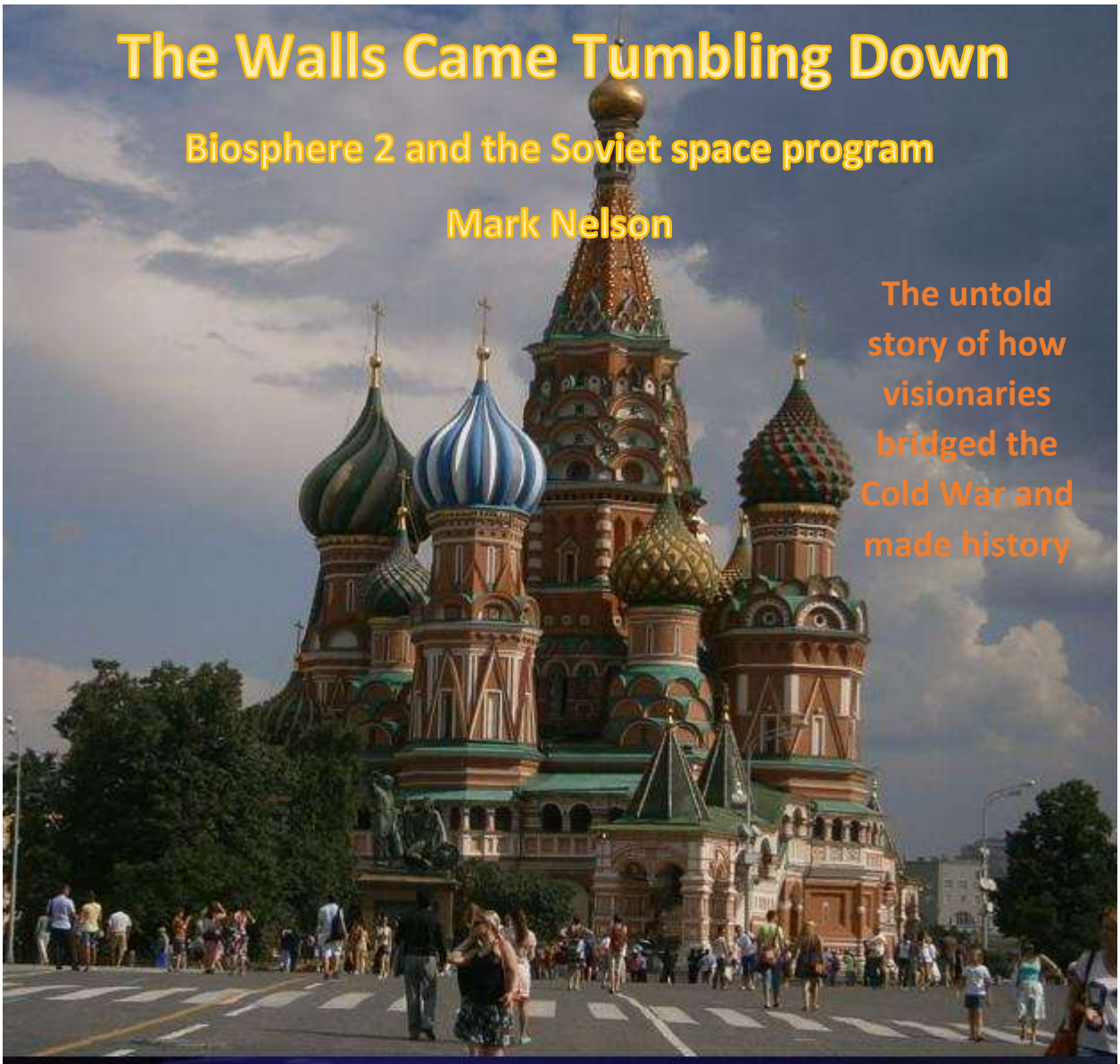
The Walls Came Tumbling Down

Biosphere 2 and the Soviet space program

Mark Nelson

The untold story of how visionaries bridged the Cold War and made history





Back cover ideas:

The Walls Came Tumbling Down is the first-ever account of the historic cooperation between leading Soviet (Russian) space organizations and the Biosphere 2 project in Arizona. Filled with the behind the scenes stories of how visionaries on both sides of the Iron Curtain/Cold War political divisions ingeniously found ways to do collaborative creative work. Their efforts deepened our knowledge of ecological systems and advanced our ability to take Earthlife into space. This riveting history is especially important and inspiring in our current atmosphere of distrust and nationalistic isolation.

"I consider Biosphere 2 one of the most hopeful things that has happened in the United States for quite a while." ***– Sir Arthur C. Clarke,*** scientist, futurist, author.

"Events of historical significance do not happen every day… We're witnessing the completion of the first very important and responsible mission inside Biosphere 2… We in Russia with great sympathy and tremendous interest have followed the advancement of this pioneering project. We believe results obtained in this experiment in combination with global studies of Earth biosphere through remote monitoring and extensive application of scientific technology will not only contribute to a better life on the Earth but will also serve the task of the human planetary exploration of the solar system." **Academician Oleg Gazenko**, Director of the Institute of BioMedical Problems, Russian Academy of Science, Moscow

"The original management of Biosphere 2 was regarded by many scientists as untrained for lack of formal degrees, even though they had engaged in a preparatory study program for a decade, interacting with the international community of scientists including the Russians involved with closed systems. The history of science has many examples where people of atypical background open science in new directions [and with] fresh hypotheses." -- ***Professor Howard T. Odum,*** *University of Florida*

"I truly believe that this great experiment, the vision of these people, the courage of the biospherians and the people who saw it through in spite of criticism, this will really lead to a tremendous increase in our understanding of environmental problems and that in turn will lead to new technologies to heal the world and make it a better place for our children and their children tomorrow." -- ***Dr. Jane Goodall,*** primatologist and anthropologist, world expert on chimpanzees.

"My only issue with this project is that it has the wrong name. It's not Biosphere 2 but Noosphere 1, for in such a small world, intelligence will be needed to make it succeed." – **Academician Josef Gitelson**, Director, Institute of Biophysics, Krasnoyarsk, Siberia where the most advanced Soviet space life support research was conducted.

Draft

Endorsements:

“I truly believe that this great experiment, the vision of these people, the courage of the biospherians and the people who saw it through in spite of criticism, this will really lead to a tremendous increase in our understanding of environmental problems and that in turn will lead to new technologies to heal the world and make it a better place for our children and their children tomorrow.” -- ***Dr. Jane Goodall,*** primatologist and anthropologist, world expert on chimpanzees.

“I consider Biosphere 2 one of the most hopeful things that has happened in the United States for quite a while - whatever the outcome of the experiment (and I'm sure it will be a success in the long run*).”* ***– Sir Arthur C. Clarke,*** scientist, futurist, author.

“Biosphere 1 is filled with life as we know it and so is Biosphere 2 filled with real life including eight real live pioneering human beings…..from time to time I’ve enjoyed conversations with some of these real live humans and the valuable perspectives already gained by the opportunity of having a hold-in-our-hands-sized planet in order to observe and gain insights into how to preserve the big biosphere, your [Earth] biosphere whose future is really in our hands as well. My hope that humankind can and will get it right for our kind and for all life on Earth has been greatly enhanced by this important experiment.” -- ***Sylvia Earle,*** *oceanographer and explorer.*

“The original management of Biosphere 2 was regarded by many scientists as untrained for lack of formal degrees, even though they had engaged in a preparatory study program for a decade, interacting with the international community of scientists including the Russians involved with closed systems. The history of science has many examples where people of atypical background open science in new directions, in this case implementing mesocosm organization and ecological engineering with fresh hypotheses.” -- ***Professor Howard T. Odum,*** *University of Florida*

“On Earth, living in an artificial biosphere is a noble experiment, suitable for pioneers.... Great things will be learned inside Biosphere 2 about our Earth, ourselves, and the uncountable other species we depend on... Already it has taught me, an outsider, that to live as human beings means to live with other life. The nauseating fear that machine technology would replace all living species has subsided in my mind. We'll keep other species, I believe, because as Biosphere 2 helps prove, life is technology. Life is the ultimate technology.” -- ***Kevin Kelly***, *Whole Earth Review.*

"The whole project seems to me like the star that's up in the air, and we look at it to see if man can survive on another planet. So the whole project is like on a table and you look at it from different angles and you look at it from different dimensions." ***Dan Old Elk,*** *Crow tribal medicine man.*

"Biosphere 2 is now widely recognized as a most imaginative and heroic project and of great scientific importance." ***Prof. S. Keith Runcorn,*** *F.R.S., geophysicist, Newcastle-upon-Tyne University, UK.*

Draft

"But perhaps Biosphere 2's greatest value has been showing what is possible. How innovative these eight people were in being able to live in a small area and make it work. The real lesson there is not so much a scientific lesson but showing how people can work together when resources are short, which is going to be the situation in the world." ***Professor Eugene P. Odum,*** *University of Georgia, Boston Globe, February 14, 1994.*

"Dear biospherians, it is a great pleasure to congratulate you with successful completion of your unique experiment. We appreciate your courage and devotion to science. We know that the results you have obtained will contribute to the science of biospherics." ***Bios 3 closed ecological system team*** *at the Institute of Biophysics, Krasnoyarsk, Siberian Academy of Sciences, September 1993.*

"Events of historical significance do not happen every day… We're witnessing the completion of the first very important and responsible mission inside Biosphere 2… We in Russia with great sympathy and tremendous interest have followed the advancement of this pioneering project. We wish it a successful continuation. We believe results obtained in this experiment in combination with global studies of Earth biosphere through remote monitoring and extensive application of scientific technology will not only contribute to a better life on the Earth but will also serve the task of the human planetary exploration of the solar system." **Academician Oleg Gazenko**, Director of the Institute of BioMedical Problems, Russian Academy of Science, Moscow

My only issue with this project is that it has the wrong name. It's not Biosphere 2 but Noosphere 1, for in such a small world, intelligence will be needed to make it succeed – **Academician Josef Gitelson**, Director, Institute of Biophysics, Krasnoyarsk.

"The achievements of the biospherians go beyond the application of state-of-the-art methods of sustainable agriculture. Biosphere 2 recreates in miniature the flows and balances that occur on Earth--but it moves through these cycles on 'fast- forward'. It is, in this sense, an ecological laboratory of incalculable value - the world's largest test-tube." -- ***Professor Richard R. Harwood****, C.S. Mott Foundation Chair of Sustainable Agriculture, Michigan State University.*

"Biosphere 2 is a new kind of telescope which can be used to look at the Earth itself. We need to take the time to understand how to use it, to discover the kind of questions we should ask, and to scale up from there."– **Dr. Christopher Langton**, Santa Fe Institute.

"We invented Biosphere 2 not only for science, but also for beauty, adventure, and hope for all humanity – and for the Earth's biosphere itself. To teach human beings to see Biosphere 1 in a new way, this is the ultimate vision behind Biosphere 2. We have the ability to be a creative, cooperative agent with evolution. This is what I call victory." **– John P. Allen**, Co-founder and Inventor of Biosphere 2.

Draft

The Walls Came Tumbling Downs

Biosphere 2 and the Soviet space program

[working title]

Mark Nelson

Draft

© Mark Nelson, 2025

Newsflash

And the walls came tumbling down

"History doesn't repeat itself, but it often rhymes" Mark Twain

Dateline: November 9th, 1989. Biosphere 2 site in Oracle, Arizona.

We were excited. Biosphere 2 for the first time on national US ABC evening news. Offices emptied and construction managers headed for the only TV on site. Our segment aired later in the broadcast.

There for the program's opening, our jaws dropped, like everyone around the world.

"I'm Peter Jennings in New York. Astonishing news just a few moments ago from East Germany. East German officials just announced in essence that the Berlin Wall wouldn't mean anything anymore. The wall built by East Germany in 1961 to keep their people in, will now be breached by anyone who wants to leave….The East German media chief of the Communist Party said a little while ago that anyone who wants to leave East Germany to go anywhere in the world is free to do so…It is perhaps the most important announcement in Central Europe since the end of the Second World War."

The upbeat segment on Biosphere 2 which aired later in the show marked a major elevation of the project's visibility. "The biggest payoff from Biosphere 2 could be a better understanding of our world, and of how we may someday live on other worlds." But the Berlin Wall falling! The world was changing fast, very fast indeed.

This story actually begins a few years earlier in Moscow then Siberia. We became eyewitnesses at the beginning of an equally unexpected development: glasnost (open-ness) and perestroika (restructuring) when Mikhail Gorbachev took power and the edifice of Soviet communism began to crack open.

We went to find like-minded maverick, innovative, out-of-the-box Russian scientists to see if we could work together and make some history of our own.

Draft

Holding hands across the Iron Curtain

I first went to the Soviet Union in November 1985 in my position as Director for Space and Environmental Applications for Space Biospheres Ventures, the company behind the creation of Biosphere 2. We had already met with NASA, European and Japanese space agency people working on space life support. We needed to explore if we could collaborate with the somewhat mysterious and reportedly secretive Soviets. Scheduled to work on a project affiliated with the Institute of Ecotechnics in Australia, I decided that a stopover in Moscow could be quite fruitful. Ever since we launched Biosphere 2, destined to be the largest materially closed ecological system, people told us the Soviets led the fields of space life support and closed ecological systems. Very fortunately, I got a few names and telephone numbers from colleagues at NASA and from Rusty Schweickart, the Apollo astronaut, who spoke at our first project workshop and later served on our Biosphere 2 Project Review committee.

This proved extraordinarily important because when I arrived in Moscow, I discovered the first of many revelations about the strange Soviet system. Moscow telephone books did not exist. The Soviet state treated phone numbers as potentially dangerous information; revolutionaries could use them to get together and plot against the government. This was still years before cell phones and the Internet.

Those precious phone numbers included one for the Institute of Biomedical Problems (IBMP), one of the largest Soviet research institutes involved with space exploration.

I was staying at the historic Metropole Hotel about a block from Red Square and IBMP let me know they would meet at my hotel at 10 am the next morning. I later realized with such short notice they could not get the requisite number of Communist Party officials to sign off on me coming to the institute.

So in strode Oleg Gazenko, the Academician who headed IBMP, Dr. Anatoly Grigoriev, his associate director and eventual successor, and a most charming translator, Dr. Leonid Zhurniya.

We sat down in the Metropole's dining room, and they promptly ordered vodka and caviar. Not accustomed to the protocols of speaking through a translator, I quickly learned that everything has greater import: you say something, the translator translates, there’s a reply, that gets translated and finally, it’s back to you. Not a great way to do small talk. It made everything more significant as you have more time to reflect on what they’ve said and to consider your next utterance.

I started describing the Institute of Ecotechnics which I chaired and our Biosphere 2 project. Though at an early design and workshop phase, we had a fairly good idea of the scale of the endeavor. Oleg very quickly took my hand and I thought, nice, a gesture of affection. Then he

Draft

held onto it quite softly but firmly and we remained that way for the rest of an hour and a half meeting.

I later learned that Gazenko served as the official medical doctor and unofficial psychiatrist and therapist for more than one generation of Soviet cosmonauts as well as the animals sent to space. Also involved in the selection process, he oversaw the training preparation and evaluation of long duration spaceflight cosmonauts. So, perhaps he also checked out my subtle bodily reactions. When I described to him our ecological restoration project in the Outback of northwest West Australia where my colleagues and I chopped out invasive weeds using hand tools and drove tractors, he appreciatively felt the calluses on my hand and nodded that yes, indeed, I had the hands of a worker.

Academician Oleg G. Gazenko, a leader in the sciences of space biology and medicine. He served as Director of the Institute of Biomedical Problems, Russian Academy of Sciences, from 1969 till his retirement in 1988 and continued his work to the end of his life.

With no clue how these scientists regarded Marxism or the Soviet system, but from my own readings of socialism and what I learned from my working-class immigrant parents, I thought of a good card to play. So, I emphasized that we not only did ecological research but that we believed in doing as much of the work as possible ourselves. The Soviets recently recognized the advent of a new class, those working in scientific and technical fields, now supplanting the traditional blue-collar proletariat (worker).

