Nordic4DFrame

Anita and Arabella: Spiders in Space

NASA supporting student science through Skylab
In September 1970, NASA announced the cancellation of the two final scheduled manned Moon landings; Apollo 18 and 19. Instead, the focus would be on the first American space station to be placed in Earth orbit, Skylab, which would be launched into space on board the Saturn V rocket from the previously cancelled Apollo 20 Moon mission. Built from surplus parts from Apollo spacecraft, Skylab would become—up to that time—the largest space station until the International Space Station was completed. Not only did Skylab contain a large Orbital Workshop, which is where the crew lived and worked, and a docking adaptor for parking the Apollo spacecraft that took three astronauts to the space station, it also had a solar observatory that used special telescopes to study the Sun in different parts of the spectrum.

Launched in 14 May 1973, Skylab was to be used to study how humans could cope with living in a weightless environment for long periods of time. Besides the astronaut crew members studying each other while in orbit, they were also to perform a variety of experiments in different areas of science and technology.

NASA also saw this as an interesting way to engage American middle and high school students in taking an active interest in science. A competition was held where students proposed experiments that could be performed by the Skylab astronauts in space. Over 3400 entries were received by the February 1974 deadline. They came from all 50 states and included students from grades 7 through 12. Nineteen (19) winning entries were eventually used during Skylab from students all across the country.

Selected experiments were in seven major areas; astronomy, botany, Earth observations, microbiology, physics, physiology, and zoology. Those students who won actively participated in the design of their experiments, the building of the equipment when required, writing the instructions that the astronauts had to follow onboard Skylab to perform the experiment, make the analysis of the results back on Earth, as well as write the final report of the experiment's results.

One of these student experiments—"ED52 Web formation"—came from Judith Miles of Lexington, Massachusetts. She had recently read an article in National Geographic magazine describing spider behavior, and thought that a study of their behavior while weightless might be interesting. While spiders may seem simple, they use their own weight to determine how thick the material in their webs should be. Since web-building spiders use both wind and gravity to begin construction of

their web, the weightlessness on board Skylab could provide a new and different stimulus to the spider's ability to make one.

Eight-legged wonders of nature

There are almost 44,000 different types of known spiders in the world. There are kinds of spiders that spin webs, and there are others that do not. And of those that do make webs, not all of them use them to catch their food. Using a web to catch food is a very energy efficient way to hunt, though it also takes a lot of energy for the spider to make one. Since a web is made out of protein, the spider usually eats it a day after making it, because it has become torn in places and also less sticky. In this way, they use the protein from the web to get some of their energy back that was originally used to make it.

The first evidence of spider webs has been found in a piece of amber that is 130 million years old from what is now the country of Lebanon. It is believed that spiders were making web silk at least 300 million years ago, perhaps even longer.

Webs are produced by special *spinneret glands* located at the rear of the spider's abdomen. Different glands produce different kinds of web silk depending on their usage in building it; for example, some silks are stronger while others are stickier. Web silk has a greater relative strength when pulled than steel, and has a much better ability to bend without breaking. Depending on the kind of spider it is, webs can be made vertically, horizontally, and at every angle in between.

The evolution of spider webs has not only been important to spiders. They have also affected the evolution of flying insects for over 100 million years. Both moths and butterflies have scaly bodies, which help them to escape from spider's sticky webs.

"Astronaut" spiders

Two common spiders of a type known as Cross, or European garden spiders (*Araneus diadematus*), and nicknamed "Anita" and "Arabella," were to be the test subjects in Judith's experiment. They were launched into orbit with NASA astronauts Alan Bean, Owen Garriott, and Jack Lousma on 28 July 1973. Like the three humans, the spiders traveled up to Skylab in their own special "space capsules" though Anita and Arabella's included food (a fly in each spider's capsule) and a water-soaked sponge as a source of moisture for them to drink from.

Webs in space

On 5 August 1973, just eight days after traveling into space, astronaut Garriott put Arabella's capsule into position on the test cage where they were hoped they would perform their web-making experiment. Unfortunately, Arabella refused to come out, and several hours later the astronaut had to physically shake her from her capsule into the cage. Confused by the lack of gravity, the spider moved around unevenly in a kind of swimming motion before she attached herself to the screen covering the cage's surface. By the following day, Arabella had made a simple web in one of the cage's corners, and two days later she had made a complete web.

