

"SPECIAL FROM THE SOVIET UNION"
SHOW 104

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EPISODE OPEN

WOODIE FLOWERS Hi. I'm Woodie Flowers, host of Scientific American Frontiers. We have just arrived here in Moscow. it's a long flight. But I'm really excited about being here. Until a couple of years ago, the U.S. and the Soviet Union were arch rivals in the Cold War. In that tense climate, even the most innocent bit of scientific information was sometimes guarded like a state secret. But now, with the incredible economic and political reforms that are unfolding, our two countries are coming together. In the spirit of this new relationship, in the next hour we are going to take you on a journey through the fascinating and little-known world of Soviet Science. We will find out how the Moscow Circus flies with the help of engineers. Meet Igor Igorovich, as he gets a remarkable new surgery to save his leg. Rescue the world's heaviest bird...down on the farm. And explore whether the human body is ready for a trip to Mars. All this and more on our special Soviet edition of Scientific American Frontiers.

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FREE-FLOWING ARTERIES

NARRATION A Moscow playground. Like anywhere in the world the kids are bursting with energy. Igor Igorovich, always wanted keeping up with grandson Phillipe to be great fun. But lately it's become excruciatingly painful. The problem is atherosclerosis, fat clogging the arteries of Igor's left leg, reducing blood flow and making exercise a nightmare.

IGOR IGOROVICH I'm afraid my disease is going to get Worse. The distances I walk are steadily decreasing. I could become incapacitated - or even paralyzed.

NARRATION Today Igor has come to medicine's Central Institute for Surgery, to see if he can be helped by a new treatment that might reopen his arteries. He'll be in the hands of radiologist Za Za Kavteladze, who first must find out just how badly Igor's arteries are clogged. The diagnostic test is routine, available worldwide. Za Za makes a small incision in Igor's back, then snakes a thin, hollow blue tube called a catheter down into Igor's leg arteries. The arteries themselves don't show up on this x-ray screen. Only the catheter does. So next, a special liquid will be pumped through the catheter into the arteries.

DR. KAVTELADZE Igor Igorovich, hold your breath please. Hold the breath. 1-2-3, 4-5-6. Stop.

NARRATION As the bright liquid fills Igor's leg arteries, the images are recorded on film. For Igor it's an uncomfortable but tolerable procedure.

DR. KAVTELADZA Are you feeling anything? Any dizziness?

IGOR IGOROVICH Yes, very slightly.

NARRATION As expected, the x-rays reveal a serious condition which Igor's own doctor explains back in the ward. His arteries are clogged in several places. Here for example, one of the arteries running past the hips shows an obvious narrowing. The result, blood flow on the left side is much healthier than on the right. The plan is to put another catheter into Igor's arteries - one with a balloon on the end. The balloon is inflated, compressing the fat, and restoring blood flow. This technique is also standard throughout the world. But it has one big drawback: The fat usually springs back within a few years. But now Soviet doctors have solved this problem. Using an invention from - of all places - the United States Navy.

NAVY FILM NARRATION This is Nitinol, a new battle compound. It doesn't look unusual, and as you can see...

NARRATION Developed in the 1950's, this miracle metal has an amazing ability to remember its shape. Flatten out a curly piece of metal. Then warm it up. And it springs back into its original form.

NAVY FILM NARRATION ...into hot water, it returns to its original shape.

NARRATION A mixture of nickel and titanium, Nitinol was first considered ideal for use in outer space. Objects compressed for travel like antennas could automatically unfold when exposed to the sun's heat. But recently it was adapted by Soviet doctors to make a spring that can be placed inside arteries. Dr. Joseph Rabkin on the right had the idea of stretching the Nitinol spring so it can be slipped into arteries. Then when it warms up to blood temperature, it will return to its original spring shape. This device, called a stent, is just what newly cleared arteries need according to Rabkin.

DR. RABKIN The stent acts much like a support frame for a subway tunnel which keeps the curve from collapsing. Well, an artery also needs support, so the stent acts like a frame.

NARRATION It's still an experiment treatment, but for Igor any procedure prompts mixed feelings.

IGOR IGOROVICH I don't know of anyone who will be absolutely unconcerned about an upcoming surgery. Even when they have to change a bandage on a finger you are a little afraid. So of course I will be nervous. But the most important thing is my doctor promises he can cure all my problems in one day. And this makes me very hopeful and happy.