I could play another card. A couple of years earlier, a friend in London gave us a translation of excerpts from Vladimir Vernadsky's seminal work, "The Biosphere." He published that first in French when he was teaching at the Sorbonne in the 1920s and in Russian when he returned near the end of that decade. Vernadsky was then a virtually unknown figure in western science, perhaps still is, but he has equal importance as a thinker and scientist for the Soviets and Eastern Europeans as Darwin/Wallace. Vernadsky founded the science of biogeochemistry and the modern understanding of the biosphere, greatly enhancing the earlier concurrent discovery of evolution by natural selection by Charles Darwin and Alfred Russel Wallace. Synergetic Press, an independent publisher affiliated with the Institute of Ecotechnics, was planning to publish those excerpts from Vernadsky's Biosphere book, making his thoughts available for the first time in English.

Vladimir I. Vernadsky, young and old. Founder of the Ukrainian Academy of Sciences and President of the Russian Academy of Sciences, he led the way in recognizing and studying the extraordinary power of biospheric life which has transformed Earth's surface. Left photo: Copyright: Sputnik/Science photo library.

Draft

I asked if we could elicit an introduction from either these gentlemen or one of their colleagues. Gazenko replied he knew an eminent scientist who could do just that. Then he playfully added: "my price is simple. The next time you come to Moscow, bring me a bottle of the finest Scotch whisky." I agreed and could see they were incredibly pleased and impressed that we knew about Vernadsky's work.

Oleg and his colleagues could also appreciate that space life support currently confined its research to simple closed systems since virtually the time of Yuri Gagarin's first spaceflight in the late 1950s. These "bioregenerative" life support systems use living plants to regenerate water and air, while producing food for the crew; thus cutting down on consumables or resupply from Earth. But these systems strictly concentrate on providing life support for humans. Biosphere 2, with its inclusion of wilderness biomes and an ocean in addition to food production, expanded the field of closed ecological systems to a larger biospheric level, you might say a Vernadskian level.

The meeting was going very well, indeed. Leonid, with a PhD in biology, was in top form, matching my exuberance and emotions when he translated. Probably quite a contrast from the more detailed, boring scientific discussions he usually did translations for.

I mentioned that we heard about Bios-3, the world's most advanced space life support work in Siberia. I did not mention that some of the top managers of NASA's space life support work told me that the top secret work would prevent us from ever seeing it. Or even that, in fact, Bios-3 did not exist except as Soviet propaganda.

Another of my phone numbers and calls went to Prof. Vladimir Sokolov, the head of the UN Biosphere Reserve Program for the USSR. When I opened the door and stepped into his office at Moscow State University, I got a shock. All around, enormous stuffed animal heads adorned the walls, especially those with large sets of horns. Later, I learned that most of the areas now designated as Biosphere Reserves evolved from the private hunting grounds of the Tsars, Russian nobles and wealthy landowners dating from the serf era. The natural alliance between hunters and environmental conservationists makes sense, leaving land untouched fits both agendas.

I also visited with Academician Nikita Moiseyev. He gained fame by doing pioneering global ecological modeling which showed the devastating after-effects of a widespread nuclear war. "Nuclear winter," caused by so much dust blocking the sun, threatened the kind of mass species extinctions that followed the Yucatan asteroid impact when the dinosaurs disappeared from our world. He was also gaining prominence as an outspoken environmentalist. At the time, the Soviet party line posture held that pollution and environmental degradation were problems of the West. In the worker's paradise, the Soviet Union, natural resources belonged to all the people. So, by definition, no problems! Why would the people damage their own environment and resources… Moiseyev proved to be a very funny man, and we laughed about the insanities of his and my country and the world.

Draft

Personally, to be in Moscow was very moving. My parents had been true believers in Marxist socialism's promise of better treatment of workers. The reality looked much grimmer in Moscow, and people told me that things were much worse outside the big cities. Even so, the paucity of consumer goods startled. Tellingly, while admiring Red Square one night, Russians came up to me offering special higher rates if I would exchange U.S. dollars for their Russian rubles. You could only exchange money at official Soviet banks which implausibly rated the ruble higher in value than dollars. A young man even tried to buy the Levi blue jeans I wore, since they were unavailable in the Soviet Union.

Strangers came up to me, asking directions, since they thought I looked Russian as I walked the streets of Moscow, adorned with a rabbit-fur hat I bought. My Jewish father was born in what is now Belarus, but then part of the Russian Empire, and my Jewish mother in Poland. But really, aside from the fur hats and long overcoats, Americans did not look so different from Russians. That surprised me, since I grew up surrounded with American Cold War prejudices that the Soviets were evil people and so must look different.

I learned why there were long lines around certain stores. Gorbachev, newly in power in 1985 as General Secretary of the Communist Party, the de facto leader, had begun to experiment with what came to be called Glasnost (opening) and Perestroika (restructuring). Like other Russians from the elite classes allowed to travel to the West, he knew the reality of what life was actually like in the West and how poor by comparison the Soviet Union was. Space exploration rated as very prestigious for the country, with abundant funding. Elsewhere, Soviet technology and innovation lagged the rest of the world, along with far worse standards of living except for the elites.

In the Metropole Hotel and on future visits to the USSR, I watched Soviet TV news with their completely dismal coverage of the United States. That reality, of poverty, minority inner-city ghettos, homeless people was true, but they were the only images and perspective Soviet citizens saw of the west. Gorbachev knew well that alcoholism held the Russian economy back. So, he restricted vodka sales as well as the sales of sugar which Russians bought to home-brew spirits. So long lines surrounded grocery stores that still had sugar.

I read "One Hundred Years of Solitude" by Gabriel Garcia Marquez while I was in Moscow – and its magic realism and improbable, not to say inexplicable, events perfectly matched my experiences in the Soviet Union. On my next trip, I went down to the Mir bookstore where a select few English books could be bought at dirt cheap prices. I chose "the Mind Parasites" by Colin Wilson, which proved another very apt read while in the Soviet Union. The book describes someone who is convinced alien beings have invaded his mind. Did dissidents who worked at the Soviet publisher choose this book as a political statement?

I tried to get tickets to theater, but they were impossible for foreigners to obtain. The land of Stanislavsky, Chekhov et al remained very passionate about theater. They did not care as much

Draft

about some extra foreign currency. I did get to the Bolshoi theater for ballet and a memorable night at the Moscow Circus, under a vast well-heated dome/tent. So wonderful to see every day Russian families having great fun. The pungent smell that emanated from the hippopotamuses remain a vivid memory. The hippos did not do tricks, just their presence added to the diversity and excitement of the circus.

My excursions to Moscow restaurants turned into another type of cultural exploration. In the few fancy restaurants which catered to foreigners, at the time exceedingly rare on the streets, I sat down and read a very impressive menu. But it turned out that almost nothing was available. I pointed at a menu entry and got the bored reply, "nyet" – no. Borscht, unlike my Jewish parents who did it as a beet soup, you could always get these cabbage-y soups along with cutletya (cutlets), sauteed meat. These restaurants strangely corroborated that at least here workers outranked moneyed customers, true to the Marx/Engels ideology. You walked in past benches filled with waiters and waitresses. After sitting down, one of them eventually and most grudgingly turned up at your table.

On my flights from Moscow to Singapore, I got more insights into Soviet realities. I booked on an Aeroflot flight to Singapore en route to Perth. On board the world's largest airline, the plane featured Kafka-esque features like the non-smoking sections adjoining the smoking ones. The airplane's air circulation paid no heed.

Flight attendants came to deliver the after-dinner dessert: apples. To my amazement, they stood in front and threw the apples to customers.

We landed at New Delhi for refueling. But something was wrong. As we sat on the airplane, we could see repair teams working under the plane's wings. While we could hear the sound of drills and other equipment, finally, we heard from the plane's intercom: "we're delayed due to problems with airport flight control." Was this how brazenly Soviet propaganda worked? They expected us to buy that explanation, while seeing and hearing people working on the airplane we were sitting in? Finally, after providing no refreshments onboard, they bused us to the terminal where we waited another few hours without food or drink.

Finally arriving in Singapore, I was relieved that Singapore Airlines took over, busing us to hotels until our Qantas flights in the morning. When I got to Perth, I sent Gazenko and his colleagues, boomerangs. I was still figuring out what it meant to live in a small closed ecological life support system. Surely, everything that goes around, comes around. Just like a well-thrown boomerang.

Our Institute of Ecotechnics (I.E.) earlier made some contacts with the Soviets. Randall Gibson, then its Chairman, met two of their scientists. Over vodka in New York, they told him about the Institute for USA and Canada Studies, a Moscow think tank that analyzes events and advises on policies towards the countries. A very political institute, with its head, Georgii Arbatov, a major advisor to a succession of heads of the Soviet Union's Communist Party.

Draft

They suggested one of that institute's leading thinkers, Dr. Gregori Khozin, as a good addition to the Planet Earth conference the Institute of Ecotechnics planned to convene in 1980. Khozin had authored a book "The Biosphere and Politics" and his talk focused on how science and technology can solve modern problems which transcend solely national interests. At the end of the conference, Dr. Khozin offered a gift to the Institute, a Matryoshka doll, with a succession of smaller dolls nested inside. He wished I.E., well and pointedly said it would thrive "if it always remembered to keep its feet firmly on the ground."

G. Evelyn Hutchinson, a seminal figure in Western ecology, wrote the introduction to the influential 1970 Scientific American issue on the biosphere. He learned of Vernadsky's work on the biosphere and biogeochemistry and privately translated some writings for use by his students as they were largely unavailable. Hutchinson's acknowledgment of Vernadsky's ground-breaking role in the modern understanding of the biosphere marked the West's first introduction to his work.

Synergetic Press, headed by Deborah Snyder, a director of I.E., decided to publish the English translation of excerpts of Vernadsky's book, "The Biosphere" which we obtained. I carried that draft manuscript to Russia in 1985.

Khozin introduced us to some of the key ecological works published in the USSR by people in the Vernadskian tradition. These included Andrei Lapo's "Traces of Bygone Biospheres" and M.M. Kamshilov's "The Evolution of the Biosphere," That book emphasized the role of biomes as building blocks of the biosphere, an important inspiration for the inclusion of seven biomes in Biosphere 2.

Schematic of the Biosphere 2 facility showing the location of the wilderness and anthropogenic biomes (human habitat and intensive agriculture)

From the Vernadsky lineage, we adopted the terminology of the human-created "technosphere" which co-exists with the biosphere. The challenge is to harmonize the technosphere with the biosphere. This thinking parallels the insights which led John Allen to coin "ecotechnics" as a new discipline when we founded our Institute in the early 1970s. This extended the work of the technology historian, Lewis Mumford, who called for a "biotechnics," technology sensitive to life, to supplant the rise of inhuman megatechnics.

John Allen developed the original biosphere/technosphere relationship, expanding the concept to include the technosphere within the larger ethnosphere, the sphere of human activities. This was a major conceptual tool for the design of Biosphere 2.

I still spent a lot of my year in the Kimberley of West Australia at I.E.'s tropical savannah project, Birdwood Downs. Since London functioned as our "eco-hub" and I loved both the city and our October Gallery project there, I most often flew from London to Australia. So, I chose my fine

Draft

bottle of Scotch whisky well and returned to Moscow to deliver it and to deepen our Russian connections.

This time with sufficient advance notice, I received permission to visit Gazenko and his colleagues at the Institute of Biomedical Problems. Housed in an ordinary looking building complex on a fairly non-descript street in Moscow, it seemed incongruous that here was a key part of their space program. Gazenko, accompanied by Leonid, his personal translator, merrily toured me around the building. I met Dr. Ganna Meleshko, the head of their bioregenerative life support section and her assistant director, Dr. Vladimir Sychev.

Ganna Meleshko, Vladimir Sychev and Margarita Levinskih in the Laboratory of Closed Ecological Systems, IBMP. In the foreground on the table, an aquarium similar to that later used in the Biosatellite experiment collaboratively done by Biosphere 2, the University of Arizona Veterinary School and IBMP in 1989.

Then grinning broadly, Gazenko said to prepare myself for a real delight as we walked outside to a small building in the compound. When we walked through the door, it felt like Johnson Space Center's mission control in Houston. Multiple screens displayed maps of the Earth, and coordinates and communications from various satellites and biosatellites (called "Bio-Sputniks"), which tested organisms' responses to micro-gravity and the space environment.

Of particular interest, was the video feed from a biosatellite being prepared for launch. In it, a chimpanzee sat in a special apparatus. As we watched, the chimp started working the restraints that kept him seated. He was making headway, and Gazenko laughed. He turned to me and said: "that is typical. Monkeys will be monkeys even in space."

Gazenko and colleague with two monkeys in spacecraft apparatus.

A few years later I learned that Gazenko selected the first dog launched into space, a Moscow street dog named Laika. It flew in November 1957 on Sputnik 2. When I asked Oleg about it, he expressed real sadness. He said they lacked the time to develop life support for extended space stays or recovery systems. The result: a one-way ticket for Laika.

Left: Mockup of Sputnik 2, Credits: RCS Energia. Right: Laika, space.com

Gazenko was a Lieutenant-General in the Soviet Air Force's medical division, a pilot, skilled mountain climber and expert in the physiological impacts of high altitudes. He also helped select and train the early cosmonauts. Oleg was in charge of biomedical studies of bodily fluids during human spaceflights and so worked closely with Soviet cosmonauts for several decades, from the early flights to crews on the Salyut and then Mir orbiting space stations. When Yuri Gagarin landed after becoming the first human to orbit the Earth in 1961, Gazenko was there. The Soviets by then launched 38 dogs into space – with 20 of them surviving re-entry. So, the soon to be

Draft

world famous first man in space (there is a huge statue of Gagarin in Moscow) joked after his return: “I am still unaware who I am—the first man or the last dog.”

Gagarin reported: “Orbiting Earth in the spaceship, I saw how beautiful our planet is. People, let us preserve and increase this beauty, not destroy it!” The impact on both astronauts and cosmonauts from seeing Earth from space, this blue-white marble against the black background of outer space, profoundly moved them. The new perspective called “The Overview Effect.”

Later in the 1960s when the first images of Earth from spacecraft orbiting the Earth and moon came back, there was a similar awakening for people around the world. These are amongst the most important early results of space exploration, giving humanity a new holistic perspective on Earth and its biosphere. Much of our knowledge of Earth now comes from increasingly sophisticated space sensing and monitoring instruments as well as the telecommunications revolution it made possible.

Earthrise, taken on December 24, 1968, by Apollo 8 astronaut William Anders while orbiting the Moon.

Unlike NASA which chose to land its astronauts in the ocean, the Soviets brought the cosmonauts down by balloon onto land. I wondered why I saw on Russian TV footage of people in space suits using fancy gear to light flares and make fires. This space-related research responded to at least one occasion when a crew landed far off-target, by a thousand kilometers or so! They spent a wintry night on a mountainside where they fended off circling wolves before a rescue team could find them.

The lost space capsule, at the Moscow Space Museum exhibit, much of which the traveling exhibition “Cosmonauts: Birth of the Space Age” used. This photograph by the author taken in 2014 while attending the Moscow COSPAR space conference.

Gazenko invited me to a dinner at his apartment. For the head of a major space institute, it seemed quite modest though comfortable. As he added my Scotch to his drinks cabinet, he proudly said he had one of the finest collections in Moscow. Prof. Yevgeny Shepelev, one of Gazenko’s closest friends and collaborators, wrote the introduction to the Synergetic Press abridged translation of Vernadsky’s The Biosphere. Shepelev made history as the first human to live for 24 hours in a closed system (called Bios-1) with just chlorella algae in 1960. We soon got to meet him and hear of his other feats of physiological endurance.

Dr. Yevgeny A. Shepelev

Shepelev wrote in the Synergetic Press publication:

Draft

"the theory of the biosphere, like Darwin's theory of evolution, Einstein's relativity principle, Bohr's theory of atomic structure, belongs to world science…. [and] it has gained practical application in advanced aerospace research. The theory [of the biosphere] has given impetus to investigations of experimental ecosystems that can act as prototypes of life support systems in extraterrestrial environments."

"Concluding the introduction of a book about the Earth's biosphere to an English-speaking reader, it is appropriate to quote the words used by the great Englishman Charles Darwin to finish his book about the origin of (new) species: *There is grandeur in this view of life.* In fact, there is grandeur in Vernadsky's concept as well, according to which the outer spheres of our planet that are penetrated by life and cosmic radiation merge into a single mechanism that acts in concert on a planetary and cosmic basis, i.e., the biosphere that stores the past of the Earth, hides its future, and warns about the hazards which man as a new force can produce."