The original experiment was to end after one spider had built three complete webs, but Garriott became so interested in the results that the experiment was made longer. In order to keep Anita and Arabella happy and healthy, they were fed pieces of raw steak from the astronaut's own food supply, and given additional water.

Anita gets a chance too
Arabella had several more opportunities to build webs inside the test cage, and on 22 August she made her best example to date. On 26 August Arabella was removed from the test cage and placed back into her capsule so that Anita could have a chance to try and make a web. Like Arabella, she was not very anxious to go into the cage, and tried to get away by climbing on astronaut Garriott's arm. Recaptured, he managed to get her into the test cage, where she too moved about with a swimming-like motion until attaching herself in one of the cage's corners.

Anita's attempts to get used to moving in zero gravity were recorded with both video and 16mm film. Like Arabella, it did not take Anita too long to begin to make good examples of webs of her own. Unfortunately, on 16 September, astronaut Garriott found her dead inside the test cage, probably the result of not enough water. Such spiders can live up to three weeks without food, but not as long without moisture. Anita was carefully put back into her capsule for later study upon returning to Earth.

Nine days later—on 25 September 1973—the three astronauts, the two spiders, and examples of the webs they wove in zero gravity, left Skylab and returned to a watery splashdown landing in the Pacific Ocean after almost 59½ days in space. During that time, they had travelled in orbit 858 times around our planet. Upon landing and opening her little space capsule, Arabella was also found dead; like Anita, she was also probably the victim of lack of moisture.

Meanwhile, back on Earth…
While Anita and Arabella were whizzing around the earth on the Skylab space station, another spider just like them was hard at work back on the ground making webs of its own for comparing to the space-woven spider webs. To make sure that all of the spiders in the experiment were starting from the same conditions, the spider back on Earth was kept in its own "space capsule" like Anita and Arabella's, and it was given a simulated rocket launch so that it too would experience the same forces that the space spiders got on their way to Skylab with the three astronauts. And, like Anita and Arabella, it was given the same amount of time to "rest" after its pretend launch so that it was relaxed when it came time to spin its webs.

When compared to the webs of the spider that stayed home—its web silk was all the same thickness—those made by Anita and Arabella on Skylab had both thin and thick silks, which meant that they were making their web silk depending on how they thought that they were being affected by there not being any gravity in space. The actual patterns of the spun webs themselves differed little between the three spiders except for some small variations. Except for the difference in the thicknesses of the webs produced by Anita and Arabella, the spiders on Skylab were able to adapt to the weightless environment of space.

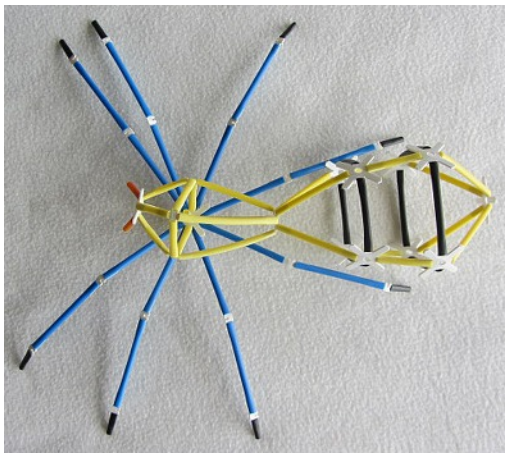
What we learned
High school student Judith Miles' Skylab experiment involving the two spiders received a lot of attention around the world. It also showed that it was possible to take some animals into space that could be useful as experiment subjects, the results of which could have benefits for us back on Earth.

Where are Anita and Arabella today?
Today Anita and Arabella can be seen in two space-related exhibits in museums in the United States; one in Virginia, and one in Alabama. They have been preserved and can be seen inside of special display capsules, which allow us to see these two eight-legged "astronauts" who, like their human companions, spent almost two months in space on board the Skylab space station.