NARRATION Three days after diagnosis Igor is back on the operating table. Before any stents are used the arteries must be opened. But two are so blocked that a balloon catheter won't fit. So another type will be tried. Rabkin's son Dimitri, explains.

DIMITRI RABKIN The catheter has a special device for rotating. Here it is.

NARRATION Called a rotor catheter, it's a tiny, liquid-powered drill, small enough to fit inside arteries. It can bore a channel right through fat blockages. The rotor must be kept clear of the artery walls so afterwards its' still necessary to use the balloon to make a wider opening. Throughout this whole procedure, Igor is groggy but awake. He can feel the balloon as it's being inflated, as seen here on the x-ray monitor, opening up his leg. But it's been a trying procedure for Igor. So his doctors decide for today they'll just treat the worst blockage. Now it's time for a Nitinol stent. In the shape of a spring it's too wide to be pushed through an artery. So the plan is to tightly wind it around the catheter. But this requires some help.

DIMITRI RABKIN Before the introduction of this type of catheter we have to cool it. And for this purpose we use a special solution of which the temperature is nearly minus 70 degrees Centigrade.

NARRATION The cooler the metal, the easier it is to take it out of its memorized shape. And when the winding is finished, there can't be any protrusions to interfere with its passage inside the artery. This is the critical part. The stent has got to reach precisely the right place on its first attempt. Once it opens up there is no chance to move it. In less than a minute the metal is at body temperature. So as soon as the ends are released, it snaps back into its memorized shape. Now the catheter is removed and there's a test to be sure blood is flowing freely. It's the moment of truth.

DIMITRI RABKIN It is a normal artery.

NARRATION And one week after surgery Igor is back walking on the Moscow streets. He'll still need another treatment, but already the pain is gone. And the stent should keep his leg artery permanently clear.

IGOR IGOROVICH This surgery made me healthy again. I can move around easily, play with my grandson. In other words, be a normal human being.

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RESCUING BIG BIRD

WOODIE FLOWERS One of my strongest impressions of Moscow is that it has more trees and green spaces than most major cities. All parks like this are not part of a pristine wilderness. They do provide a home for birds, squirrels, and other urban wildlife. And they give people a little reminder about just how important true wilderness really is. And that's a critical lesson these days because all around the world wild land is disappearing. Even in the vast territories of the Soviet Union.

NARRATION Five hundred miles to the southeast of Moscow is the Saratoy region of Russia. It's a land of farmers, a breadbasket of the Soviet Union. Here wheat is king and it's grown on almost every inch of this immense flat plain. The wheat is vital to the whole Soviet Union, but what often gets ignored is its tragic impact on wildlife. Take the case of the Great Bustard, the world's heaviest flying creature, a strange and wonderful bird. They are naturally shy of people, so to see them in the wild you have to get up early in the morning and hide in a specially made blind. That's what biologists have been doing for the past three years as part of a crash program to save the Great Bustard from extinction. Today there are just a few thousand of the majestic birds left in the world. Yet earlier in the century hundreds of thousands used to come here every spring, flying in from as far away as Africa to find each other on one of the world's few

bustard breeding grounds. Males would proudly display their feathers in a ritual dance to attract females who went on to lay their eggs in the tall wild grass. But then came big agriculture and the wild land disappeared. Now eggs were ending up in the middle of farmers' fields and were constantly being smashed. The bustards were in trouble, until a local wildlife official got involved.

ANATOLE HRUSTOV When we disrupt the ecological balance, for instance by wiping out the Great Bustards, we can't even imagine what it will lead to. Everything in nature is interconnected, interdependent. And so our goal is to restore this ecological balance.

NARRATION Anatole Hrustov may sound like a typical environmentalist, but in fact he's a hunter who would like nothing more than to see the day when bustards can be stocked along with other game animals. He insists it makes perfect sense for a hunter to be in charge of a project to save endangered species.

ANATOLE HRUSTOV Great Bustards used to be hunted until the 1930's. And then they became extremely rare. But hunters are so close to nature. So they noticed the disappearance of the bird. They were the first to pay attention. And then they got others to pay attention too.

NARRATION Today that attention is focused on Anatole's ambitious program to protect Great Bustard eggs. He and his staff of biologists are traveling from farm to farm, trying hard to convince tractor drivers that the bustard's future is in their hands.