The receptivity I received in Moscow excited John Allen, the inventor of Biosphere 2 and its Executive Chairman, also a co-founder and fellow Director of I.E. He suggested that for the next encounter, we'd send a large group, including six directors of Biosphere 2, and stay long enough to forge collaborations. I looked for ways to accomplish and lessen the costs of our trip. For simplicity's sake, a simple tourist visa worked. Discovering that seven people would qualify us for group discounts with Intourist, which handled all foreigner travel and tours in the Soviet Union, proved the key. That would qualify us for very reduced rates for meals and hotel rooms. The deal included an official tour guide and van which took us around to see the sights and learn the history of Moscow. Fine: tourists in the morning, then make our own arrangements to meet with space and science institutes and artists/cultural events for the rest of each day.

These were momentous times in Moscow. Gorbachev's Glasnost brought news of happenings once unthinkable under previous Soviet censorship and control. We followed these events in the English language Moscow Times and from people we were meeting with. Our group included John, Ed Bass, Marie Harding, Kathelin Gray, Deborah Snyder, Robert Hahn, and me.

We stayed at the Hotel Rossiya, the largest hotel in the world at the time with over three thousand rooms, a police station + prison, night club and concert hall, just a few minutes' walk to Red Square and the Kremlin. I am amazed to read that it rated as a 5-star hotel; only its vastness impressed. Once, one of our group missed an outing when he got stuck in a hotel elevator in-between floors. I also observed when scientists came to visit us, they invited us for a walk, leery of hidden microphones if we spoke in the rooms of the hotel.

They related a classic Soviet urban myth: A visiting European soccer team manager worried that spy microphones could transmit his strategy talks with his coaches and players. So, he minutely explored his hotel room, finally finding a screw under a carpet. He unscrewed it, thinking he'd found the hidden device, only to learn that a chandelier crashed to the ground one floor below.

Hotel Rossiya, a block from Red Square, along the banks of the Moskva River, photograph: Mikhail Metzel/AP

Draft

At our first meeting with Oleg Gazenko at IBMP in November 1986, we were thrilled when we finally got to meet his renowned colleague and long-time friend, Yevgeny Shepelev. They were joined by other IBMP scientists, and we sat around a large conference meeting table. Oleg put a small paper Soviet flag into the flag-holder and asked which flag he should use for us. After we explained that we were not a state organization, but a non-profit research organization (I.E.) and a joint venture company (Space Biospheres Ventures), Gazenko laughed and said he did not have a pirate flag but put up a United Kingdom flag since I.E. was admitted as a research organization and was registered there, and a US flag for Biosphere 2. He said mischievously, "I admire the freedom and bravery of pirates. If we begin working with you, can we know how long your organizations will last?" Ironically, the Soviet Union itself dissolved just five years later.

Around the IBMP conference table, November 1986. From left author, John Allen, Yevgeny Shepelev, Oleg Gazenko.

We all went out to a fine Moscow restaurant for lunch; I delightedly ordered blini, though they turned out to be a different dish than the Jewish blintzes of my childhood. Like the cabbage-y borscht and my knowledge of Marxism/Leninism, these Russian foods and Soviet realities were quite different from what I expected.

We lunched with Vladimir Volikov who wrote "Operation Risk" on the extreme environmental studies IBMP conducted. These included some in the Arctic with extreme cold as well as high-altitude studies. Some of their research seemed quite incredible: people living on drifting ice floes or slowly dehydrating in tents in the Karakorum Desert. In the latter, IBMP gave the volunteers an insufficient daily intake of water then monitored them until they quit, or medical risk terminated the experiment. Shepelev was the last one left. They forced him to stop despite his eagerness to continue since his dehydration approached limits where humans die. Gazenko had also been both a researcher and subject in these experiments. I had a new-found respect: these people were bad-ass, not armchair academics. Our kind of people.

The following day, we filed into a small auditorium at IBMP. Gazenko left, then came in with his arm around a gentleman's shoulders. Leonid gleefully translated: "This is your surprise. Please let me introduce you to Dr. Josef Ivanovitch Gitelson of the Institute of Biophysics, Krasnoyarsk, Siberia. Your informants at NASA were incorrect; he exists, and he runs the Bios-3 facility there."

Josef brought a large 35 mm film canister under his arm, a half hour Soviet TV documentary about the Bios 3 project. We waited till the following day to see it, as the projectionist, nursing a hangover, did not show up for the work that day. He incurred some muted wrath when he eventually returned. So we continued our lively discussions.

Watching the documentary we could see how far advanced their work was compared to what we knew was not happening at NASA or in Europe. Crews of two and three people lived for six months in their facility, cleaning virtually all their air (though some problems with buildup of trace gases occurred), regenerating their water and producing more than 50% of their food with a variety of food crops, from potatoes to wheat and a range of vegetables. All of their work was

Draft

miles ahead of the field and extremely exciting to see. What we did not know then was that Krasnoyarsk was a closed city because of its anti-ballistic missile installations. No Westerners could visit, and even Soviets needed special permits.

The meetings with Gitelson, Gazenko and the IBMP scientists were exhilarating. Finally, we were with people who shared our enthusiasm for advancing space life support and for the potential of closed ecological systems as a potent tool for understanding ecosystems and the biosphere. What a difference from NASA and other space agencies which almost totally ignored and underfunded life support, despite the plans for long-term space stations, moon bases and even human exploration of Mars.

Early attempts to build bioregenerative life support systems that could support humans aimed at total simplicity. So they used just one type of algae. Both NASA and the Soviets chose chlorella, a single-celled green algae which did an excellent job of regenerating air and water. Unfortunately, though excellent protein, eating more than 30 grams (around one ounce) per day brought on nausea.

NASA rejected the appeals of ecologists to take a more diverse approach and closed down its space bioregenerative life support research for over a decade before beginning its CELSS program in 1979. The CELSS acronym is interesting. Originally it stood for Closed Ecological Life Support Systems, significantly they now changed the name to Controlled Environmental Life Support Systems. Goodbye closed and ecological.

NASA has always had a strong engineering/techno bias. I read with some amazement in their papers on life support that their default attitude amounted to: we trust machines and technology, life is unpredictable and harder to control, so let us see how we can develop systems that use as few types of organisms as possible. Imagine their heartbreak when an algae monoculture failed to be sufficient to regenerate air/water and feed humans. The Russians, led by work at IBMP and especially at Krasnoyarsk, accepted the need to incorporate typical crop plants which feed us on Earth. Bios-3, with its range of vegetables, grains like wheat and starchy tubers like potatoes, evolved from Bios-1 (which Shepelev lived in) and Bios-2 in Krasnoyarsk more heavily reliant on algal bioreactors.

Another telling moment of that series of meetings occurred after we continued our discussions after normal working hours. Oleg diplomatically pointed out that he and his colleagues were most happy to continue our conversation; the problem concerned the driver of the Institute's car who did not want to stay at work. The Soviet Union was "a dictatorship of the proletariat," Oleg explained with a straight face (there were the usual "international relations" observer on hand in the shadows to make sure no one said anti-Soviet, revisionist or heretical comments), so the choice was either to take the chauffeured car ride back to our hotel right then or use the Metro. We scarcely hesitated, choosing to continue the stimulating discussions and to later navigate the splendid Moscow Metro.

The Metro which we frequently used during our stay proved one of the highlights and most beautiful aspects of the city, unlike the dirty New York City subways with obnoxious graffiti I grew

up with. The Metro planners decided that art belongs to the people and made each station quite distinctively unique. I know we gained a few points in Oleg's estimation of how real we were by that decision to use public transport, though extremely easy to make.

As we continued our discussions of how we could work together, Oleg suggested a joint international conference in an important and neutral country, owing to Cold War tensions, could be a good starting point. That marks the genesis of the idea to convene an international workshop on closed ecological systems. Gazenko suggested either Vienna or London as good locations. I knew, given our base at the October Gallery, that the latter would be a logical choice.

With introductions from Gazenko, other doors in Moscow opened. We met with Valeri I. Barsukov, the energetic director of the Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences. His passions included space geochemistry and the emerging field of comparative planetology for gaining insight into Earth and our solar system. We had already met some of the US leaders in this field, especially the group at the USGS Astro-Geology center in Flagstaff, Arizona which included Eugene (Gene) Shoemaker (after whom the half of the Shoemaker-Levy Comet is named, along with his wife and scientific colleague, Carolyn Shoemaker), Jack McCauley, Carole Breed and Maurice Grolier as well as Farouk el-Baz at Boston University. Gene spoke at our 1981 I.E. conference. So highly regarded for his contributions to astrogeology, Gene's ashes were launched to the moon in 1998 aboard the Lunar Prospector.

Jack McCauley gave talks at the 1977 I.E. Desert conference and at our 1981 Solar System conference. He showed images of deserts on Earth and Mars and we guessed which planet they were on. Wind erosion shaped these deserts on both worlds and as a result many identical features. That demystified the Red Planet and indeed planets, at least rocky planets, in general: the same forces shape them. Could they harbor life now, or support it in the future?

Jack also described the excitement of sitting in an auditorium at Jet Propulsion Lab in Pasadena, California as the first images of a planet or one of its moons appeared, line of pixels by line of pixels from the spacecraft.

He called the times we were living in the Greatest Age of Exploration. We brought that spirit to our project to design, build, and operate the world's first human-made biospheric system.

Barsukov lit up with excitement when we told him our plans for Biosphere 2. We built a research and development center and in a few months would begin the construction of the facility. Barsukov jovially said he would demonstrate that Russians and Americans could work well together. With a laugh, he told us it was 4 am in Rhode Island then picked up a phone and called Prof. James Head at Brown University to tell him about our project. Though we could hear that Jim was groggy having just wakened, he was ebullient and friendly. Another leading planetologist, he and Barsukov started twice a year workshops at Brown and in Moscow in 1973, surmounting Cold War tensions. They shared data from each country's planetary missions and exchanged scientists and students. This marked the beginning of our deep friendship with Jim, a fearless volcanologist as well as planetary scientist. I later attended one of the joint meetings at Brown

Draft

and gave a paper on the life and legacy of Vernadsky, well-known to the Russians but unknown to the Americans.

V.I. Barsukov, director of Vernadsky Institute of Geochemistry and Analytic Chemistry from 1976-1992.

We read in a tourist brochure about a Vernadsky Museum in Moscow. But though we spent mornings with our well-informed Intourist guide, she didn't know even if it existed. When we mentioned this to Barsukov, he leapt up. "I know exactly where it is. Follow me!" He led us down a nearby hallway and when he opened a door we were astonished to find Vernadsky's study preserved exactly as it was when he died in 1945. Even more poignant, an elderly woman who took care of the room, proudly told us that she was one of Vernadsky's last students.

V.I. Vernadsky in his working room, Petrograd, 1921. Used by permission from the from the Memorial Office-Museum of Academician V.I. Vernadsky, Moscow.

Vernadsky could speak 15 languages fluently, and the current 1945 issue of the journal Nature, published in the UK, sat on his study table, open to the page he had been reading. Piles of books lay nearby. Barsukov told us that when they demolished Vernadsky's house, the study was meticulously moved and recreated, fittingly in the Institute which he started, served as first director and which now bears his name. Vernadsky also founded a dozen other scientific institutes. We had been seeing lots of Russian Orthodox icons, sacred images, in the beautiful churches of Moscow. This felt like a scientific shrine.

On the cultural front, Moscow was ablaze with notable reversals. "Repentance," a dark almost hallucinogenic film from the Georgian director, Tengiz Abuladze, had been censored and almost destroyed when made a few years earlier. Now Gorbachev made the decision to release it. It dramatizes the Gulag prisons, purges, and executions of the Stalinist years in Georgia.

Kathelin Gray, the artistic director of our Theater of All Possibilities and a director of I.E., took the film she and Shirley Clarke made about the avant-garde jazz musician, Ornette Coleman, the previous June to the Moscow Film Festival. "Ornette: Made in America" won an award and Kathelin, the film's producer, served as head of the U.S. delegation to the film festival. She made important contacts with Soviet and Eastern European film and theater people which opened cultural doors now. So Kathelin received a precious ticket to the first screening of "Repentance" at the Cinematographer's Union.

She recounted that the audience fell silent during the screening and appeared nervous when it ended. Stalin had been infamous for his Kremlin screening of films at 3 am, when invited guests, high-ranking Soviet officials, were terrified to applaud lest they be revealed as a revisionist or reactionary and sent to Siberia. When the audience saw distinguished figures, including the Union's new director, Elem Klimov, applauding, the masterpiece received a standing ovation.

Draft

Klimov restarted the careers of a number of filmmakers, including Tarkovsky, sidelined because of their critical portrayals of Soviet life, and resurrected long-suppressed movies.

Gorbachev took Abuladze with him on his first official visit to New York in 1988. Ironically, the government banned “Repentance” a year later.

Poster for Repentance, which won a prize at the Cannes Film Festival in 1987 (Wikipedia).

John and Kathelin met with Oleg Yefremov, the head of the Moscow Art Theater Company which Konstantin Stanislavsky and Vladimir Nemirovich-Danchenko founded in 1898. Stanislavsky’s work has been enormously important in the history of theater and a major inspiration for our affiliated traveling theater company, Theater of All Possibilities, which John, Kathelin and Marie Harding founded in San Francisco in 1967.

In John Allen’s memoir, Me and the Biospheres, he recounts what happened at the meeting: “Who, in your opinion, is the real successor to Stanislavsky?” I asked the director, Oleg. “It’s Michael Chekhov,” he replied. He pulled down two Chekhov books in English. “See, they printed his words, but we can’t print them in this country!” Earlier, Kathelin connected with the Michael Chekov Theater School in New York. Michael Chekhov emigrated after encountering hostility when Stalin came to power and censored and murdered writers, actors and artists. Stalin believed the function of art was to paint a positive image of life in the Soviet Union to its people. Chekhov thus avoided the fate of another great theater director, Vsevolod Meyerhold, tortured and executed for his “bourgeois Formalism” and for not following the dictates of state-approved Socialist Realism.

The poet Andrei Voznesensky emerged as one of the bright stars of the previous semi-opening starting in the mid-1950s when Khrushchev denounced the “cult of personality” after Stalin’s death. But the authorities forbade Voznesensky to recite poetry in public for many years. Through Kathelin’s connections, we received a few tickets to his poetry reading at a hall near Pushkin Square. Kathelin and I went along with Leonid as our translator. Tremendous excitement and buzz surrounded the auditorium as we approached. Many hundreds of people crowded the area, hoping for cancellations, or standing room only tickets.

Inside, every seat was full. The atmosphere in the hall was charged, very emotional. The audience knew how historic the evening would be; they hoped the beginning of a new era in their lives. The crowd remained completely quiet while Voznesensky read his poems, hanging on every word. At periodic intervals, ushers collected questions from the audience for the poet to answer. Leonid busily translated the questions which ranged from political ones to Andrei’s opinion of Russian pop bands.

What a revelation. Just as top Soviet scientists were truly culturally sophisticated, well-educated people, men of vision and not just talented technicians, Russians revered poets for their moral compass. They were listened to as prophets, wise people who could see what was vital and

Draft

worthy of enduring vs. what was popular but of no lasting value. A Soviet TV channel was dedicated to poets and poetry. Andrei stressed in a few answers that reform-minded people had not sufficiently backed Khrushchev's opening in the 1950s because they did not go far enough; so, it was vital that people strongly support Gorbachev and his allies so they could go further in opening Soviet society and reforming institutions.

A few years earlier, while in exile in the U.S., the dissident Russian writer Alexandr Solzhenitsyn, decried the moral poverty of the West. He asked what's the use of being free to write and create poetry if no one listens to you, if you endlessly pursue material prosperity like most Americans. In Moscow shops were threadbare (and one is told it is far worse outside of the big cities like here and Leningrad), few people owned cars and most lived in brutal Stalinist architecture high-rise buildings that reminded me on the low-income "projects" of the US, nevertheless I could see a glimpse into the depths of the Russian soul in this reaction to a poetry reading.

Another of their great poets, Yevgeny Yevtushenko, invited our group to his dacha in Peredelkino, where both government officials and men of culture went to enjoy their rural get-away cabins not too far from Moscow. Born into a Ukrainian family exiled to Siberia, he suffered cycles of periodic censorship and restoration for his outspoken writing. His famous poem "Babi Yar," which obliquely condemned Stalinist era antisemitism, commemorated a ravine near Kyiv where the Nazis killed a hundred thousand Jews. It had no memorial until 1991.