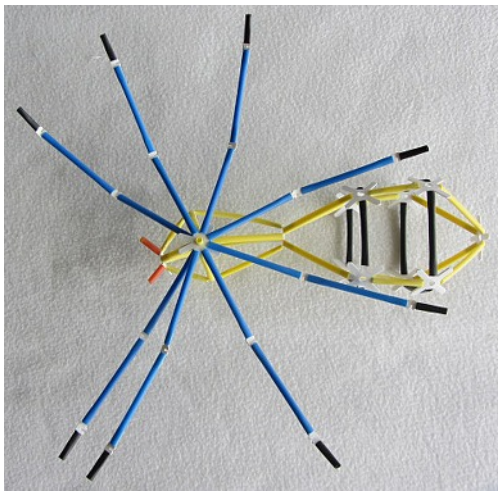
Activities for students with 4DFrame materials:
After performing some library or online research about them, design and build a 4DFrame model of an Earth-orbiting space station and be able to identify the functions of its various parts—for example power source, living space, observatory, laboratory, docking station, etc.—and be able to explain their usage.

After performing some library or online research and reviewing the pictures of the 4DFrame spider example below, build your own 4DFrame model of a spider that includes all of the various features that distinguish spiders—for example eight legs—from other kinds of insects.

After performing some library or online research, build a 4DFrame model of a spider web to go along with your spider model; what does the web you made say about how your spider collects its food?



Top



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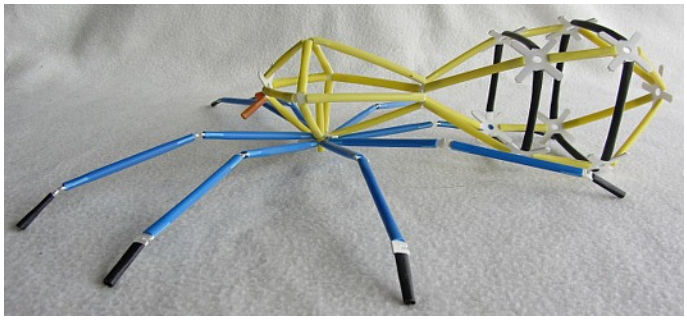
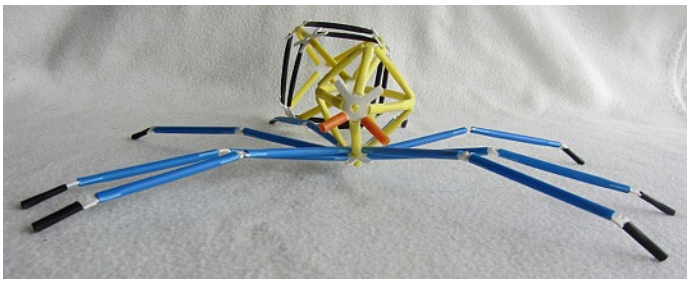
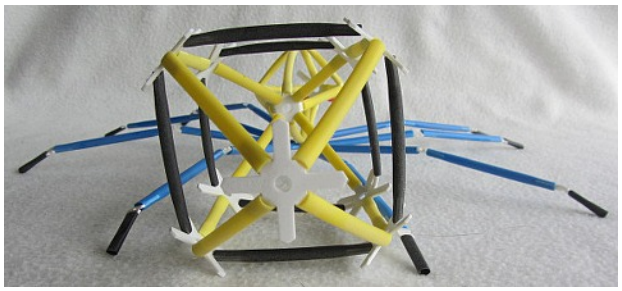


Side

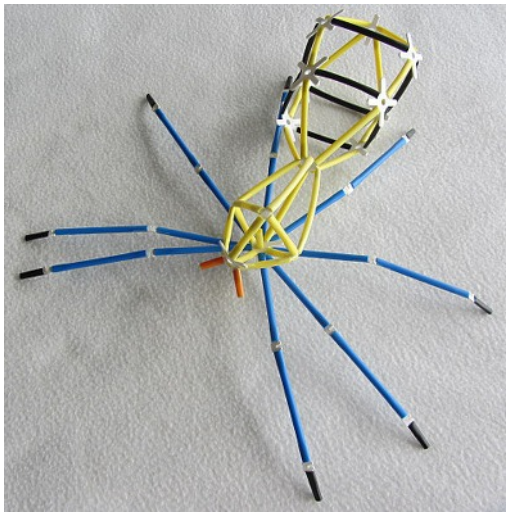
The 4DFrame spider model above has a body length of @21cm.
The width of the legs from side-to-side is @30cm.