ANATOLE HRUSTOV Our goal is to save the Great Bustard right here on the land we have affected.

NARRATION The pitch is simple. If they can keep their eyes open for bustard eggs and not run over them, they can save the species. For each egg rescued, there is a reward of three rubles, about a quarter of their daily wage. It might seem that spotting the dark eggs in these vast fields would be next to impossible, but in fact they are often impossible to miss. Bustards sitting on the nest won't budge until the last, second. And so the birds automatically tell the driver where to look for eggs. The procedure the drivers are taught is straightforward. First they have to protect the eggs against predators. Then they plow around the spot. According to this driver it's not the three ruble reward that inspires him to make this effort.

TRACTOR DRIVER If people aren't going to save them, who else will? Do you think aliens will come down and do it?

NARRATION Later in the day the driver leads biologists back to the site he has carefully protected. To save the Great Bustard from extinction, Anatole figures his program must collect several hundred eggs per season. This year they are up to numbers 100 and 112 in mid season. The eggs are marked immediately so their progress can be monitored from now on. In three seasons so far they have saved over six hundred eggs, but this is a job that will never end. Biologist Valetie Maseikin explains.

VALERIE MASETKIN There are no longer any wild uninhabited places left. So the only Great Bustard which can survive are those that will with the help of man.

NARRATION That help continues back at headquarters where all collected eggs are placed in an incubator. The eggs take about 25 days to hatch. For the newly hatched bustard chicks there is a critical step somebody has to teach them how to eat. The steel tweezers don't look very friendly - and that's the point. The chicks mustn't realize it's a human feeding them. They will soon have to fend for themselves back in the wild, so they mustn't learn to associate food with people. But the cold-shoulder treatment doesn't apply to all the birds. About half will come to think of biologist Ludmila Borovskya as Mom. This radically different treatment is designed for birds that are destined to remain in captivity, birds the biologist hope will be a second source for eggs.

LUDMILA BOROVSKEYA We want to raise a bird which is less aggressive, less jumpy, a quieter bird which can be in contact with humans and not be afraid.

NARRATION These adult birds were raised in captivity and you can see why Ludmila wants bustards that are comfortable with people. She and her husband Sasha have to regularly handle the birds, to check their health for example. Maintaining proper weight - up to forty pounds for a male - is an important measure. Covering their eyes, by the way, helps calm them down. These captive bustards won't start producing eggs for at least ' another year. The oldest male, now aged five, is just beginning to display mating behavior. So it's still not known if captive breeding is going to work. But for the biologists, there is also the uncertainty about releasing other birds back into the wild.

VALERIE MASEIKIN I am working so hard to save these birds. There is a part of me in every one of them. So when I release them back into the wild, it's like letting a part of myself go. I look at their photographs and I start wondering: Will they be okay? I really worry about them.

NARRATION Nevertheless, the basic point of the rescue program is to keep a large population of bustards living in nature. So at the age of six months, half of the birds are set free.

LEADER 1-2-3. Go!

NARRATION After so much time in captivity, they are not exactly sure what to do with their newfound freedom. But eventually they fly off to find their wild cousins. Birds previously released have joined in with the migration south for the winter. And they have returned here again the next year. But whether these efforts to save the Great Bustard will succeed in the long run, only time will tell.

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HIGH STAKES MATH

ALEXEY PAZHITNOV Hello.

WOODIE FLOWERS Alexey Pazhitnov?

ALEXEY PAZHITNOV Yes.

WOODIE FLOWERS This is Woodie Flowers. I'm down in the lobby.

ALEXEY PAZHITNOV Come up. I'm waiting.

WOODIE FLOWERS You know, this guy is famous all over the world. Yet in the Soviet Union, almost nobody knows who he is. That's because he designs video games. And here, few people have the personal computers or Nintendo machines that are necessary to play them. So my question is: What's the designer of best-selling video games doing in the Soviet Union?

WOODIE FLOWERS Hi. I'm Woodie Flowers.

ALEXEY PAZHITNOV I am Alexey. Nice to meet you.

WOODIE FLOWERS Within minutes of meeting we were sitting at his computer, loading up the game Tetris. This is Alexey's international bestseller, and of course, he soon had me playing it.

ALEXEY PAZHITNOV Have you played Tetris before?