Yevtushenko lived sparsely in the small wooden cabin. One luxury was a wood-fired sauna. He performed at the Caravan of Dreams Performing Arts Center in downtown Ft. Worth, Texas, which our group had built. It originally housed a jazz night club, restaurant, theater and rooftop bar with a cactus/succulent geodesic dome. Kathelin, the artistic director of Caravan of Dreams, picked Yevgeny up at the airport. The first thing he wanted: to go shopping for real ostrich leather cowboy boots.

All these creative people we met in Moscow, whether scientists or artists, had mastered figuring out how to manifest despite the Soviet system of control. Yevtushenko carried on his writing, occasionally given great license and periodically censored. When he heard how we had come under the radar, using simple tourist visas, and a part day Intourist guide for camouflage, he admired our ingenuity. "Why did no one else think of this? To come here to Moscow, sit down for a few days, and make appointments as though you lived here."

After our discussions at the dacha, Yevtushenko walked us to the Peredelkino cemetery and with great reverence led us to the grave of Boris Pasternak, the Russian writer who the government blocked from accepting his Nobel Prize in literature. Thousands came to his funeral in 1960 against the government's wishes. Yevtushenko told us that Russians revered Pasternak for his poetic translations of Shakespeare as much as for his books like Dr. Zhivago. He also led us to lines of graves with little ornamentation, those for Russian soldiers killed in Afghanistan. Yevtushenko called that war "the Russian Vietnam" and predicted its cost and the revulsion from the killing of so many young men would hasten the demise of the Soviet system.

We went into the beautiful Russian Orthodox church nearby, with its ornate and moving ornamentation, not least the Pantocrator (the risen Christ as ruler of the universe on his throne) which takes precedence over the crucifixion, the centerpieces of Catholic and Protestant churches. Touchingly, the few people worshipping inside were all elderly women. Yevtushenko stopped us in the vestibule, telling us the local people only allow people from Moscow this far inside.

Boris Pasternak's grave at Peredelkino. Example of Pantocrator from St. Petersburg Russian Orthodox church.

We met up with Elem Klimov, whom Kathelin had met at the Moscow Film Festival, and the director Rolan Bykov and watched the latter's film "Scarecrow" (though a more apt translation might have been "Weirdo") at the Cinematographer Club. A haunting tale of bullying of an outsider and standing up to social pressure, featuring a cast of 12-year-old actors, it became controversial, briefly shelved but later released. Bykov received the Order of Lenin in recognition of his courageous filmmaking during that tumultuous 1986 year in the Soviet Union.

He recommended we also see another much delayed but finally made and released film playing in the little theater nestled below the Rossiya Hotel and the Moscow river. "Dead Man's Letters," one of the darkest films I have ever seen. Set in a post nuclear war town, Bykov plays the lead, an old physicist, now surviving with his wife and a few colleagues in the basement of a museum. After everyone dies, his final letter urges remaining children in an orphanage to leave. The final scene shows the children, wearing gas masks, venturing into an apocalyptic desert. No one knows if the war is over or if there are other humans left.

Our Intourist adventures took us all over Moscow. What I remember most is what happened on the final day. John Allen, with his encyclopedic knowledge of history, continually added to what our guide knew. Many of the stories were ones not taught in Soviet classes and certainly not to an official tour guide. This and that famous person? Well, the authorities purged them; their plays were never performed again; they were sent to the Gulag; they were executed or so pilloried and economically ruined that they committed suicide.

Mayakovski, the great pre- and post-revolutionary poet, actually authored a poem where he pleaded "if they erect a statue to me, blow it up!" Naturally, the Soviets who at first shunned the avant-garde member of the Russian Futurists, built a statue for him after he suicided and renamed the square Mayakovski. His radical poems and plays, often satirizing Soviet bureaucracy ("where is the 5-year plan for poetry?"), were ignored so he could be turned into a caricature of the proletariat poet. This proved the fate, if not worse, of many. Official history denied the very existence of the vast Soviet prison complex, the Gulag, or the state assisted famine of the 1930s, aimed at destroying the prosperous farmers (kulaks) as class enemies so their land could be collectivized, which killed untold millions especially in Ukraine as well as the rest of the Soviet Union.

Draft

At the end, with tears in her eyes, our Intourist guide said: “I have a twelve-year-old daughter. She has grown up without knowing any of this. What should I tell her now?” A poignant question, perhaps the central one facing Gorbachev and the reformers who wanted to open the country up economically and culturally. Could they preserve the power of the Communist Party? How could they rewrite their propaganda and tell people the truth without people realizing that for 70 years they had been told a pack of lies. Khrushchev started telling the truth in the late 1950s, then decided this was too risky and shut things down again. Nevertheless, the power elite deposed him as Party leader. These late 1980s in Russia were both exhilarating and scary, knowing we were there at the beginning of a great leap. Would the Party’s hierarchy shut it down? If not, what would it lead to?

A reminder of the brutality of the Communist regime occurred in Red Square at the gates of the Kremlin. We went to enjoy the beauty of the architecture. It is surely one of the most wondrous city spaces and also filled with so much history. At the time, Lenin’s mausoleum attracted thousands every day. We saw the lines of people patiently waiting to see the embalmed leader. Somewhere deep down, the Russians substituted Lenin for the Pantocrator.

Innocently strolling around, we were passing a gateway to the Kremlin when suddenly a guard came running full tilt at us with a nasty looking baton in his hand. To avoid a beating, we took quick evasive action. Now out of his range, we turned to see what the hell. A fancy large black vehicle with tinted windows came at a surprising speed through those doors chauffeuring a big boss of the Party. We could only imagine the consequences for the gate guard should that car be delayed by the presence of common people.

Panorama of Red Square at night; below, St. Basil’s at one end of Red Square (photos, Mark Nelson)

Another episode demonstrated the cold-heartedness of the Communist system. One morning, hotel staff told us to move to another part of the Rossiya Hotel. Given barely enough time to pack up our belongings, they marched us over to a different quadrant of the vast complex. The rooms were not dissimilar from those from which we had been evicted. No reason given, but after numerous enquiries we learned that a large number of delegates to an All Republics governmental session arrived, and the Rossiya was told to put them in one part of the hotel. Fair enough, but no politeness nor even half-hearted apologies: “Foreigners! (and as far as the Rossiya knew, we were just ordinary though fairly rare hard currency tourists) Move! Now!” In the streets afterwards, I began to appreciate the reach of the once Russian but now Soviet empire, extending over an astonishing 11 time zones; for the first time I saw people of different races, with distinctive regional clothing in Moscow.

We held a farewell dinner at Oleg’s. We all crowded into the apartment, Leonid and the seven of us. Gazenko ever the charming, elegant, and urbane host. Oleg initiated and coauthored with

Draft

NASA the space science bible, “Fundamentals of Space Biology and Medicine,” and its numerous updated editions. Shepelev wrote the chapter on Closed Ecological Systems for its initial edition.

Oleg had a profound sense of humor and irony. When we told him that while in general NASA research papers emphasized the problems, how hard to grow plants in space, the Soviets seemed far more optimistic. This was because Tsiolkovsky, their near-blind space visionary schoolteacher, not only invented rockets but also wrote of space greenhouses to keep humans alive. “Well,” said Oleg, “I account for it in the following way. At my dacha, my flowers and vegetables grow really well. My neighbor’s garden is hopeless, and he also wonders why mine is better.” At this he stopped for dramatic effect, then asked “How do you say it in English? Ah yes, green thumb. I told him that some people have a green thumb, and some do not.” And then he laughed contagiously.

In the interim, I got on the task of organizing this conference in London that Gazenko had suggested. I organized the annual conferences for my Institute, so in my role as Chairman of Institute of Ecotechnics a major ecological consultant to the project, we also organized the many design and engineering workshops and conferences needed for Biosphere 2.

I contacted our great friend and member of the Biosphere 2 Project Review committee, Prof. Keith Runcorn. His work as a geophysicist on paleomagnetism proved vital in validating plate tectonics (“shifting continents”), a once much-scorned hypothesis, which revolutionized our understanding of Earth’s geology. The Royal Society, the world’s oldest and most prestigious scientific organization, elected Keith to be a Fellow. So, yes, let us have our meeting there!

In due course, Keith secured a room at the Royal Society for a two-day meeting in July 1987. He chuckled when I asked him of any difficulties. “There are some old codgers there who still do not realize that space exploration is a reality. They still have not grasped that men have landed on the Moon!”

A stellar group of speakers convened for the “International Review of the History, Current Work and Future of Closed Ecological Systems” held in the Wellcome Lecture Room of the Royal Society. Josef Gitelson and Henry Lisovsky, the chief plant specialist at Bios-3, came as did as did Ganna Meleshko and Vladimir Sychev from IBMP. From NASA, Mel Averner, the head of the CELSS program and Bill Knott who ran their Breadboard food production unit at Kennedy Space Center. The renowned ecologists, Ramon Margalef from the University of Barcelona. H.T. Odum, the founder of ecological engineering from the University of Florida and Walter Orr Roberts from the National Center for Atmospheric Research (NCAR) in Boulder, Colorado also participated.

Speakers from Biosphere 2 included Margaret Augustine, CEO and co-designer, John Allen, Biosphere 2’s inventor and Director of Research and Development, Linda Leigh, in charge of our wilderness species accessions, Carl Hodges, head of the Environmental Research Lab at the University of Arizona, whose team consulted on general engineering and agriculture/food systems and Prof. Roy Walford, from the UCLA School of Medicine, leading the biomedical program for the closure experiments.

Draft

The final session concerned future lunar and Mars applications of closed ecological systems and included Runcorn, from the University of Newcastle upon Tyne, Jim Head, from Brown University, and Michael Duke, head of Solar System exploration at the NASA Johnson Space Center in Houston.

Royal Society, London, 1987: first conference on Biospherics and Closed Ecological Systems: at podium left, Josef Gitelson, director of Bios-3 and the Institute of Biophysics, Krasnoyarsk; seated from left: Margaret Augustine, Biosphere 2 CEO and co-designer, Ganna Meleshko, pioneer in closed systems, IBMP; Clair Folsome, University of Hawaii, created first laboratory closed ecospheres and served on Biosphere 2 Project Review Committee, Bill Knott, head of the NASA Breadboard Project, Kennedy Space Center, Florida. Standing on right: Mark Nelson, chairing the conference, and asking question from audience: Roy Walford, UCLA Medical School and Chief Medical Officer, Biosphere 2 closure experiment, 1991-1993.

I had fun chairing the meeting with its lively sessions. Meeting in the Royal Society was awesome. In-between sessions, they invited us for a tour. They showed us with pride the book which every Fellow of the Royal Society had signed upon their election. A who's who of world science with Sir Isaac Newton one of the first, but also Darwin, Rutherford, Einstein, Faraday, and more recently people like Stephen Hawking. A staggering 280 Nobel Prize recipients could also put FRS after their names. Newton's papers on alchemy remained under lock and key at the Royal Society, evidence that either there are still some taboos in Western science or that they are incredibly valuable.

The Royal Society secretary shows us the sign-in book of the Fellows of the Royal Society.
Kathelin Gray, Secretary RS, John Allen, Walter Orr Roberts, Roy Walford, Keith Runcorn.

The Royal Society is near Buckingham Palace. A very funny incident occurred when Queen Elizabeth, accompanied by the visiting queen of Morocco, came trotting by in the street below in ornate carriages flanked by colorful riders on horseback. The Soviets, I noted, were the first to the window, soon accompanied by everyone else, gawking unabashedly at the pomp and circumstance of celebrity and royalty, whatever their political and ideological differences. The meeting could only resume after the royal parade passed out of sight.

Josef Gitelson and I enjoyed instant rapport, and he and Lisovsky arrived a couple of days earlier to see London. I accompanied them on one of their walks as they tirelessly crisscrossed the city, maps in hand, to take in its history and sites. Even for eminent scientists, foreign travel was an exceedingly rare privilege, and this was the first time for all of the Russians to see London.

Oleg Gazenko, Josef Gitelson, Mark Nelson seated, standing Kathelin Gray, John Allen, Deborah Snyder, Robert Hahn in IBMP conference room

Josef Gitelson, right, author standing and Edward Bass at table

Draft

at conclusion of our first meetings at IBMP.

The opening session of the meeting tracing the origins and history of closed ecological systems was extraordinary. Clair Folsome, one of its pioneers, described the start of research with laboratory-sized "ecospheres," aquatic and marine closed ecological systems. Ganna Meleshko reviewed the beginnings of bioregenerative life support work starting in the late 1950s in the Soviet Union. Bill Knott from the NASA CELSS program traced their work to their most advanced food production unit in a retrofitted Mercury capsule at Kennedy Space Center. Gitelson recounted the work at his Institute of Biophysics culminating in their Bios-3 facility. Then Margaret Augustine placed Biosphere 2 into that historical context.

There were lots of informal meetings as well, like this one in the October Gallery's upstairs library. From left: Margaret Augustine, Josef Gitelson, Mark Nelson, Henry Lisovsky, Ganna Meleshko, a Russian translator.

A few other highlights of the meeting: Ramon Margalef explaining that the biosphere fed off the necrosphere, recycling the precious organic nutrients they deposited. H.T. Odum, who delighted in feisty intellectual combat, demonstrating his ecological models which did not necessarily indicate that Biosphere 2 could function well. Later, I laughed at a dinner when H.T.'s wife, Elizabeth, body-languaged and nudged him with her foot under the table to be nicer.

Session on ecological modeling, Walter Orr Roberts, John Allen and H.T. Odum at the Royal Society, 1987.

Prof. H.T. Odum showing his ecological models, 1987.

Later, after I left Biosphere 2, I did my PhD with HT who with his brother, Eugene, had founded systems ecology. They were some of our fiercest and most knowledgeable friends in the US scientific community. They were among the ecologists who tried unsuccessfully to convince NASA after the failure of single algae life support to take a more ecological systems approach.

We put up all the non-Biosphere 2 speakers in a small hotel a short walk from the October Gallery, appropriately enough at one end of Cosmo Lane. At the conclusion of the meeting, all the participants gathered for dinner on the main floor of the October Gallery. The energy in the room was electric. This was the first time that the NASA people met the Soviet leaders in space life support, and it felt as if all of us helped elevate how to live in space to the prominence it deserved. John Allen always said that Biosphere 2 aimed to help biospherics catch up with astronautics (our ability to send spacecraft through our solar system). For fun, Rusty Schweickart asked near the end of the celebratory dinner how many thought that we'd discover that Mars supported life. A strong majority raised their hands.

The poll: Rusty Schweickart asking who expected that Mars still supported life, October Gallery, London, 1987.

Draft

Delivering concluding remarks at the end of the First International Workshop on Closed Ecological Systems and Biophysics, Royal Society, 1987.

We planned a day of informal tours after the formal conference concluded. By now, everyone was quite convivial and sharing a bus trip seeing the sights served as a fitting end to the historic gathering. Keith Runcorn, who prided himself on his knowledge of scientific and cultural history arranged for us to visit Hampton Court, the residence of Henry the 8th and later other British monarchs. Sir Ghillean Prance, the designer of the Biosphere 2 rainforest, was then the director of the Royal Botanical Gardens at Kew. He toured us through their new Princess of Wales conservatory which features plants from several biomes. Our last stop took us to Greenwich to visit the maritime museum and the royal observatory with its zero longitude meridian line, the starting point for measuring distance both east and west around the Earth, as well as Greenwich Mean Time (GMT). The symbolism resonated.

Participants at the Greenwich zero meridian line. Deborah Snyder, IE Director and head of Synergetic Press, straddles the official line.

The Soviets convened a 3-day Space Futures Forum in October 1987 on the 30th anniversary of the launching of Sputnik, the first satellite to orbit the Earth. Gazenko arranged for my invitation. NASA, still reeling from the explosion of the Challenger Space Shuttle the year before, prevented most of its scientists from attending, forbidding them to accept the Russians' offer of flights and accommodations. Only six people from NASA attended. The Cold War was still going strong.