Front



Tail



¾ Perspective

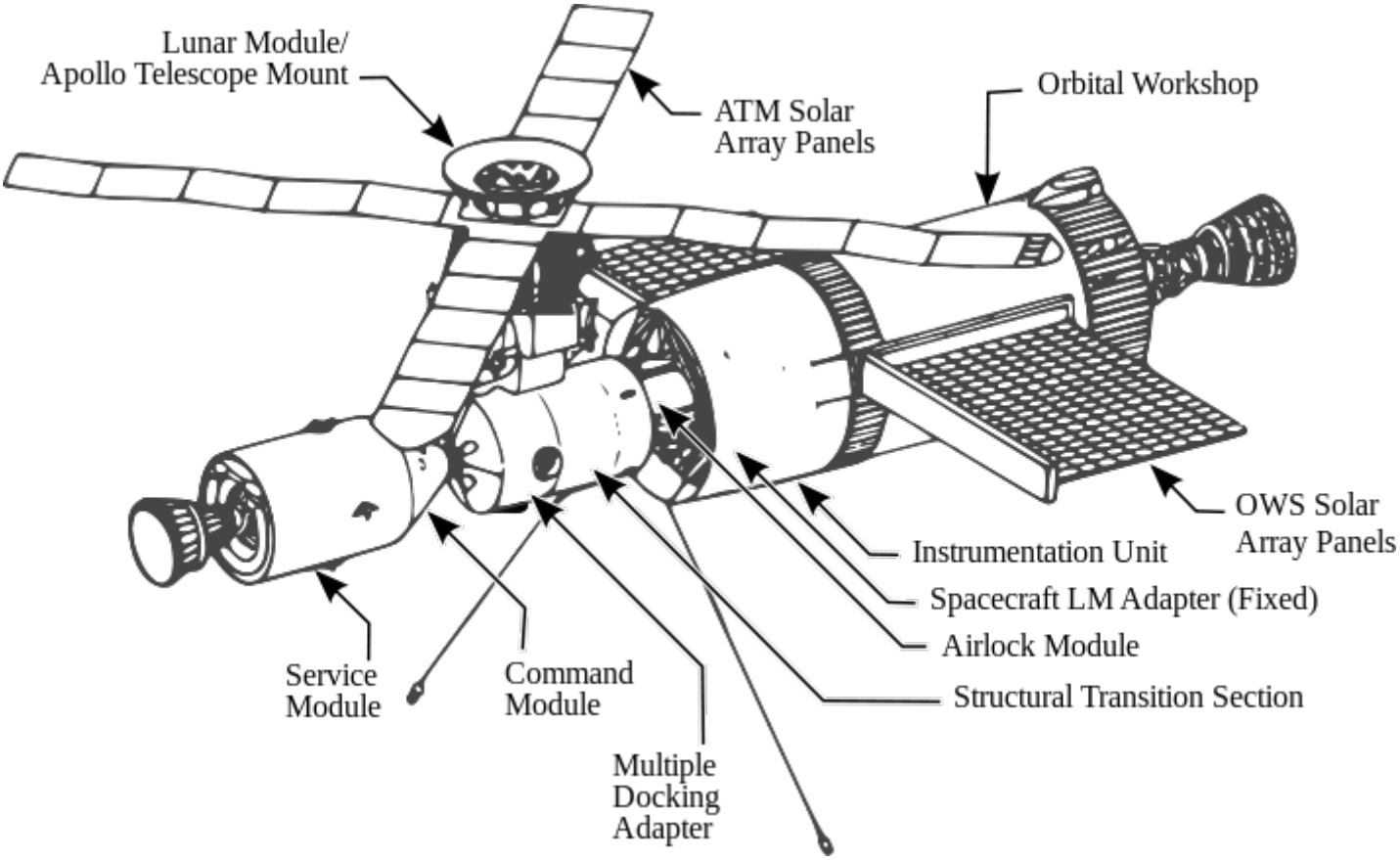
Questions for students:
Besides Anita and Arabella, the two spiders that were on board the Skylab space station, what other kinds of animals have traveled into space? In addition to these, can you also find examples of plants that have also been sent into space? What are some of the possible benefits to studying other such simpler forms of life in space?

There is more than one way that the different types of spiders to catch their food. How many different examples of spiders' ways to get prey can you find? Remember, not all spiders make webs, so how do they find food to survive?

A variety of manned space stations have been launched into Earth orbit. When was the first one sent up, and how many have been orbited since then? Be sure to note which countries were responsible for doing so, and list several examples from each of some of the things learned during their time in service.