WOODIE FLOWERS No, I have not...

ALEXEY PAZHITNOV The rules are simple. There are...

WOODIE FLOWERS The object, he explained is to position these geometrically-shaped pieces so that when they drop down to the bottom they fill in a complete line.

ALEXEY PAZHITNOV Every time you have to solve this problem.

WOODIE FLOWERS I like to solve problems, but this was a lot more challenging that I had imagined. Making another deep hole but, let's see.

ALEXEY PAZHITNOV That left gravitates. Rotate one time. OK.

WOODIE FLOWERS Okay.

ALEXEY PAZHITNOV No, no. Don't rotate it.

WOODIE FLOWERS With Alexey's experience coaching, I started to relax. And then I realized how he could invent Tetris. He's a mathematician. Mathematicians here do have computers and geometrical puzzles have a lot in common with modern math.

ALEXEY PAZHITNOV The main object of mathematicians is not the number at all. Numbers are too simple for mathematicians now. And, the mode of thinking of mathematics, is not to, it's not a calculation. It's very close to puzzles, I think.

WOODIE FLOWERS Alexey's puzzles usually stimulate the mathematical mind, and Muddle, his new game, is a good example.

ALEXEY PAZHITNOV Your task is to put them away from the fields from this small window. In this order. This will be first, and this...

WOODIE FLOWERS I began to suspect Muddle was not for novice players. The goal is to get all the objects out of the box, but the difficult part is, they can only be moved in groups which must be chosen by the player. If you put together spades and clubs, or diamonds and hearts, you can move a group to the right. Selecting all green backgrounds or all orange ones lets you go to the left. To go up you have to choose between circles or squares. To go down you have to mix red and black suit. If you think you are confused...now I had to do it.

ALEXEY PAZHITNOV And now move the circle up.

WOODIE FLOWERS Now I want to separate that guy and bring him down. And, whoops, that's not a good idea, I'll bet. It took intense concentration to avoid getting stuck. I could see this game was geometry, logic, and strategy, all rolled into one.

ALEXEY PAZHITNOV You made it! You see this game is rich enough. I like it very much but maybe it's a little bit complicated.

WOODIE FLOWERS Right now I understand why you call it Muddle because my mind is kind of a muddle right now. All of Alexey's creations have a mathematical twist, and that's what makes them entertaining. The object of this new children's game, for instance, is to collect as many coconuts as possible. And players have to balance their time between going for water, watering trees, planting new ones, and collecting fruit. It's very different from just zapping aliens from space.

ALEXEY PAZHITNOV You see there are different kinds of pleasures. I feel that for me, for me personally, the best kind of pleasure is the pleasure of intellectual activity. So this kind of pleasure I would like to present to my customers, to my players.

WOODIE FLOWERS Alexey is one of many talented Soviet mathematicians. And their creativity is also leading into other unexpected directions.

NEWS ANNOUNCER There are thousands and thousands buried in the rubble. They know buildings that have hundreds and hundreds of people in them...

WOODIE FLOWERS Imagine being able to predict an event like this. A 1988 earthquake in Soviet Armenia. It was a major disaster, claiming nearly 25,000 lives. For centuries people have tried to foresee when and where such giant quakes would strike next, but successful predictions have always been a dream, until perhaps now. This unassuming building houses Moscow's Institute for the Mathematical Prediction of Earthquakes. An organization which attracted serious worldwide attention after predicting the Armenian quake one year before it occurred. The international team of mathematicians and geologists here has developed a revolutionary prediction technique that seems to work any place on earth. It all starts deep underground in thousands of earthquake monitoring stations like this spread around the world. The instruments in these stations register every little shake of the earth's crust, creating a seismic record. For many years earthquake scientists had studied these records in hopes of finding some warning pattern that heralds a big quake. The standard procedure is to examine the records of a small area, about 50 miles wide, around where a big quake occurred. But as I learned from the Institute's director, mathematician Vladimir Kalis-Borok, looking at such a small area may be a mistake. He and fellow mathematician Vladimir CasaBokov gave me an analogy. This just looks like two blobs of color, right? But widen the view and a pattern emerges: It's two men boating on a river. Well, to see a pattern in earthquake records, the mathematicians also had to widen their view, examining areas 300 miles wide

and comparing the records leading up to dozens of earthquakes - instead of just analyzing one.