At that meeting, I more fully appreciated that Oleg was also a man of philosophical depth and great humor. Serving on a panel during the forum, Gazenko pointed out that to date humans experienced little difficulty functioning in microgravity, despite some loss of bone tissue; their major problem was in dealing with the stress of returning to Earth's gravity. He recounted what a Russian cosmonaut reported who just returned to Earth after six months, setting the record for living in space. Lying on his back, an admirer placed a bouquet of flowers on his chest. Not adapted to Earth's gravity and also suffering from the bone thinning which occur red during his months in near zero gravity, the flowers felt like a crushing weight to the cosmonaut (!).

Oleg noted that the human form changed in space. Freed from Earth's strong gravitational force, people elongate, gaining 2-3 inches (5-7.5 cm). Also, the fluids rise in their bodies, changing their facial features. Oleg compared cosmonauts to figures from Modigliani paintings and mused that our sense of beauty will alter as we adapt to living in space. A Russian member of the audience rose to indignantly ask if we did not owe a debt to our species, Homo sapiens, who after all were paying the costs of space exploration. Oleg smiled and took his time before he replied. I felt over an extended period he had deeply thought about the implications of humankind expanding into space. He finally said: "perhaps we will evolve into new species as we explore space."

Draft

Portraits by the Italian artist, Modigliani.

Oleg always referred to me as an incredibly young man. Looking around at the Forum, I saw a preponderance of elderly scientists. The photos of the members of the Soviet Union's Central Committee of the Communist Party and other bigwigs also indicated some sort of gerontocracy. I turned 40 years old in 1987, and certainly Gazenko, Shepelev, Meleshko belonged to an older generation. Perhaps referred to in this way, added to the feeling I developed for Oleg as a father-figure, and I delighted and felt honored that he treated me as a kind of son.

It seemed a momentous occasion when Gazenko, Shepelev, Gitelson and Zhurniya finally saw Biosphere 2. This happened in 1988 when several of them came for meetings with NASA on cooperation in space in Washington D.C. Josef and I presented papers at the annual Princeton, New Jersey conference sponsored by Gerard O'Neill's Space Studies Institute. Then Josef and I took the train down to Washington D.C. and meeting Oleg, Leonid, and Yevgeny there, we flew out to Tucson, Arizona since Biosphere 2 was 40 miles north of the city.

Our honored guests donned hard hats to visit the vast Biosphere 2 under construction, with stainless steel liners to make the facility air-tight below soil level. Special cranes lifted the glass panes of the over 6000 spaceframes of the superstructure. Over 20 kilometers (12.5 miles) of virtually air-tight joints enabled Biosphere 2 to function as the world's first closed ecological system to study biospheric processes.

Crews working at night to avoid extreme Arizona daytime heat sealing Biosphere 2's glass spaceframes

Our Soviet friends visited the research greenhouses where we were developing the agricultural systems and the candidate biospherian crew members trained as "subsistence farmers." The plant introduction greenhouses housed 3000+ species of plants from around the world prior to their insertion for the analogue wilderness areas from rainforest to desert.

The Russian pioneers in the field visiting Biosphere 2. Here, they inspect the research greenhouses of the Biospheric Research and Development Center at the project site in Oracle, Arizona. From left: Josef Gitelson, Oleg Gazenko, Yevgeny Shepelev and Leonid Zhurniya.

(Left) Oleg Gazenko and Yevgeny Shepelev in conversation. Gitelson, Nelson, Gazenko and Shepelev at Biosphere 2 during construction.

The term "noosphere" is virtually unknown in the United States but is widely known in Russia due to the work of Vernadsky and others he worked with in Paris in the 1920s, then in Kyiv, Ukraine (then a republic of the Soviet Union) and finally Moscow. Vernadsky was a great scientist and an optimist. Though his biospheric work showed that man had become "a powerful geologic force" through our technologically enhanced ability to move matter, Vernadsky believed we were

moving towards a new era. He sometimes called it the Psychozoic era and also used the term noosphere. Derived from the Greek word “noos” for mind, the noosphere is a sphere of intelligence in which humanity learns to harmonize its actions with the global biosphere and becomes a conscious, cooperative agent of evolution. Vernadsky saw the development of the noosphere as the next step in the evolution of the Earth’s biosphere. It is especially important as we enter this new era called the Anthropocene in recognition of the magnitude of human impacts on our world.

Our Russian friends gave talks for the Biosphere 2 management, staff and public. Touchingly, Gitelson in his talk said his only critique of Biosphere 2 was its name; it should have been termed “Noosphere 1.” In such a small facility, packed with both life and supporting technology, to design, operate and study the mini world we’d need intelligence. I wonder if Josef and our other Russian intelligentsia realized that in the late 1980s for Americans, even the term “biosphere” seemed exotic and unusual. When my colleagues and I spoke on the phone and mentioned Biosphere 2, I usually had to spell the word.

Aerial photo of the Biosphere 2 facility, Oracle, Arizona.

We learned that international cooperation in space life sciences could proceed despite technology transfer restrictions between the two leading space nations. This was probably because ensuring the safety of humans in space transcended political frictions. So, we began discussing with Gazenko and IBMP the idea of taking part in a Biosatellite (Biosputnik) flight of the small space greenhouses they were using to study aquatic plants and animals. We secured the involvement of researchers at the University of Arizona’s Veterinary Sciences school and began communicating with Ganna Meleshko’s team on ways to enhance planned space experiments.

In 1988, the Russian government invited John Allen and I to participate in the commemoration of the 125th anniversary of Vladimir Vernadsky’s birth in St. Petersburg to Ukrainian parents. Held mid-way through perestroika, and the event held first in Leningrad, then Kyiv and finally Moscow offered mind-boggling montages of old and new Soviet realities. In Kyiv for example, the program called for an event at the V.I. Lenin State Library, by the day of the event renamed the V.I. Vernadsky State Library (while he worked in Kyiv he founded the Ukrainian Academy of Sciences). No one mentioned the significant name change. When I asked one of the Russian scientists in attendance, he laconically replied: “there are plenty enough things named after Lenin in this country. He will not miss one library.”

On the other hand, as our bus went through the capital of Ukraine, a Russian seated next to me observed the street signs and sadly said: “No signs in Ukrainian, only in Russian. Here in the heart of Ukraine.” A reminder that geopolitically, the Russian empire morphed into the Soviet empire, or sphere of influence.

Draft

The commemoration included the screening of a new Russian TV documentary on Vernadsky's life. The film emphasized the independence from ideological agendas and devotion to scientific truth that Vernadsky always showed, despite a number of students of his being purged and sent to the Siberian gulag during the Stalin years. The mention of those events caused quite a stir amongst the Soviets and Ukrainians in attendance. Russians only discussed such things in private with trusted friends. Noone knows why Stalin never purged Vernadsky; perhaps his renown in scientific circles and his mostly non-political manifestations protected him. Horrified by the adoption of Lysenko-ism by official Soviet science since Lysenko contradicted modern understanding of genetics by claiming, without much evidence, that characteristics acquired during an organism's life transmitted to their offspring. Vernadsky, a liberal democrat before the Russian revolution, overcame his distaste for Soviet ideology by devoting himself to the advancement of science as the road to the noosphere, beyond politics.

By the time we reached Moscow for the final events at the Academy of Sciences, notably there were no displays of typical Soviet hammer and sickle symbols. The celebration of Vernadsky's legacy, which included founding over a dozen research institutes, become the occasion for championing the independence of science from political control.

But some things had not yet changed. When one of the European scientists needed to have his work seen by the translator to prepare better for the translation, the old and distinguished professor needed to write it out by hand, because there was no way to get permission to use a photocopier. Authorities considered photocopiers a potential printing press, and like all information-disseminating devices, they were kept under strict control.

Similarly, when we arrived in Moscow and contacted Oleg to see if we could come to IBMP for meetings, a long silence ensued on the phone. He did not have the time to get all the required permission signatures to come to the Institute. Problematic since we were in the midst of designing a collaborative small closed system experiment to fly on an upcoming Russian Biosatellite (Bio-sputnik) space flight. After a pause, Oleg told us to be in our rooms at the Rossiya Hotel near Red Square at a specific time the next day.

The next day Vladimir Sychev and Leonid Zhurniya arrived at the Rossiya with unusually bulky winter coats on, looking a little furtive and secretive. Sure enough, as they took off their coats, underneath they concealed the prototype aquarium and other instruments. With broad smiles, they reported: "Oleg carefully considered the 'problema.' Even if you could not come to the Institute to see the space hardware, no law prevented the space hardware from coming to your hotel to visit you!" So, the addition of the amphipods (small shrimp-like crustaceans) we proposed to the mini-closed system could proceed. Oh yes, another interesting twist: they lacked enough time to officially get sanction for the changed space experiment. But the IBMP scientists with control over Biosatellite experiments decided to simply deliver a payload different from the official manifest to the launch site.

Draft

This incident gave me some insight into how Academician Gazenko and his institute scientists, and Prof. Gitelson and his Bios-3 team ingeniously accomplished their research goals despite a bureaucratic system which might otherwise entangle them in endless red tape.

Our joint experiment flew in space on a biosatellite flight in 1989. But after retrieval of the payload from the landing site in Kazakhstan and transported to Moscow, Murphy's Law, or the special Soviet version of it took over. I knew IBMP sent the samples to Biosphere 2 so we could deliver still cold samples and organisms to our collaborating scientists. But IBMP could not send a telex for some reason, only known by those "specialists in international relations." So, we received no word.

I frantically called Leonid, as I made sure to have his personal phone number. I woke him up; he was flustered. "they told me the samples were sent by the fastest air service." Where did they go? He thought they had flown from Moscow to New York's Kennedy airport. I called and called until I could find someone willing and able to personally look for a package from an Aeroflot Moscow flight. Astoundingly, they addressed the precious cargo "Biosphere 2, Arizona, United States." So, the baggage handlers simply put it aside, not knowing how or where to send it. Eventually, we received the space samples, and though we lost the advantages of quick delivery and packaging in special cool containers, the university scientists were able to get satisfactory results and publish their data. In a way, this incident encapsulated the insanity of the Communist system: able to launch and land biological experiments from space orbit, but unable to send international communications and properly address packages.

Biosphere 2 benefitted enormously from the generous support and scientific experience freely offered by the veterans in the field from Oleg's IBMP and Josef's Institute of Biophysics. They spoke from experience and in sometimes memorable terms.

The telegram Shepelev sent just before John Allen became the first person to do a human closure experiment in our Biosphere 2 Test Module in 1988 contained words born of experience and wisdom. "Courage my friends! Remember that the human is the most unstable element in the ecosystem." Josef and Nicholai Pechurkin, Associate Director of the Krasnoyarsk Institute of Biophysics, reminded us (contrary to most NASA engineers who are in love with technology and fearful of living systems because they cannot "control" life like they can machines): "Remember the golden rule of closed systems: life is dependable, and technology can only be relied on to break down. The only question is when it will break down!"

John Allen in the Biosphere 2 Test Module during its first human closure experiment, 1988.

Russian researchers, such as Dr. Elena Gitelson from Moscow, Dr. Lydia Somova and Prof. Nicholai Pechurkin from Institute of Biophysics (IBP), came to work at Biosphere 2, sharing their knowledge and experience with problem areas like medicine and internal human microbial biodiversity. Taber MacCallum, a future biospherian crew member who managed our analytic

Draft

laboratory inside the facility, went to IBMP to work in Meleshko's lab. Gazenko and Gitelson made this cooperation possible because of their support of Biosphere 2.

The scientists in Meleshko's lab impressed Taber. But because he was a US citizen, he was not permitted to talk with other researchers at IBMP, not even to take lunch in the institute's cafeteria. Lunches were brought to them in the lab. He could hardly believe that at this prestigious space research facility with over 300 PhD researchers, some of the most fundamental procedures required old-fashioned labor intensive methods, since they lacked digital equipment. He deliberately left behind his automated pH meter as a gift.

IE worked with IBMP and Gitelson's IBP to organize the Second International Workshop on Closed Ecological Systems in Moscow and Krasnoyarsk, Siberia in September 1989. But this took some clever diplomacy. Krasnoyarsk, a heavily industrialized and militarized city, unfortunately served as the location of a missile radar installation the Soviets finally admitted was in violation of US-USSR arms control agreements. A closed city, even for ordinary Soviet citizens. The Institute of Biophysics and their Bios-3 facility required a short drive from the city.

Gorbachev paid a visit to IBP in 1988. While there, Josef and his team showed him messages from Biosphere 2 and explained that their colleagues in the West were very eager to see the advanced life support work there. The Soviet leader agreed, and plans could advance for the meeting. Josef later admitted to me that they "doctored" some of our communications to make their case stronger.

So, after a brief one-day start to the conference at IBMP Moscow, we prepared to board an Aeroflot plane to Krasnoyarsk. I made friends with a young scientist at IBP, Mikhail Sadowski, and as we waited to board the plane, I noticed he hand-delivered a large cardboard box to make sure it made it on the flight. When I asked him, he sheepishly whispered to me it contained toilet paper. Our hosts worried the conference hotel might run out of that vital supply: such embarrassing things happened in the Soviet Union.

It may have been a coincidence, but we departed Moscow around midnight and after a 4-hour flight arrived at 4am. We drove through the city while still dark en route to IBP. So, whatever military installations were there, the first group of Western scientists to visit certainly did not see them.

Gitelson's institute warmly welcomed us. That is putting it mildly. Many of them were smiling but in tears, overjoyed to be finally meeting people working in their field from the rest of the world and proud to share what they had accomplished. The Bios-3 facility was located in the basement of the Institute. There had not been a closure experiment for a few years, so we walked through the facility, visiting crew bedrooms, dining and socializing room, algae tank, and hydroponic food crop chambers. The whole facility, only the size of a small apartment, made history when 2 or 3 crew stayed inside for as long as six month experiments. Our arrival was big news: we made the front page of the Krasnoyarsk newspaper the next day.

Newspaper photos, top left John Allen whispering to author, (top right) Walter Adey, of the Smithsonian Marine Systems Lab, consultant to Biosphere 2's ocean/marsh, (below) group around Bios-3 model includes Frank Salisbury, Utah State Univ. NASA crop breeder, Henry Lisovsky, and Carl Hodges, Univ of Arizona Environmental Research Laboratory

Some of the outside scientists at 2nd International workshop, Krasnoyarsk
From left: Anders Hansson, Sheffield University, author, Carl Hodges, Walter Adey, John Allen, Taber MacCallum, Biosphere 2, Roger Binot, ESA, Frank Salisbury, Utah State University.

After the tour of Bios-3 and the Institute of Biophysics, the conference moved to Shushenskoye, a charming small town famous during Soviet times as the place where Lenin lived during his Siberian exile. They built a museum which later became a celebration of Siberian peasant life before the revolution.

In Shushenskoye, author, Institute of Biophysics translator/English teacher, Josef Gitelson and Nicholai Pechurkin.

A large number of the Bios-3 scientists were at least partially fluent in English. The meeting had presentations of the large body of research they conducted between the late 1960s and 1984; the last time they conducted a human closure experiment. They were truly far ahead of anyone else in the field. During their experiments, a dozen crops produced up to 70% of the food, and fully regenerated oxygen and water. To supplement the diet, they imported animal protein and exported solid wastes. Catalytic oxidation of the inedible parts of the crops boosted carbon dioxide levels to maximize plant growth. They operated the facility at levels between 350 and 1700 ppm. NASA to this date have not matched this, nor the Europeans. It would be thirty years before Chinese scientists equaled and surpassed these accomplishments in their Lunar Palace facility and at the Chinese Astronaut Training Center in Beijing.

Top: Josef Gitelson and Henry Lisovsky inspect wheat crop inside Bios-3; Below: a medical check of one of the crew inside Bios-3 by outside doctors.

Frank Salisbury reported on the wheat plant breeding his team at Utah State University conducted for NASA. They produced incredibly productive, early maturing ultra-dwarf wheat varieties which permitted dense plantings. Roger Binot reported on the European Space Agency's space life support programs. As a microbiologist, he researched how microbes could complete nutrient cycles by digesting human wastes and purifying trace gases to maintain a healthy atmosphere. In 1989, ESA launched their MELiSSA (Micro-Ecological Life Support System Alternative) project, simulating a terrestrial ecosystem and dividing it up into separate

Draft

compartments which would later be integrated together. Our large Biosphere 2 delegation shared our progress and current research priorities. Construction was proceeding rapidly and the insertion of soils and plants into the biomes had just begun.

There was a great deal of camaraderie. The hotel we stayed in featured a nightclub, where many of us listened to music, consumed copious amounts of vodka and beer, and talked deep into the night.