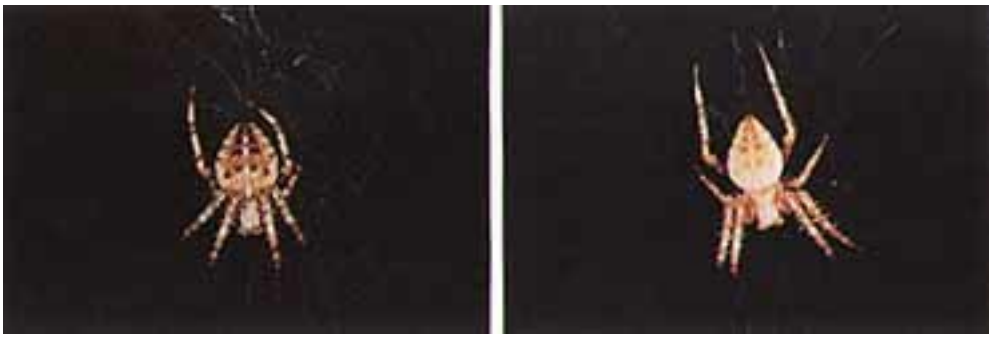
If you had the possibility to have a science or technology experiment that you designed to be part of a manned space station mission, what would it be? Explain possible benefits from the experiment, how it would be designed, what equipment—if any—would have to be built, how would you go about writing the instructions that the astronauts would have to follow onboard the space station to perform the experiment, how would you go about making the analysis of the results back on Earth, and tell what would be the best way to present the final report of the experiment's results.

A picture gallery of "Spiders in Space"

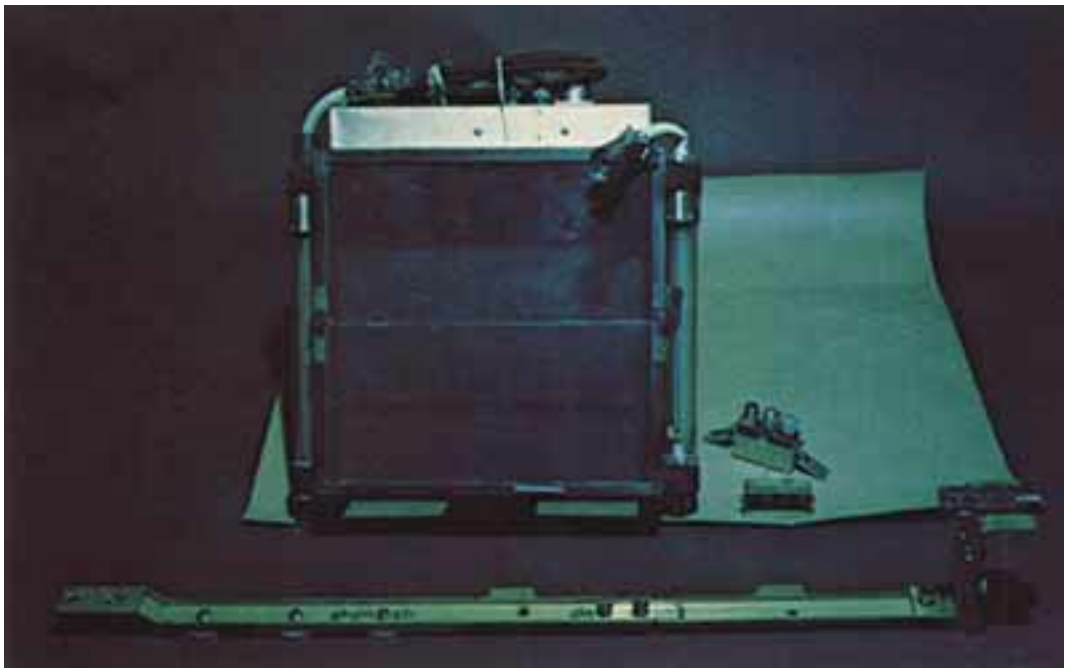


This line drawing shows the various parts of the NASA's manned Skylab space station. Compare this to the photograph of the real one taken by the astronauts below on page 9. **(NASA)**