KALIS-BOROK This is the earthquake...

WOODIE FLOWERS As Kalis-Borok explained, there were many patterns in these earthquake records. But to see them required looking at the data in some special ways.

KALIS-BOROK One way, here for example is a way to count the number of events in a sliding window. So here you have nine events in a sliding window. So here you have nine events. Here you have four. Eleven. There you have about fifteen.

WOODIE FLOWERS The rolling average as it's called, produced patterns like this showing that most big quakes came just after a peak of mild earthquake activity. The other analyses were much more complicated, but each one revealed another specific pattern of activity leading up to big earthquakes. No one pattern showed up all the time. So Kalis-Borok came up with this prediction method.

KALIS-BOROK We will declare an alarm with sufficient number of these phenomena, is slightly anomalous.

WOODIE FLOWERS To test this method, the Institute staff went back through half a century of old earthquake data. Pretending it was coming in little by little, they found they could predict 90 percent of all the big earthquakes that had occurred during that time. This was a tremendous success. So next they tried predicting the future. As they watched over the whole world, California began looking suspicious. In 1985 this method warned an earthquake would strike within a few years someplace within this 300-mile circle. In 1988, another warning just to the south. And then it happened. The big California earthquake of 1989.

NEWS ANNOUNCER ..a building there collapsed and burst into flames as a...

WOODIE FLOWERS It was a tragedy for Californians, but it was the second time the Institute's method had worked. Even though the prediction method isn't precise about the time and place, governments around the world are now taking these predictions very seriously. And there are more quakes predicted for the future. While evacuations might not be justified, if the prediction method continues to hold up, at least it will be clear where highways and buildings are vulnerable. Disaster planners will know where it is most important to train local officials. And extra medical supplies and personnel can be standing by. Of course, a more precise prediction would be better. So the Institute is now refining

its techniques, working hard to further narrow down the warning in time and place. And here Kalis-Borok has an ambitious goal.

KALIS-BOROK I think we can make probably less than a hundred miles, but this is speculation, and less than a year. But that would be, that would require a lot of luck and a lot of work.

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KLUTZY KOSMONAUTS?

WOODIE FLOWERS Space. The Soviet Union was the first country in the world to cross this frontier, back in 1957, with the launching of a tiny satellite called Sputnik. It was an outstanding scientific achievement. And as it turns out, the beginning of a long-term commitment to explore the skies. As you can see here in this Moscow space exhibition, during the past thirty years the Soviet Union has launched thousands of satellites and dozens of space programs. But most impressive of all, they have put so many cosmonauts into orbit around the earth that it has become routine. But many space scientists are asking: Is it time for a human mission to Mars? Now that's a controversial question. First, Mars is many millions of miles away so getting there and back will be very expensive and technically complex. Sending along a two-year supply of food, water, and oxygen is bad enough. But as we will see in this story, there's another critical problem: Can the human body tolerate the trip?

NARRATION The big problem is returning to gravity after a long time in weightlessness with a landing on Mars or coming back to earth. When cosmonaut Yuri Romanyenko returned from a 96-day mission in 1979, he was unable to walk and needed three months to recover. In a Mars landing, there would be nobody there to help.

YURI My heart felt weak. I was sweating a lot. I couldn't feel my legs at all. Actually, it felt like they were filled with lead. I couldn't move without help. It felt like I was coming out of a severe illness with a high temperature. Like recovering from a terrible cold.

NARRATION Why space travel has such effects is something the Soviets began investigating seriously just after that Romanyenko mission. And today, one of their key laboratories is the space station Mire. Since its launch in 1986, 28 different cosmonauts have lived and worked here. Most find their first days amusing, awkward, and hazardous. Back on earth all cosmonaut missions are

closely monitored at the Institute for Biomedical Problems by doctors like Inessa Koslovskya.

KOSLOVSKYA Getting back, at first they have a lot of...They do movements but it seems to them that they do exactly is necessary but they go sour and have...

NARRATION Within about a week though, cosmonauts adjust to weightlessness. In fact, working in zero gravity soon becomes as comfortable as working on earth. But adapting to life in space has a down side too. As missions stretch on for six months or even a year, on-board monitoring shows the cosmonauts' bodies change in ways that make it hard to return to gravity. The heart shrinks in size by up to ten percent, because in weightlessness it doesn't have to pump so hard. Bones lose calcium because they are not holding up any weight. And muscles lose their strength because working in space requires very little physical effort.