During the toasting at dinners at Shushenskoye, we learned what Yuri Gagarin said to Sergei Korolev, the Chief Designer, at the moment of launch. He used a slang expression "Poyekhali!" meaning "Let's go!" or "Off we go!" That became a meme at Biosphere 2 and was a frequent toast at celebratory meals.

During my trips to Moscow, I had already been well-initiated into a Russian tradition. Once you opened a bottle of vodka, it had to be completely drained! I joked that was because the lousy Soviet vodka caps could never be properly put back on the lid, but there was also "in vino veritas." By the time you drank all that vodka, you dug deep and could fully relate to the deep Slavic soul of the Soviets you were drinking with. Vodka becomes a truth serum, revealing what lay beneath the superficial persona presented to the world. By the end, you might stagger a bit, but you felt like a blood brother with your drinking companions.

I also bonded with the kind people who lent me a Russian hat, overcoat, and sweaters to withstand the Siberian fall. We flew Pan Am to Moscow, but Aeroflot were the baggage handlers and my checked bag never arrived. So, I possessed just the clothes I wore and a small carry-on with papers and presentation materials.

Each day, after the presentations, we met to work out a statement about this new science we were all engaged in. Bioregenerative life support systems for space, closed ecological systems of varying complexity up to mini-biospheric ones, and the Earth's biosphere which is also a very tightly sealed and recycling system supporting life. The excitement built and the discussions lively and heated.

Some of the Soviets wanted the new science to be called "biospherology" – logy, the study of, biospheres. No, that is an ugly word. Others, especially our Biosphere 2 delegation, argued for using the term "biospherics." That term is more action-oriented, elegant, and complementary to astronautics which was already widely used. Biospherics carried the day, and all the participants signed a declaration about this new science and the importance it could play in helping us understand living systems, from planetary biospheres to small closed ecological systems supporting just humans and food crops. [See appendix A for the Krasnoyarsk declaration]

Every night there were celebratory dinners with extensive toasting and impromptu speeches. In the midst of so much goodwill, the two "specialists in international relations" stood out like sore thumbs. With the physique of stereotypical FBI agents, they just silently observed and closely listened. That ensured no politics or ideologies were discussed, but those were far less interesting

Draft

than what we were talking about. I learned that Josef Ivanovitch Gitelson was Jewish, which relieved me as I had grown up hearing about Stalin's antisemitism. When he learned that my Katznelson was my father's family name before it was anglicized, we had even more reason to bond. Gitelson said the reason they made such rapid progress is that Sergei Korolev, the famous Chief Designer of the Soviet space program, understood how vital these life support systems were for our future in space, so Bios-3 had been well-funded.

John Allen was also in his element, meeting the heirs to the Vernadsky tradition and the mystic Cosmism movement in Russia which produced some of the greatest figures in Russian science including Mendeleyev (the Periodic Chart of the Elements), Vernadsky and Tsiolkovsky, who saw humanity's destiny as spreading through the Milky Way. In 1987, John and I co-authored a book Space Biospheres, explaining the origin and aims of Biosphere 2. John, himself both a geologist/engineer/ecologist/Harvard MBA and deep thinker, at the book's conclusion wrote about expansion into space as a means for Earth life to achieve "cosmic immortality." That phrase dismayed some people in the project's public relations department.

While we planned ways we could start cooperating, an odd "field trip" occurred near the end of the conference. I suspected the influence of the international relations people, because we went to the massive concrete hydroelectric dam on the Yenisei River. Gitelson's colleagues told us this dam had caused ecological disaster. It disrupted the natural ecology downstream, altered the temperature of the river. But it remained a Soviet prize project, still the fifth largest in the world, which powered important regional industries. So off we bused to see this ugly and brutal dam.

The trip did allow us to see some of the beautiful forests, the famous Siberian taiga where we stopped and hiked. But the way this trip proceeded proved astonishing. Two police cars escorted the bus. But they drove in front of the bus and forced oncoming cars off the road. Literally. With extremely sparse traffic, no reason existed for them to do so. Behold an exercise of power and intimidation, pure and simple. I sat in the front seat of the bus, near Carl Hodges and Walter Adey. We all took in this scene while Carl and Walter mused that if police did something like this in the U.S., someone would pull out a rifle and take them out.

Exhilarated by the conference, we laid plans that the next conference could be held during Biosphere 2's first closure experiment, making the gathering interbiospheric, with crew inside participating with those outside in Biosphere 1.

A strange coda about my lost suitcase. After I got back to Tucson, I started a lost baggage claim with now-defunct Pan Am airlines. Then a postcard arrived from Aeroflot saying they found my suitcase and giving the details of the flights to get it to Tucson. I went to the airport but nothing had arrived. Then another postcard from Aeroflot informed me the bag was on a different flight, a few days later. Again, nothing actually came. My bag was pretty special; how many got to fly on two different flights? I got reimbursed for the lost bag, but the memory lingered. Departing from Moscow's international airport on another trip, with some extra time. I asked an airport employee if they had a lost and found. He said follow me and we took an elevator down to a basement. As we stepped out, a Kafkaesque scene. The basement was enormous and completely

Draft

filled with hanging bags. In the crazed notion I might find the bag, I went racing up aisle after aisle. No luck. There must have been thousands of bags there. The dark humor thought hit me that this “lost but not found” served as an unofficial perk for airport workers: like a department store where they could open up bags and go shopping for free.

Sadly, in 1990, Clair Folsome quite unexpectedly died of heart failure due to an injury sustained during a marathon run. He made plans to spend his sabbatical year working with Soviet microbiologists he met through our contacts in Moscow and Krasnoyarsk. He contributed a lot to the design of Biosphere 2 and deepened our appreciation of the role that microbes play in all Earth ecosystems. He spoke at the initial Biosphere 2 workshop in December 1984 launching the project. We all keenly remembered the title of his talk: “Microbes, the unsung heroes of the biosphere.”

Left: Prof. Clair Folsome, University of Hawaii, with one of his closed ecospheres; right: author holding one of his oldest ecospheres in the living exhibition at Biosphere 2.

Clair served on the Biosphere 2 Project Review Committee and after his sudden death in 1990, his historic collection moved to Biosphere 2 for display. As long as these aquatic or marine systems contained sufficient microbial and algal diversity, which nature readily supplies, these ecospheres remain indefinitely viable, a testament to the power of ecology at the micro-level.

Concurrent “Track Two Diplomacy” Initiatives during the 1980s

Other citizens’ diplomacy efforts were also underway during the 1980s aimed at promoting informal dialogue between the Cold War adversaries. Esalen Institute in northern California near Big Sur was the originator of many of the most important ones. Hence the efforts came to be called “Hot Tub Diplomacy” as the retreat center was famous for its hot tubs as well as workshops in innovative approaches to medicine, education, consciousness associated with the Human Potential Movement.

Tensions between the two countries was at its peak following the 1979 Soviet invasion of Afghanistan and the US boycott of the Moscow Olympics the following year. People in the U.S. were terrified at the prospect of a nuclear war and the Soviets were living in a virtually closed society with foreign travel limited to diplomats and the elite. Determined to find other ways to link people from both countries, a first gathering in 1980 at Esalen launched the Soviet-American Exchange Program. This led to many Soviet and US citizen gatherings organized by Michael and Dulce Murphy, founders of the institute, and others. Joseph Montville coined the phrase "track-two diplomacy", which has become well-recognized as a supplement to official diplomacy between nations. Jim Hickman, the first head of the Soviet-American Exchange Program described its goals as “to seek common ground with Soviet citizens, in order to move forward to an expanded consciousness of global awareness for the human race” (Birgit Menzel, New Age

Diplomacy: the role of the Esalen Institute in ending the Cold War, https://newageru.hypotheses.org/1903).

Later, using new satellite communications, a series of “spacebridges” enabled citizens from both countries to directly speak to one another. These included the “Astronaut-Cosmonaut Dialogues” (1982–1985), which resulted in the creation of the Association of Space Explorers. Rusty Schweickart was a leader and one of 25 founding members. He had been deeply affected by the experience of seeing the Earth from an orbiting spacecraft, writing:

“You look down there and you can't imagine how many borders and boundaries you crossed again and again and again…The Middle East - you know there are hundreds of people killing each other over some imaginary line that you can't see. From where you see it, the thing is a whole, and it's so beautiful. And you wish you could take one from each side in hand and say, "Look at it from this perspective. Look at that. What's important?"…And you realize...that you've changed. That relationship is no longer what it was… you're the sensing element for man… It's a feeling that says you have a responsibility. It's not for yourself…And when you come back, there's a difference in that world now, there's a difference in that relationship between you and that planet, and you and all those other forms of life on that planet, because you've had that kind of experience” (http://www.context.org/iclib/ic03/schweick/ first published in “Rediscovering the North American Vision” in IC #3, 1983).

They held their first meeting in 1985 and these planetary conferences, hosted by a different country each year, continue to this day. From 25 they’ve now grown to over 400 space explorers. In 1989, they collaborated with Kevin Kelley in publishing “The Home Planet” which features spectacular views of Earth from space and accounts from many astronauts and cosmonauts of how the Overview Effect transformed their perspectives.

First planetary conference of the Association of Space Explorers, Cernay, France in 1985. Rusty Schweickart is fourth from the left in back row (www.space-explorers.org).

The Esalen Soviet-American Exchange Program sponsored linkages in fields ranging from psychology, medicine to literature and the arts. They helped organize the consequential first visits of Boris Yeltsin and Mikhail Gorbachev to the United States in 1989 and 1991. Disbanded in 1991, it continues its work as Track Two: an institute for citizen diplomacy.

We had choices to make as there are many international conferences devoted to space research annually. Consulting with the Biosphere 2 management, I proposed that we limit ourselves. The principal ones we presented at were COSPAR (the international committee om space research of IUCN), which held its assemblies in different cities every two years, the Space Studies Institute meetings of Gerard O’Neill’s group at Princeton University and the International Conference on Environmental Systems (ICES). I participated in the COSPAR and SSI meetings and these became important for deepening our Russian connections as well as the rest of the international space science community.

Draft

At the 1990 COSPAR meeting in Den Hague, Netherlands, Shepelev invited me to join him outside the meeting halls. We left a boring presentation and Yevgeny needed a cigarette. He also wanted to share an educational experience. With a broad smile and stage whisper, he recounted how he left his pioneering 24-hour experiment to the cheers of his fellow workers at IBMP. On an impulse, sometime later, he quietly went back to the chamber and re-entered, almost gagging at the smells of the internal atmosphere. The green algae regenerated the carbon dioxide he exhaled, turning it into oxygen. But they did a far less successful job reducing the myriad of trace gases that accumulate in a closed system, which gave it a very foul odor. Perhaps like the urban myth of a lobster in the slowly warming pot, he had habituated to it during his stay and could no longer smell it. An excellent warning as we prepared for the challenges ahead in Biosphere 2.

Dr. Yevgeny Shepelev peering into the life-packed Biosphere 2 Test Module during his visit. He might have been reflecting how much better his 24-hour closed system experiment would have been if the chamber grew green plants and not just algae to clean the air and water plus provide food.

I met Josef Gitelson several times at the Princeton Space Studies Institute conferences. He reported on historic and current work his institute was conducting, while I reported on various aspects of Biosphere 2's design and development. At the 1991 meeting, I could show slides of a fully constructed and operational Biosphere 2. Poignantly, I also shared these developments with Gerard O'Neill who was one of the first to envision life in space on orbiting stations but was clearly approaching the end of his terminal illness.

Josef had a huge interest in the history of science. So, while we were in Princeton, we found the office Albert Einstein occupied at the university and also at the Institute for Advanced Studies. It turned out Freeman Dyson, the renowned physicist and author, who I had met when he came to Biosphere 2, uses that same office now. Finding the house Einstein lived in took more effort. Josef found out the street and house number and so we navigated, in days before Google maps, to find it. To our surprise the house sported no historical marker. We politely knocked at the door and a woman who lived there answered. She readily said we could take photos and commented that very few people ever came to find the house.

Top, Josef Gitelson in front of Albert Einstein's house in Princeton, New Jersey (photo Mark Nelson).

We invited Dr. Yuri Shkolenko, an author and editor at Progress Publishers in Moscow to our 1990 annual conference in Aix-en-Provence, France, the site of IE's Mediterranean biome project and our frequent site for such conferences. I received an embarrassed note from him that he'd only be given $30 dollars of foreign currency, not enough to pay for a taxi from the Paris international airport he'd be arriving at and the domestic airport for the flight to Marseilles. We arranged for a friend to meet him and ferry him to his next flight. Shkolenko had written a good history of spaceflight, "This Space Age." We felt sad that the Soviet bureaucracy burdened him in this way.

Draft

When Nicholai Pechurkin, the associate director of IBP, came to Biosphere 2 to share their research and help the project, I took him around Tucson. He asked for a copy of the musical, "Jesus Christ Superstar," unavailable in the USSR. I took him to a Blockbuster store and he marveled at the vast collection of movies available and how effortlessly I could buy it. But when, needing some food, we went to a typical American supermarket, Nicholai was really speechless. The endless aisles of packages, cans, vegetables, meats, beer and liquor astounded him. On the drive back to Biosphere 2, he kept mournfully intoning: "My poor, poor country." Nicholai was a man deeply versed in Russian history and culture, appreciative of its contributions to the world. But what he witnessed made him realize how meager material aspects of Soviet life really were.

In 1991 I took my last trip to Moscow before I joined seven other "biospherians in training" to start our first 2-year closure experiment. Change had come to the city. Flashy billboards now advertised a wide variety of Western goods, taxis were everywhere. I realized that, oh yes, before there had been no street advertising, though there were endless Soviet jokes about how much higher production would if people didn't leave their work on the rumor that certain stores again stocked some items, like shoes, previously in short supply. McDonald's opened its first store in Moscow a year earlier, but there were still long lines to get in to taste previously forbidden foods. I sadly remembered how Gazenko proudly told us in 1986 that companies like Coca Cola wanted to sell in the Soviet Union, but that for health reasons they had been refused. He claimed ice cream had been invented in Russia and that the ice cream sold on Moscow streets contained only real ingredients, and was not chemically-laden like so much processed fast food of the West. In the name of opening and welcoming trade, standards had fallen.

I went to visit our earliest Russian friend, Gregori Khozin. He lived in a typical Soviet apartment block complex, devoid of landscaping and gentle touches. They literally looked like the architects randomly dropped them near each other. I regularly bought Russian science books translated into English. In every one of them, an obligatory paragraph in the preface or introduction quoted a passage from Marx or Engels, to show that their ideological founders wrote about ecology or spaceflight or whatever the book's topic. I told Gregori how incredible I found it to read in some of these books that ecological problems, even pollution, were unknown in the Soviet Union since all natural resources belonged to the people. At the time, there were rumors going around Moscow that radioactive wastes had been buried beneath popular parks in the city without the public being informed. He shrugged. He didn't need to say it out loud: the truth was still dangerous.

I paid a visit to Arbat Street, a small demonstration of the new order, as the authorities allowed privately owned small shops and cafes to operate. Disappointed that the area only covered a very few streets; it had the feel of a Potemkin village of free enterprise.

With a free afternoon, a friend suggested I take Moscow public buses to the studios of Mosfilm, a large Soviet movie and TV company, in the Sparrow Hills of the city. Strange that I could just walk up and enter the film studios. Mosfilm was famous, not only for output, though it did 3000 films between 1920 and 1991. But Sergei Eisenstein's movies, those of Tarkovsky, and even a Akiro Kurosawa joint Japanese-Soviet production had been filmed here. I looked in at one studio

Draft

as they rehearsed a bar fight for a Western. They silently worked out the sequences of breaking chairs, bottles, the back and forth of fistfights and when guns were drawn then people called out a break. When I suddenly saw all these actors and actresses start speaking Russian, I realized they did look just like American cowboys, barmaids, prostitutes etc.

There were other changes that pointed towards the turbulence to come. Staying at the old Academy of Sciences hotel, and on a whim I went up to its bar one night for a drink and snack. Inside were a few elderly men, I assumed scientists, and a table with three young women, heavily made up and dressed to party. A very strange juxtaposition. I hadn't seen sex-workers before in Moscow.

