Brownlee, D. E., (1993). A direct measurement of the terrestrial mass accretion rate of cosmic dust. *Science, 262*(5133), 550-3.

[2] Anders, E., (1989). Pre-biotic organic matter from comets and asteroids. *Nature 342*, 255-257.