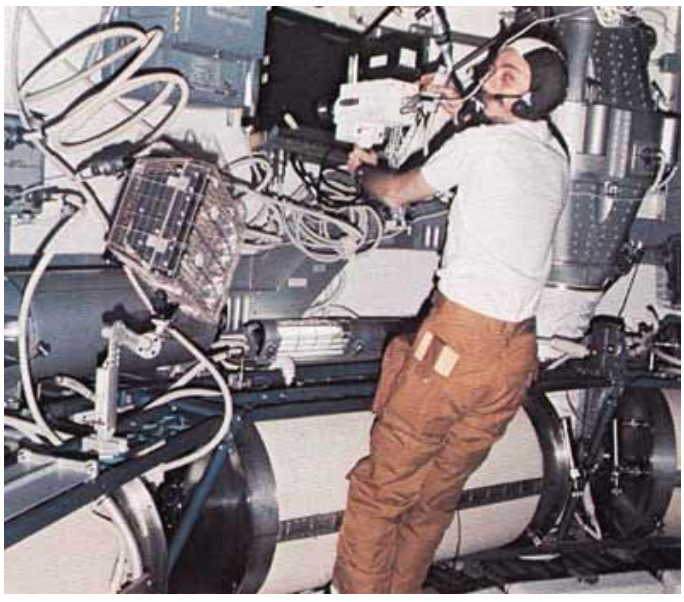
A typical Cross, or European garden, spider (*Araneus diadematus*) as you might find in your yard at home.
(Jon Glittenberg, CC3 Wikimedia)



Spiders Arabella (left) and Anita (right) that were launched into space for their experiment during the Skylab 2 mission. (NASA)



The spider test cage (left) and the spider transport capsules (small tubes on right) that were part of the "ED52 Web formation" experiment designed by student Judith Miles. (NASA)



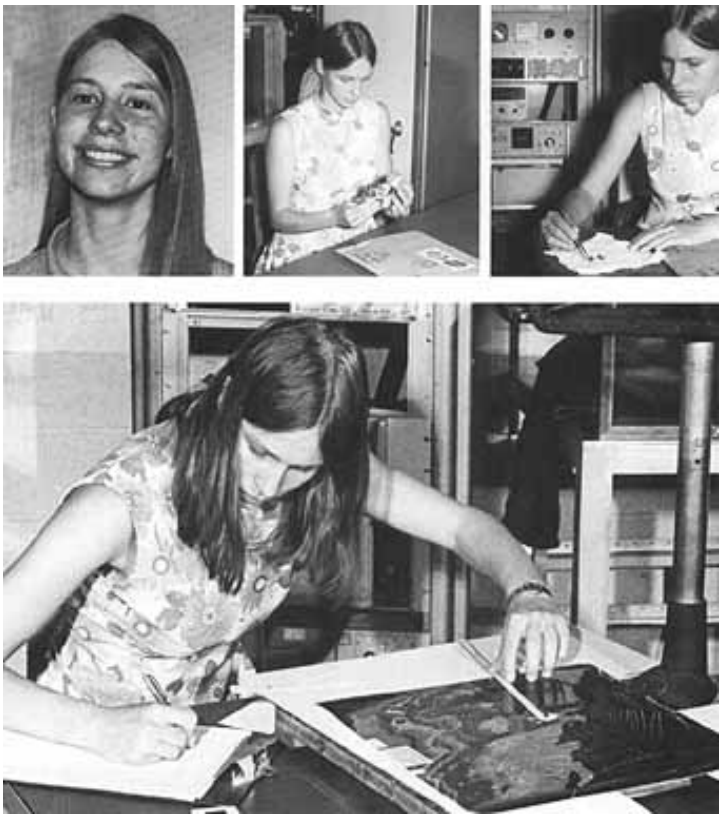
Skylab 2 astronaut Owen Garriott uses a video camera to record spider Anita making a web inside of the test cage. (NASA)

Arabella's first, less than perfect, web that she made under the influence of zero gravity. **(NASA)**

Arabella's perfect web after she mastered working in the weightlessness of space. **(NASA)**

The web of this Earth-bound control spider looked just like Arabella's and Anita's on board Skylab after they learned how to work in zero gravity. **(NASA)**

This view of Skylab was taken by one of the three astronauts when they— and the two spiders—departed the space station during their return to Earth. Note the missing left OWS Solar Array Panel. It was torn away from Skylab during its launch into Earth orbit. The gold-colored thermal blanket was used to help protect the Orbital Workshop from the Sun's heat since the OWS did not have enough electrical power due to the missing Solar Array to help keep it cool. (NASA)



High school student Judith Miles examines the results of the web-building spiders after their return to Earth. (NASA)