KOSLOVSKYA All these muscles are not used in space and since they are not used, it is very old rule which all biologists know: That which is not used, it disappears.

NARRATION To stop this disappearing act, cosmonauts were given exercise equipment. Three to five hours per day became standard practice, and this helped muscles stay strong. But cosmonauts still had problems coordinating their muscles once they got back to earth. So at the Institute, scientists began trying to find out why. The first step was to produce on earth the same coordination problems created by space travel. This experiment, for instance, uses a kind of water bed. Climbing in is researcher Mikhail Borisov. The water completely surrounds Mikhail, allowing him to float comfortably for weeks at a time. It's sure not as thrilling as going into space, but it's as close as a non-cosmonaut can get.

MIKHAIL BORISOV It's quite comfortable. I swim like a fish in the warm water.

NARRATION This experiment is testing Koslovskya's theory of how human coordination breaks down. From birth, she says, the body is constantly detecting its own weight, using special nerves called pressure receptors. Changing patterns of high and low pressure readings tell the brain how the body is in position. And in turn the brain uses this information to coordinate muscles. But in the weightlessness of space, all pressure readings are zero so the pattern is always the same. Coordination becomes difficult until the brain adapts. And the situation should be similar in Koslovskya's immersion experiment.

KOSLOVSKYA The weight, body weight, is distributed equally along the surface. So there is no gradient between different points of the body - which accepts this

pressure. So for pressure receptors, the immersion is accepted exactly like weightlessness.

NARRATION Subjects spend two weeks in the tank. Not enough for muscles to deteriorate, but easily enough to produce the same coordination effects of space if Koslovskya is right. Coordination is tested daily. Even the movement of eye muscles could be affected by lying in the tank. In fact, this eye-tracking experiment shows during the first few days subjects have great difficulty following a series of lights. But after a week, coordination gets better again, just like in space. But the ultimate test of Koslovskya's theory comes immediately after subjects are out of the tank. It should be like cosmonauts returning to the earth.

DOCTOR How do you feel? O.K. stand up carefully. Try to stay straight.

NARRATION The idea is to see how difficult it is to remain upright after getting a measured push.

DOCTOR Now I am going to push you.

NARRATION Subjects consistently sway back and forth for several seconds following each push. By comparison, they recover much faster before the experiment. So after spending two weeks in the tank, coordination is thrown off and now doesn't work in gravity, evidence that Koslovskya's pressure receptor theory is right. Another experiment suggests what may be happening in the body to disrupt coordination. Pressure receptor nerves which in the tank got accustomed to the same steady pressure all day long, now overreact and send signals that are too strong.

KOSLOVSKYA To the small accumulation, they give big response. To the stimulation which were not enough to stimulate them before, they answer now. So it means that the response is not proper.

NARRATION But now attach a board to the subject's feet. Pull it tight so as to create pressure along his body, as if he were standing up on earth. And look what happens. Using this simple device for only a few hours each day, Koslovskya's group finds they can dramatically reduce coordination problems. Eye-tracking hardly deteriorates. And coordination remains good after leaving the tank. So now it space recommended exercises take advantage of this Soviet discovery, with elastic straps pulling downward on this cosmonaut, for instance, his knee bends feel much the same as they would on earth. Better exercises have meant today's cosmonauts can live and work in space for up to a year, and come back with very few coordination problems. Of course, cosmonauts still have to exercise two to three hours a day - a waste of valuable research time. And

these exercises still don't solve the problem of bone loss. But Soviet scientists have solved at least some of the medical challenges for long-term space travel.

WOODIE FLOWERS If humans decide to go to Mars there would almost certainly be a political challenge too. With the cost expected to exceed several hundred billion dollars, realistically one or more nations will have to share the expense. So we decided to ask some Soviet citizens about how they feel about a joint US-Soviet mission.

MAN It would have Russian enthusiasm plus American practicality and technology.

ANOTHER MAN It is very important and necessary for mankind.

GIRL It would be nice not to go only with Americans. Somebody else too.

ANOTHER WOMAN We will gain knowledge. It will be cooperation. This will bring us together in my opinion.

MAN It would take us not only to Mars, but even further.

WOMAN This is absolutely unnecessary. If we want to increase the friendship between our two countries, we can do that here on earth just as well.