In late 1989 when I also stayed at the Academy hotel, I met a Czech scientist. He was leaving in the morning to another Soviet city for meetings. We chatted and I mentioned my love for Milan Kundera's books. He looked at me sorrowfully: "I know he's a great Czech writer, but I've never read his books. It's forbidden in my country. I could get sent to prison if caught." I was in fact reading one of Kundera's books. So, I stayed up and finished the book so I could give it to him the next morning. A few months after I got home, I received a postcard from him. With a photo of Prague's famous castle, he wrote in large letters: "From Czechoslovakia, the free heart of Europe!" Seismic changes were happening in Eastern Europe and the Soviet Union.

A friend took me to see an art exhibition in an unlikely location. Filling all the wall space in a Moscow apartment, with no sign outside or even on the door, hung framed cartoons and caricatures of Communist Party leaders and the founders of the Soviet state, Lenin and Stalin. They were extremely funny, and in the context clearly sacrilegious. The apartment was crowded with mostly young, professional looking people who laughed and were clearly celebrating the works. I had been learning about and reading in English translations, some of the samizdat (self-published) underground writings, political and literary, that circulated in Russia and Eastern Europe. Even classics such as Bulgakov's "The Master and Margarita," and Pasternak's "Dr. Zhivago" were only available in underground, rough copies. Solzhenitsyn's "The Gulag Trilogy," like many other such books, was smuggled out and published abroad while circulating in samizdat editions at home. They finally published the Gulag trilogy in the Soviet Union in 1989 as a result of the perestroika opening.

Cover cartoon from the Soviet satirical magazine, Krokodil, November 1991 showing people waving goodbye to a statue of V.I. Lenin, https://sites.miamioh.edu/havighurst/2021/11/29/the-1991-project-20-26-november-goodbye-lenin/

By the early 1990s, Moscow taxi drivers got as rude and combative as they are in other cities. When I needed to get around Moscow, they insisted on getting paid in dollars rather than Russian rubles. I vividly remember my taxi ride out to the airport. My taxi driver did not speak much English, but he understood me when I asked him about Soviet-version communism and the Communist Party. I mentioned "apparatchniks," a phrase denoting the middle management

bureaucrats who carried out the dictates of the Party. As we drove through the city, he angrily pointed at apartment blocks where the fat cats, the so-called vanguard of the proletariat lived, and hiss: “Mafia! Mafia!” He laughed and laughed; the days of the Party and even the Soviet Union were clearly fast running out. Though how fast that happened was shocking.

I had been living inside Biosphere 2 for about three months, near the beginning of our 2-year closure experiment, when Gorbachev turned over his power to Boris Yeltsin, head of the Russian Federation on Christmas Day 1991. The Soviet Union ceased to exist and in its place was a Commonwealth of Independent States. There was such chaos that a Soviet cosmonaut, Sergei Krikalev was stranded in space until it could be determined in which country he should come back to Earth. He was launched to Mir space station by the Soviet Union but returned a citizen of the Russian Federation and landed in Kazakhstan, which became an independent country while he was in the Mir space station. When he finally came back, even his home city had been renamed from Leningrad to St. Petersburg.

There had been some strange synchronicities between our work and the changes in both the Soviet Union and the regimes they controlled in Eastern Europe. The first time Biosphere 2 was featured on a major network’s prime evening news hour; we came down to watch the news. They aired the Biosphere 2 segment, but the lead story surprised, the fall of the Berlin Wall. That was November 9, 1989. History, often rhyming, never repeating, for sure was moving fast!

We organized the Third International Workshop on Biospherics and Closed Ecological Systems for April 1992. By then, we had been inside for more than six months, breaking the record then held by Bios-3. I was part of the eight-person biospherian crew and in my role as head of the Institute of Ecotechnics did a lot of the invitations by phone from inside the facility. Great fun, and unexpectedly Biosphere 2 won worldwide fame as the project inspired millions, much of it through the recent technology of satellite linkups. Getting through secretaries and getting people’s attention proved easy when I told them I was calling from Biosphere 2. “From where? Oh, I will get you right through!”

A large delegation came from Moscow and Krasnoyarsk. Sad though to be only able to speak with people through two-way radio at the glass. Still, the Russians remained some of our most knowledgeable colleagues as they had plenty of experience with their own crews in isolated environments. From our concerns about keeping CO_2 from getting too high, we decided to devote one day of the conference to global climate change modeling and mechanisms to keep the atmosphere healthy in Biosphere 1 (Earth) as well as Biosphere 2.

Interbiospheric dialogue. Dr. Roy Walford (top center), UCLA School of Medicine, presenting on biomedical research in Biosphere 2 to participants in the 3rd International Biospherics conference at Biosphere 2, April 1992.

Several sections highlighted the history and current work in bioregenerative life support. In one, Ganna Meleshko told us of a 30-day closure experiment at IBMP in the years following Yevgeny’s

closure, in such confined conditions that the test subjects could only stand or sit down – without room to fully stretch out. When we asked how they had endured this, she laconically replied nyet problema; the volunteers were good Party members.

Josef Gitelson, in his talk at the conference, stressed the necessity for human intervention to keep the biogeochemical cycles working correctly in enclosed ecosystems. This had struck me from our first conversations in 1986 when Josef pointed out that humans inside the system actively participate in their life supporting system. It started my thinking about what it would be like to be not just a passive recipient of ecological life support, like all of us mostly are in Earth's biosphere, but able to work with and significantly affect the system in which we are an integral part.

In Biosphere 2, the biospherian team has been learning how to manage this living world so that it supports our food production, our atmosphere and the health of the different biomes, all at the same time. The biospherians are not a "luxury item" in the biosphere. Using Gitelson's perspective, humans are also needed to maintain its high level of complexity and structure. Thus, humans are both a disturbing force and a restoring force. With any human-made system, technology is needed to replace natural functions the biosphere normally does. Who else is there to operate the technosphere in service of the biosphere's health and our own?

Since humans wield this power, there has to be a comprehensive overview, which included people on the outside in Mission Control and other participating engineers/scientists, to help understand the total situation to make the best decisions. This is also true in Earth's biosphere, but in a mini world the consequences of human actions are clearer and more rapid. It led our team in Biosphere 2 to say, "There are no small actions in our world. Everything we do has an impact."

After our first visits to Moscow, we learned that NASA scanned the Russian literature and put out a quarterly digest of their space-related research. So, we read about the great variety of their research including pretty extreme experiments with human subjects. For example, a series of experiments investigated people's circadian rhythms. A group was put into an apartment without clocks or windows for several weeks as researchers observed how they organized their days. Or ones that featured clocks in that ran more slowly or faster than actual time to observe what daily rhythms people followed without those cues.

During our two-year closure experiment, Academician Gazenko served on the Biosphere 2 Science Advisory Committee (SAC). He and Leonid Zhurniya came to Arizona for one of its meetings in January 1993. At the time, a lot of tension was felt both inside and outside Biosphere 2, as a power struggle was underway between those for developing biospheric science or reverting to narrower, more academic-style research. In the midst of this drama, Oleg's familiarity with Soviet power politics, born from decades of experience, came to the forefront. He reported that he had never seen such hostility from some members of a scientific advisory committee who acted as if they were enlisted in an effort to take over the project. Oleg urged John and the other owner/managers of Biosphere 2 to keep very thorough written records to

protect themselves, especially useful in experiments involving humans. In the Soviet Union, he had vast experience in maintaining scientific veracity and continuity in the midst of power struggles.

Carefully observing the biospherians from outside the glass, Oleg was certain that our mental and physical health was excellent, despite rumors to the contrary. He told the SAC that in his opinion, the crew adapted well to life and environmental conditions inside Biosphere 2. He spoke with all eight of us and said he was confident in our well-being. He shared his simple test for judging if people were adapting to a new environment: a feeling of freedom.

This was also confirmed a few months later by environmental psychology evaluations which showed the biospherian crew matched the explorer profile, very similar to such tests of astronauts. Interestingly, there was little difference between the women and men biospherians. Though some crew complained of depression, there was no evidence of that in the psychological tests. In conclusion, Robert Bechtel, professor of environmental psychology at the University of Arizona, told us that if he were lost in the Amazon, he couldn't think of eight people more capable of ensuring his survival.

Oleg reassured John and the other Biosphere 2 managers that the frictions amongst the crew were nothing new. I recall in a Russian book on space exploration, one cosmonaut described the tight living conditions with his crew mate on their spacecraft, before drily noting: "a perfect recipe for homicide." Gazenko earlier noted: "There are few positive emotions in space. Not physical but psychological stress is the most difficult thing to cope with for cosmonauts. We should help the crew to overcome this problem."

The physical isolation and confinement to interacting with a limited number of people were difficult. This was probably the hardest part of living for two years inside Biosphere 2. One perk for the crew was unlimited phone calls to family and friends, who also could meet us at the glass (there was a special place with a telephone inside and outside to make conversations easier). Several of the crew scheduled regular private phone therapy sessions during the closure experiment, and we frequently talked about group tensions and issues between people, even using a "talking stick" ceremony so everyone could speak without being interrupted. Group morale waxed and waned. Being on a calorie-restricted diet, especially the first year until our bodies adjusted, and the unexpected decline in atmospheric oxygen levels also contributed as stressors.

We knew about these issues before going in, the difficulties of ICE (Isolated Confined Environments) and the us-them split that often polarizes a crew from outsiders, including Mission Control. On one mission, Soviet space station cosmonauts cut communications with their ground control for a day, then resumed them without explicitly revealing the problem. What held the biospherians together was our love of the project, shared desire to accomplish as much research as possible, and the knowledge that keeping our mini-world healthy was key to our well-being. So no one subconsciously sabotaged others' work or of our living world, which often happens on expeditions.

Draft

We learned that Gazenko added a small amount of cognac (7.5 g a day for each person) to the Soviet space diet as a morale-booster after learning that a medical doctor on the Salyut space station smuggled cognac aboard and shared a small drink with the crew each evening. Similarly, the British Navy maintained a tradition of a "tot" of rum for the sailors every evening. The biospherian crew could relate to that. We made banana wine (best), Tibetan beer-like chung from rice (acceptable) and whisky from red beets we grew in our farm (the very worst). Reserved for birthdays, holidays and special events where we also had a large feast, having these drinks were guaranteed to raise spirits even if they would not have won any awards outside.

Oleg said sometimes it took years for cosmonauts to fully tell him what really happened during their months-long stays on space station missions with just one or two companions. Oleg had seen it all. I had the immense pleasure to visit with him and John by two-way radio through the Biosphere 2 windows. We reflected how far the journey had progressed since we sat together in the Metropole Hotel, and I first described the vision of Biosphere 2 to Oleg.

John Allen and Oleg Gazenko come to visit the author inside Biosphere 2 during the two year Mission 1 closure experiment in January 1993. We shared the "biospherians handshake" and an inter-biospheric conversation (photos, right: Deborah Snyder, left: Abigail Alling, Biosphere 2).

The Biosphere 2 two-year closure experiment came to a successful conclusion on September 26, 1993. Oleg and Leonid were on hand to join in the celebrations and planning for Biosphere 2's future. During this period, Oleg discussed his hopes for a Russian Biosphere project. "Biosphere 3" might be another chapter in the comparative biospheric experiments that Biosphere 2 made possible. Oleg suggested the Russian facility would be radically different to Biosphere 2 designed to be as clean and healthy as possible, with organic, chemical-free agriculture and biomes patterned on the tropical regions of the Earth, from rainforest to mangrove to coral reef ocean. Biosphere 3, by contrast, would start as a polluted world. Oleg knew in detail the terrible environmental damage mostly covered up in the Soviet Union, including microbial and fungal pollutants. IBMP discovered many people got ill from eating pollution-contaminated mushrooms, fueling a national health concern about environment toxins.

The challenge for the Soviet/Russian biosphere would be to find ways of cleaning it up, making that experimentally polluted mini-world healthy again, in the process developing new bio-remediation technologies.

Outside Biosphere 2 on "re-entry day", September 26, 1993. From left: John Allen, Dr. Sylvia Earle, marine biologist and then head of NOAA, Robert Hahn, Biosphere 2 Director of Communications, Dr. Jane Goodall, chimpanzee researcher, Prof. Harold Morowitz, George Mason University, Dr. Leonid Zhurniya and Academician Oleg Gazenko.

We received a telegram from Krasnoyarsk a week before the "re-entry"

> "It is a great pleasure for me and my colleagues to congratulate the initiators of your unique experiment, the crew and all biospherians on the occasion of the closure

anniversary. The results achieved are of interest for the scientific community and we are convinced they shall be deep and extensive. Your selfless pioneer work aims for the benefit of humankind and for better understanding of life on Earth." Signed, Prof. Josef I. Gitelson, Director, Institute of Biophysics, Academy of Sciences of Russia, Siberian branch.

Oleg spoke at the re-entry ceremony, beamed to nearly a billion people around the world.

> "Events of historical significance do not happen every day; but if early in the morning in remote locations somewhere at the foothills of the Santa Catalina mountains, you hear majestic music by Vivaldi, you definitely know that something extraordinary takes place. We are witnessing the completion of the first mission, very important and responsible mission inside Biosphere 2. We know that the fate and the life story of this beautiful construction can be compared with the fate and the life story of the long distance runner. But once upon a time, Aristotle observed that beginning is already more than half of the entire deal. Let us hope that the enormous databank accumulated by the biospherians throughout the entire mission will be quickly, promptly, and very carefully processed and made available for the scientific community around the world. We in Russia with great sympathy and tremendous interest have followed the advancement of this pioneering project. We wish it a successful continuation. We believe results obtained in this experiment in combination with global studies of Earth biosphere through remote monitoring and extensive application of scientific technology will not only contribute to a better life on the Earth but will also serve the task of the human planetary exploration of the solar system. I wish you success. I wish to congratulate the crew who is ready to complete the first pioneering mission and wish a lot of success to the next crews."

Biosphere 2 crew leaving the facility on re-entry day. From left: Abigail Alling, Roy Walford, Linda Leigh, author, Jane Poynter, Sally Silverstone and Mark van Thillo. Greeting us are Norberto Alvarez-Romo, in charge of the Biosphere 2 data system and William F. Dempster, systems engineer for Biosphere 2 (Getty Images, Tim Roberts).

After the re-entry ceremony, Oleg and Leonid stayed on for discussions, further developing ideas for Biosphere 3 in Russia. This biosphere would include biomes typical of more northerly climates, boreal deciduous forest, taiga, tundra, Arctic desert, and steppe. Methods of bioremediation to bring health to the biospheric system would be its primary research objective. We envisioned Biosphere 2 as the beginning of comparative biospherics. Biosphere 1 remains of course our planetary biosphere, but given the stakes of our ecological situation, we need Biosphere 3, 4, 5… There should be many biospheres, for major universities and world cities, for both public education and inspiration as well as research.

Imagine how wonderful to have high level international meetings inside a mini biosphere, so leaders could finally understand that we are part of the biosphere, not somehow separate from the "environment?" They also could serve as amazing educational experiences for students. They and small closed ecological systems could also be a testbed for the ecological safety of new

technologies and chemicals, genetically modified organisms. This would make more sense rather than finding out their unintended consequences after they are introduced in Biosphere 1, our planet's life support system.

Oleg Gazenko presenting author with the Yuri Gagarin Commemorative Medal for International Cooperation in Space and the Environment, October 1993 at Biosphere 2 after re-entry from first closure experiment.

Oleg had been elected as a delegate to the Russian parliament. He cut stay short because of intense political upheavals in Moscow. These included the October Coup, a constitutional crisis between President Boris Yeltsin and the Russian parliament. It ended with the military storming of government. With the collapse of the Russian economy that followed in the 1990s, the dream of the Russian biosphere faded. Even IBMP and IBP as well as most scientific institutes faced unprecedented budget cuts.

Before Leonid and Oleg returned to Moscow, I invited Leonid to a dinner at my elder brother's house in Oracle, Arizona. I also invited Sasha, a Serbian medical doctor who was in training for a future experiment in Biosphere 2. By then, Leonid had become a dear friend and we spent time together every time I went to Moscow. The evening was sobering, Sasha told terrible stories from her time working in a hospital In Belgrade of the atrocities committed by the Bosnians in the civil war then raging. I pointed out that the Serbians (and Croatians) were also guilty of brutal ethnic cleansing and were hardly the only victims. She denied it and cold-bloodedly replied that the Bosnians were Islamic and all Christian Europe was silently cheering on the Serbians to get rid of them once and for all, like exterminating rats in a house. It made my head spin to hear someone I thought I knew speak like that.