MAN I would like to be on the plane. I would like to fly there myself. I would love it.

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DIGGING UP THE PAST

NARRATION We are in Turkmenistan. Two thousand miles and a half a world away from Moscow. With Iran and Afghanistan just over the border. It's a place with its own distinct culture. For one thousand years people here have followed the prophet Mohammed. They are Moslems. But centuries earlier, what prophet followed them? The Turkmenistan desert is revealing the answer. Recently uncovered from its sands are the remains of ancient and immense buildings. This one was excavated in 1981. This one, with its enormous fortress-like walls, two years later. And this, which promises to be the largest yet, is just now being excavated. Even in September it's still over 100 degrees out here. But the archaeology students dress accordingly. To do work like this in the middle of the

desert, you've got to be a bit of a fanatic. Just like the discoverer of these sites, archaeology professor

VIKTOR SARIANIDI. He is here to explore the unknown.

VIKTOR SARIANIDI Maybe it is palace. I don't know exactly. That's very, because we only found, we are beginning our excavations. We don't know exactly what is this. It's interesting.

NARRATION Sarianidi is interested in results. So in some areas he is using machines to shift large amounts of dirt. It's a controversial method. Maybe he will destroy something unwittingly. But with small crews and tight budgets, it's the only way to work, he responds. Once his crews get down to these walls, though, they are very careful. And they certainly seem to know just where to dig.

OLEG ROZENTHAL is their top wall finder. Since mud bricks aren't much different from desert sand, it's not so simple.

OLEG ROZENTHAL There has to be a wall here someplace, but where, we don't know.

NARRATION Oleg looks for clues in the color and texture of the desert floor.

OLEG ROZENTHAL Here, look. It's easy to see. One side is dark and the other side is much lighter.

NARRATION Well, maybe it's easy for him. In fact, he's so sure of his judgement that he starts digging out the sand inside the walls. He uses texture as his guide, picking out soft dirt, leaving the harder material in place. Two days later he has traced the walls. And confirmed his judgement with something you often find against the wall of a room.

OLEG ROZENTHAL In the corner which we have excavated there is a vessel. It is a big one, a common type, probably used to store liquids and grains. So far we have only found two walls, but there will be four. In fact, I think I am uncovering one right now.

NARRATION Three foot high walls is all that's left of the buildings now, after 3500 years of erosion by the desert. But imagine what this building used to look like - a massive structure, perfectly laid out, all with an elegant symmetry. Sarianidi calls it a fortress but that's just guesswork. What's certain is the people who built it were highly civilized.

VIKTOR SARIANIDI Building this entire fortress was a giant undertaking. It shows that the people who lived here, the architects, already knew mathematics, already knew astronomy, already knew the fundamentals of geometry.

NARRATION In fact, Sarianidi has discovered nothing less than a new civilization. His team is busy piecing together what these people he calls them Bactrians - were like. Flourishing at the same time as the Pharaohs of Egypt, they are now taking their place as the world's fifth Bronze Age civilization. Long buried in graves and erosion-filled rooms, ancient Bactria is slowly emerging. Elegant drinking vessels. Oddly styled figures - a God maybe? Animals of the desert, a centipede. A scorpion. Cylindrical seals showing some kind of ritual. And a distinctive kind of pot decorated with animal figures. This one was reconstructed from pieces unearthed in the second building Sarianidi excavated - which he believes was a temple. In spite of his bulldozing image, Sarianidi is actually a careful investigator. It's his usual practice to take soil samples in and around pottery. And the shattered pieces of the animal figure pot were no exception. The samples went for chemical analysis and the results were startling. They contained unmistakable traces of two local plants which apparently had been mashed by grinding stones, also found here at this site.

VIKTOR SARIANIDI During excavation of the central part of the temple, we found these grinding stones. And as you can see, they are worn flat from constant use. On the stones we found traces of ephedra and poppy.

NARRATION Poppy produces opium. And ephedra contains a powerful hallucinogen. Mix either of these plants with water, and you have got a drink which packs quite a punch. All that's left is to strain out the stocks using a piece of goatskin and a 4000 year old filter cone, also found in the ruins. Actually it's not such a surprise to find the Bactrians used drugs. Many ancient civilizations incorporated them into their rituals, as a way to feel closer to the Gods. But there was more to the ritual life of the Bactrians as revealed by these pits which had clear signs of soot on their walls. Sarianidi is convinced these pits were used to illuminate altar platforms, now eroded but once situated immediately behind the pits.