Leonid had been reeling from the collapse of the Soviet Union and the subsequent political upheaval. First, there had been the almost successful coup against Gorbachev by the hardline communists who had never approved of his reforms; and now, the October coup. Leonid, who's health also began to suffer, lamented his country's future. "We have no tradition of democracy. I think Russia can only be saved if a strongman arises and takes power. A strong, Napoleon-like dictator." Knowing how that original story ended, his foreboding sense of gathering national calamity sounded ominous.

We had invited to Biosphere 2 a renowned space biologist, Dr. Galina Nechitailo, who along with her husband Dr. Alexander Mashinsky, worked at IBMP and other Soviet institutes. They authored the seminal book, "Space Biology: Studies at Orbital Stations" and gained fame for their pioneering work with plants and animals in space. The latter included quail, a potential part of a space-based bioregenerative life support system because of their small size, egg and meat production. Their studies on Russian space stations demonstrated that while adult quail could not get used to microgravity, chicks born in space figured out how to fly.

But Galina and Alexander arrived after the corporate take-over of Biosphere 2 in April 1994 by our partner. By June, our group who held a 50% ownership as well as managing the project

reached a legal settlement and left. Columbia University who started managing the "world-class facility" (as they called it in their press releases), disparaged its creators and the previous science at the facility, ignoring all the leading scientists involved. Columbia must have been embarrassed that world-class scientists like Galina were disappointed by the absence of the original team who created Biosphere 2, indeed for some years, we were virtually persona non-grata. Galina is resourceful and soon contacted us anyway.

Photo in the Moscow Museum of Space Exploration shows Galina, her husband, Alexander, far right, and colleagues examining plant experiments for the Mir space station.

She soon became a great friend and ally. She attended several of our annual conferences at Les Marronniers Conference Center in Aix-en-Provence, giving talks on her work and the future of space biology, and frequently stayed at the Institute's London base, the October Gallery.

John Allen and Galina Nechitailo at an Institute of Ecotechnics conference, Aix-en-Provence, France

In London in 1996 with the cooperation of Oleg Gazenko and Josef Gitelson, we organized a 4th international conference on Biospherics and Closed Ecological Systems. The third meeting had been held during the 2 year closure experiment (which might be termed the first "inter-biospheric conference" since I and other biospherians participated and gave talks through video linkups from Biosphere 2). At the Linnean Society, we shared some of the most striking findings from the Biosphere 2 experiments and Japanese researchers shared their excitement in the progress of their own facility, the Closed Ecological Experimental Facility (once called "Biosphere J"). In the hall where Darwin's first presentation of his and Wallace's new theory of evolution through natural selection were made, all the participants keenly felt the truth that the newer generations of scientists "stand on the shoulders of the giants who came before them."

Top: author with Lydia Somova and Nicholai Pechurkin beneath Darwin painting; Above: John Allen and Yevgeny Shepelev at the 4th International Conference on Biospherics and Closed Ecological Systems, held at the Linnean Society, London, 1996.

Speakers at the Linnean Society meeting, London, 1996. From left to right: back row: Mark Mills, T. Heflin Jones, Craig Litton, Ray Collins, author, John Allen, Galina Nechitailo, Nicholai Pechurkin, Frank Salisbury, Lydia Somova, Roger Binot, Ganna Meleshko, Alexander Mashinsky, Sergei Zhukov. Front row: Seishiro Kibe, Tsutomu Iwata, Yevgeny Shepelev, Abigail Alling, Phil Dustan, Sally Silverstone, Andrew Brittain. Not in photo: Sir Ghillean Prance, William Dempster, William Challoner, FRS.

In the years after Biosphere 2, we continued to work with Academician Gazenko and the Russian space community. Through Galina Nechitailo, we were able to grow out descendants of the Mir space station wheat seed (the first crop plant grown from seed to maturity in space conditions)

Draft

in the “Laboratory Biosphere,” a small materially sealed system we built in 2000 at our Synergia Ranch property near Santa Fe, New Mexico to investigate potential space crops, atmospheric dynamics and plant/soil interactions from an ecological perspective.

Laboratory Biosphere, Synergia Ranch, New Mexico where we conducted closed ecological system experiments from 2002-2008.

After a few years absence, I started participating in COSPAR meetings again. Together with Nicholai Pechurkin, we added one to two day sessions devoted to Closed Ecological Systems and their Earth and space applications to the COSPAR space science meetings. We first met again in Warsaw at the year 2000 General Assembly. These every two year meetings were a time to reconnect with friends old and new from IMBP, IBP and other Russian institutes and Eastern European countries working on space life support as well as those from NASA, ESA, the Japanese, and Chinese who were ambitiously entering the field. COSPAR assemblies are huge, generally 2,000-3,000 space scientists participate.

Nick Pechurkin and author walking the streets of the medieval Old City of Warsaw, rebuilt after World War 2. With Lydia Somova, exploring “in vino vertitas” in an underground bar/restaurant during the 2000 COSPAR.

The COSPAR division of space life sciences elected Nicholai Pechurkin the Chair and I was elected Vice-Chair of the COSPAR division of space life sciences, and we served for a decade from 2002-2012. In addition, we worked as Main and Deputy Scientific Organizers for the sessions on Closed Ecological Systems. Nick, Lydia Somova, and I spent time together a lot during these COSPAR meetings, and all being interested in art, history, ecology, we also explored diverse cities: Warsaw 2000, Houston, 2002, Paris, 2004, Beijing, 2006, Bremen, Germany, 2008, Montreal 2010, Mysuru (Mysore), India, 2012, Moscow 2014. Sadly, poor health (and US visa requirements) prevented their coming to the Pasadena, California 2016 COSPAR, the last COSPAR assembly I attended and presented papers.

In the earlier COSPAR sessions of the 1980s and early 1990s, I learned that despite the beautiful presentations, the majority of NASA proposed space exploration projects never happen. The Soviets generally had lousy presentations, but they operated running space stations, Salyut then Mir, and reliable resupply spacecraft. Meanwhile NASA halted human space exploration after the Challenger space shuttle accident and the agency, partly due to Congressional demands for changes, spent a decade and tens of billions of dollars redesigning and redesigning the international space station before finally launching it.

Sadly, in more recent years, the Russians no longer have the financial strength and motivation to allocate so generously to space like they did in the Cold War Soviet years. International cooperation has become necessary and the norm. I presented a paper at a 1994 space conference in Huntsville, Alabama and found it fascinating to hear NASA officials, who had previously dismissed Soviet space science and technology, talk openly about changing their attitude given the importance of working with the Russian program. Only the Chinese now seem to be going it

Draft

pretty much alone, for national pride and seeing an opportunity to become the leader in space exploration and eventual long-term habitation.

Lydia Somova shared some interesting anecdotes about the Soviet space program. A program sent into space a cosmonaut from each allied country in Eastern Europe and India as well. Lydia worked as a pioneering microbiologist, but she told me that like her Siberian mother before her, she had an innate way of healing and could effect cures by laying on hands. Soviet ideology frowned on naturopathy or shamanic skills so she kept her powers private. She told me that amongst the "friendship cosmonauts," one from India in addition to his prescribed tasks, practiced meditation and did yoga while in the micro-gravity environment in the space station.

International leaders in space life support, COSPAR. From left: Dr. Chen Dong, Lunar Palace, Beihang University, Beijing, Dr. Alexander Tikhomirov, Bios-3, IBP; Dr. Christophe Lasseur, MELiSSA, ESA; author; Dr. Ray Wheeler, Kennedy Space Center, Prof. Shuangsheng Guo, Chinese Astronaut Training Center, Beijing.

I started editing space life support system papers for the Elsevier journal, *Advances in Space Research*. In the early years, I personally took on the job of improving the English of the papers submitted by Russian authors. Later, Elsevier added language experts to do the task. After serving in that position from 2002-2014, when Elsevier created a new journal, *Life Sciences in Space Research*, I became an Associate Editor handling topics related to space agriculture, life support and closed system facilities. This has kept me abreast of new developments, such as Bios-3 becoming affiliated with the European Space Agency MELiSSA project and two Chinese groups with ambitious goals and achievements in bioregenerative life support systems.

Right: Prof. Tom Hei, Columbia University, editor-in-chief of *Life Sciences in Space Research*,
Jose Stoops, the publisher for Elsevier and author with an issue of the journal, Moscow COSPAR 2014.

Oleg and Leonid participated in the Institute of Ecotechnics' 2004 conference, The Noosphere: Art, Science and Ventures, at Les Marronniers conference center in Aix-en-Provence, France. Appropriately enough, despite his concerns with the challenges facing the world and his beloved Russia, Oleg presented a visionary talk on "the contours of Noospheregenesis" and shared his unique historic perspectives on humanity's first steps into space and our adaptability and future evolution.

Oleg Gazenko speaking and Leonid Zhurniya translating at the 2004 Institute of Ecotechnics' Noosphere Conference, Aix-en-Provence, France.

John P. Allen, FLS, speaking on "The Noosphere and the Planetary Integration of Art, Science and Enterprise."

Draft

Speakers photo from the 2004 Institute of Ecotechnics' Noosphere conference at Les MarronnI.E.rs conference center, Aix-en-Provence, France (full list of speakers and titles is available at http://ecotechnics.edu/2004.html). Oleg is seated 2nd from the left; Leonid is standing next to John Allen.

Left, Leonid, John, and Oleg; right, Oleg with Deborah Snyder, I.E. director and head, Synergetic Press. Standing, on left, Oleg's grandson and Leonid Zhurniya.

Left: Oleg and John say goodbye; right: author and Oleg share another biospherian handshake

In 2006, The Russian Academy of Sciences invited me to give a talk and sit on a panel at a Future of Space Forum. That also allowed me another chance to visit and hang out with Oleg. He resigned from IBMP in 1989 under perestroika rules that institute directors must retire at 65. Oleg turned 71 and despite his stellar 20 year at its helm, Anatoly Grigoriev became the director. Gazenko continued as his advisor and retained his interest the frontiers of space biology and physiology. In November 2007, Academician Oleg Georgievich Gazenko passed away, aged 88.

With Oleg Gazenko in the study of his Moscow apartment, September 2006

Synergetic Press published Vernadsky's "Geochemistry and the Biosphere" in 2007 after years of pain-staking translation into English. Olga Barash, the daughter of Ganna Meleshko, did the main translation and Frank Salisbury served as the scientific editor. Academician Alexander Yanshin, a founder of the Vernadsky Foundation and Vice President of the Russian Academy of Sciences, wrote the introduction.

In 2008, I again went to Moscow for a conference on international space cooperation. Against the backdrop of the financial crisis unfolding on Wall Street, the foreign delegates were bused to the new, super-modern, Moscow headquarters of the Russian Academy of Sciences. A sea change from the 1980s, when staying at the Academy of Sciences hotel, involved fairly haphazard experiences. What essentials are out of stock, unavailable today?

I paid a visit to IBMP. Vladimir Sychev most graciously hosted me. He now headed their space life support lab, after the passing of Ganna. He showed me the latest advances in equipment for space greenhouses for raising potential food crops. He shared videos of cosmonauts and now astronauts since NASA got over its collective Russo-phobia and cooperated much more with the Russian and other international space agencies. Everywhere I went in IBMP, people knew me, even younger scientists. I asked Vladimir why? He regarded me for a long moment before answering: "Are you serious? Biosphere 2 and…you are the guy that Gazenko held hands with for so long!"

Draft

So maybe I finally found out that Gazenko did not do that as a matter of course.

Facility at IBMP for 500 day enclosures simulating a voyage to Mars. Russian and international volunteers formed crews for the isolation and operational experiment. Above: crew after completion of 520 day trial.

At IBMP, Sychev toured me around the mock-spacecraft where international teams studied the problems for small groups of people on a trip to Moscow. The 500-day experiments included one where sexual jealousy led to allegations of abuse, fights among the crew and finally forced the termination of the closure. Later phases included only men from Russia, Europe, India and China. He also briefed me on recent research at IBMP, including new cooperation with Utah State University on space plant equipment.

Vladimir Sychev at IBMP with a new compact space greenhouse with LED lights.

With Vladimir Sychev and Margarita Levinskih at IBMP. Poster of a future space colony. The Soviet space program's motto: "we must grow our own apples on Mars." It became a musical hit.

COSPAR held its 2014 general assembly in Moscow. I neared the end of scientific papers that my colleagues and I could write using the data that escaped disappearance after the Biosphere 2 take over. I had not been to Moscow in years and the contrasts stunned. There were now so many cars available that there seemed to be a permanent traffic jam from the city center to 20 miles out. The few billboards that so shocked me in 1990 after their complete absence before, now seemed as numerous as in a typical U.S. city. On the other hand, life continued. People still wed in Red Square and overlooking Moscow at the Lenin Prospekt. My Russian scientist friends stayed mostly mum about Putin and politics; the most common refrain being "we don't think about him as long as he leaves us alone."

I and other foreign scientists stayed at the famed Moscow State University near the meeting halls where the plenary and workshop sessions took place. For me, getting to know the newer Chinese scientists pushing the field forward proved inspiring as well as catching up with older friends from Russia, ESA, Japan, and NASA. We watched live the video feed of the first ever landing of a European Space Agency spacecraft on a comet, but in a throwback to earlier days of Soviet incompetence, or just bad timing, the live feed dropped out only a few minutes before it touched down.

Bittersweet to be in Moscow again. Galina showed me some of her favorite new art installations, then took me to the Lenin Prospekt overlook of the city and the nearby church and monastery. We lunched with Sergei Zhukov, the founder and mover and shaker of the Moscow Space Club.

Draft

Left: Galina and author at welcome reception at Moscow COSPAR, 2014; with Sergei Zhukov, director of the Moscow Space Club and now general director of ZAO "Center for Technology Transfer" Rosaviakosmos.

At the end of the COSPAR assembly, our Russian friends arranged a celebratory dinner bringing together veterans and up-and-coming scientists in bioregenerative space life support.

Moscow 2014 – in the group are Prof. Liu Hong, head of Lunar Palace project, Prof. Christophe Lasseur, head of MELiSSA project, ESA, Drs. Ray Wheeler and Mike Barta, NASA, Yuli Berkovich, IBMP and Dr. Alex Tikhomoriv and his daughter Dr. Natalia Tikhomirov, Bios-3, IBP Krasnoyarsk.

Toasts, tears, memories of accomplishments and hopes for a better future in space and on Earth, Moscow 2014.

Epilogue

Looking back on the intertwined history of Biosphere 2 and the space life support community in the Soviet Union and now Russia, I am struck by the synchronicities that brought us together. On the other hand, perhaps inevitable that such a daring project which drew inspiration from Vernadsky's work interested Russian scientists deeply versed in his approach.

We all shared a sense of urgency in our work, and the intention to do pioneering research which could shape the future. These included work to understand and better steward the biosphere we live in; developing bioregenerative life support systems to enable humans to truly explore and live long-term in space, escaping our "planetary cradle" (as Tsiolkovsky saw this evolution); and creating a new kind of Earth laboratory showcasing an experiment to learn how technological humans and our biospheric life support system can co-exist harmoniously. In the process, we all were working to make ecology and biospherics experimental sciences to give us the tools and the insights to alter the current disastrous degradation of Earth's biosphere.

The legacy of both the Soviet life support pioneers and of Biosphere 2 continues, indeed deepens, as humanity faces the challenges of learning to live in cooperation with our planetary biosphere. We will all need to draw deeply on our intelligence and our love and reverence for life to make this happen. Someday, Earth's biosphere will also dialogue with other biospheres, both those identified in space and human-made, adding a new chapter to the emerging science of biospherics and another type of overview effect.

In 1993, while still inside during the second year of the closure experiment, I wrote: "in Biosphere 2 we are under the necessity to act as noospherians, intelligent partners with our world. It is small enough that we understand with every breath of air we take that our biosphere's health is our health. It is a foretaste of the change of thinking that we as global inhabitants of Earth must make if we are to succeed in living sustainably."

Draft

To survive and thrive on Earth and to expand in space, we will need to evolve, as Gazenko suggested, into a new kind of human: *Homo noosphericus*.

Draft

Appendix A: The resolution agreed to at the Second International Conference on Closed Ecological Systems, Krasnoyarsk/Shushenskoye, Siberia in 1989.

Edit: 30 May 2025

83 photos excluding front and back cover

24,575 words

86 pages

Draft