VIKTOR SARIANIDI It's likely that on these two platforms sat the images of the gods. And in their honor a fire was burning here. What does this mean? Of course fire plays an important role in many religions of the world. But here we have the rituals of fire and ephedra drinking together. It's the first time known to science that these two rituals occurred simultaneously.

NARRATION To Sarianidi, it's a very exciting discovery because fire and a drink from ephedra are both used by one of today's religions. They are followers of the prophet Zoroaster. Most are in India, but they are worldwide. The strange thing is

Zoroaster was born 1000 years after the rivers feeding ancient Bactria dried up and the civilization crumbled. So Zoroastrians must have taken over the rituals of a pre-existing religion, one that had been Bactrian. Archaeologists, of course, have their own rituals which often show up worldwide. Complaining about archaeology is one of them.

SONG Honestly I am tired of digging here in the sand. I don't get any excitement here.

NARRATION But in truth archaeology is a passion for these people, as it has to be. After all, what else is going to send them back into the desert with pick and shovel tomorrow at dawn. But why the passion? It's because the rewards are unique.

VIKTOR SARIANIDI We have discovered an entire new country. Its culture, its civilization its uniqueness must have had a strong effect on its neighbors. It's a new page in ancient history!

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TRICKY TRAPEZE

WOODIE FLOWERS A rehearsal at the Moscow Circus. Every year directors here develop about a hundred new acts. And as you can see, they are quite spectacular. Don't think it's all just daring and artistry though. Before an act makes it from the director's imagination to the circus ring, often some careful engineering is required. That's what we found out when we went behind the scenes at this brand new trapeze performance.

NARRATION Before looking at the engineering though, first let's meet the director. This is Valentin Gnuishev. He believes that even a circus act should have a message.

VALENTIN GNUISHEV Russians have always been involved with wars. With Napoleon, with the Tartars, with the Germans, with Afghanistan. It seems we have always been fighting a war. And that's a great misfortune. I want to show the horror of war, the horror of these periods of delusion the history of these misguided actions.

NARRATION These ideas came to Valentin after hearing a Russian symphony called "Chimes". When he asked the chief engineer to build his new trapeze, he brought the music along. The act will be complicated and taxing for all involved.

Three high bars at different heights. A swing for two catchers instead of one - something never before tried by the Moscow Circus. And then, daring double flips and near-impossible catches. At first the chief engineer is skeptical about having so much weight on one swing. But Valentin is passionate about the concept and persuades the engineer to give a preliminary okay. So the proposal is sent to the Engineering Laboratory where ideas are tried out on paper before any hardware is built. The most basic issue tackled here is the length of the trapeze swing. Keeping in mind the height of each performer, engineers calculate how long to make each swing so that jumpers and catchers won't miss each other. Then there are detailed calculations to predict the maximum force on every piece of the ring, including support wires. Components can't be built without such analysis, but they also reveal a critical problem in the joints which support the swing. Unlike conventional straight trapeze swings, this one is narrow at the bottom and wide at the top to achieve a look desired by the director. This angled design creates high side-to-side forces that would snap a conventional joint which only moves back and forth. So the engineers return to the drawing board to work out a solution. It's a universal joint which swings not only back and forth, but also side to side, in effect, creating freedom of movement in any direction. Such a joint has never been used before in a trapeze. While it looks good in theory, the performers will actually have to use it. This will be their first test. Safety is taken very seriously. Performers make and hang their own nets. And, never trusting calculation, they also check the tension on all support wire, using a force gauge. As they start warming up, the swing's joint looks good. But will it hold up under the impact of repeated catching? As for the force gauge, things look fine. It reads about 250 kilos, well under the wire's limit of 400.

VALENTIN GNIUSHEV Take your proper positions everyone. Take your positions!

NARRATION Now it's time for real gymnastics. Will the jumpers and catchers meet as calculated? One catch after the next fails. Perhaps the swing is too short. Valentin is getting nervous. But gradually, things come together. And even after two months of rehearsal, the new joint is still in good condition. So when the time comes for the first performance, nobody has to worry about safety. It's another dazzling trapeze act for the Moscow Circus.

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