INTERNATIONAL SEMINARS ON PLANETARY EMERGENCIES

Executive Summary Plenary Report

55th Session

Chairman: A. ZICHICHI Co-Chairman: C. GALBIATI

18th – 24th August 2023

55th Session of the International Seminars on Planetary Emergencies
Executive Summary

Overview

The 55th session of the International Seminars on Planetary Emergencies at the Foundation Ettore Majorana and Centre for Scientific Culture (FEM) (https://ettoremajoranafoundation.it/) took place between 20-23 August 2023 in Erice, Sicily. The in-person event was an excellent opportunity to refresh the spirit of the Seminars, which started in 1981 in midst of the Cold War. Each year, nuclear physicists, and advisors to leaders of the most powerful nations had the opportunity to freely exchange ideas and have discussions, at times very heated, thinking about the possible benefits in finding room for positive collaboration among nations that were on the brink of war. One significant result of those discussions was the historic Seminar in August 1987, where Professor Zhou Guang Zhao (Scientific Advisor to Premier Deng Xiaping), Professor Edward Teller (Scientific Advisor to President Reagan), Professor Eugenij Velikov (Scientific Advisor to President Gorbachev) and Professor Antonino Zichichi (Chairman of the International Committee 'Science for Peace', President and Founder of FEM), reached an Agreement for International Scientific Collaboration East-West-North-South without Secrecy and without Frontier.

The Seminar this year had eight sessions in which over 90 scientists from 25 different nations participated and spoke. Topics covered include nuclear weapons, arms control-devolution of global security, origin of the Covid -19 pandemic, the oil markets and the energy transition. Critical infrastructure, cyber security challenges, progress on small modular nuclear reactors, pollution and water crisis, environmental contaminants and children's health were the other subjects covered. The key messages of each of these eight sessions are summarized below.

Professor Zhou Guang Zhao (Scientific Advisor to Premier Deng Xiao Ping), Professor Edward Teller (Scientific Advisor to President Reagan), Professor Antonino Zichichi (Chairman of the International Committee 'Science for Peace') and Professor Eugenij Velikhov (Scientific Advisor to President Gorbachev), shaking hands after reaching the Agreement for International Scientific Collaboration East-West-North-South without Secrecy and without Frontiers.

Keynote Address, Professor Cristiano Galbiati

The occasion of the first post-pandemic session of the International Seminars on Planetary Emergencies offers the occasion to reflect upon the relevance of the Ettore Majorana Foundation in fostering crucial occasion for academic debate of the most important issues affecting our societies. How does it come that this tiny place in a remote corner of Sicily can host such profound discussions among intellectuals coming from all corners of the world, which, collectively, can punch above the sum of their individual weights in producing well respected and strikingly effective opinions?
I found two different answers to this question.
A first important factor is the history of Erice and the unique drive of the School's founder, Prof. Antonino Zichichi, who spent sixty years in building an Institution that carries with full effectiveness the Founder's own *gravitas* and passion for science and evidence-based processes and decision.

The second is the centrality of physics. It is the most basic and oldest of the physical sciences. And it so crucial to the understanding of our world that even in Aristotle's work the foundation the first philosophy is "metaphysics", i.e., τὰ μετὰ τὰ φυσικά, "those after the physics". Today, physics is more central than ever to the understanding of the modern world.

The focus of the 55th session of the International Seminars on Planetary Emergencies at the Foundation Ettore Majorana and Centre for Scientific Culture is squarely placed on the broad theme of energy, the central concept of physics.

Large-scale availability of cheap energy has been crucial to the development of modern standards of living. Its availability and scarcity are among the primary sources of conflicts and trade agreements. Methods to increase the availability of energy and policy to regulate its control and access are crucial for the peaceful development of our societies and affect each and every one of the topics discussed by the Permanent Monitoring Panels of the International Seminars on Planetary Emergencies. Control and sharing of energy are the keys to fostering strong and free democracies.

As then California Governor Ronald Reagan stated in his Inaugural Address, on January 5, 1967:

"Perhaps you and I have lived too long with this miracle to properly be appreciative. Freedom is a fragile thing and it's never more than one generation away from extinction. It is not ours by way of inheritance; it must be fought for and defended constantly by each generation, for it comes only once to a people. And those in world history who have known freedom and then lost it have never known it again."

Session 1 Summary
The Devolution of Global Security
Session Chairman: William Barletta
Mitigation of Catastrophic Risks PMP Chairmen: William Barletta and Adnan Shihab-Eldin

Since Professor Antonino Zichichi convened the first session of the International Seminars on Nuclear War in August 1982, illustrious scientific leaders from across the globe have focused upon issues of existential importance with a goal of alerting and energizing the public and its elected officials. The greatest urgency in the 1980s was the grave threat to humanity posed by tens of thousands of nuclear weapons possessed by the U.S. and the Soviet Union. The illustrious participants during those early years included science advisors to American President Reagan, Soviet President Gorbachev and Chinese Chairman Deng Xiaoping. Formal presentations analyzed the risks to strategic stability of new offensive and defensive weapons and the disasters that would follow their use. However, especially thanks to their long, informal conversations, prominent scientists from the "great powers," plus those from both allied and non-aligned nations, carried home the message of mitigating the catastrophic risks of the nuclear age, and thereby energized political processes that ended the Cold War.
With the dissolution of the Soviet Union and the signing of the START 1 Treaty, mitigating the strategic nuclear threat was well under way. By 2001 80% of the worlds strategic nuclear weapons had been dismantled. But other emergencies rose to the fore, expanding the August meeting to the current International Seminars on Planetary Emergencies. Most notable among the emergencies were threats to water supplies, terrorism, infectious diseases, and risks to energy supplies. During this period the PMP on Mitigating Catastrophic Risks (MCR) was formed with an initial focus on international terrorism, but with a flexible charter to include many existential risks.
This year, the MCR returned to the original theme of the Seminars: the devolution of the international security regime and the expanding nuclear threat across the planet from the relative stability of the early 1990s. That period was marked by the end of the Cold War accompanying the dissolution of the Soviet Union. Nuclear weapons were removed from the Ukraine, Belarus, and Kazakhstan, three states of the former USSR. The U.S. Secretary of State, James Baker, offered Russia his broad assurances that its denuclearization of the Soviet "sphere of influence" would not create a power vacuum yearning to be filled.

Already during the Clinton presidency, the U.S. and its allies began a steady program of backing away from those informal assurances that NATO would not seek to expand toward the Russian border. By 2014 NATO had reached the Russian frontier in the Baltic states, and the U.S. active support of the overthrow of a pro-Russian regime in the Ukraine was soon followed by Russia's annexation of the Crimea. By 2021 relations between Russia and the NATO allies were the worst in 30 years, culminating in the Russian invasion of the Ukraine. As the US provided massive military aid–including tactical intelligence to Ukraine–and urged other NATO countries to do likewise, Russian military officials have issued frequent reminders of possible use of nuclear explosives in Ukraine. The "nuclear taboo" seems evermore endangered.

Across the globe in Northeast Asia, Nuclear tension is mounting to a level never seen before. The Chinese nuclear arsenal, which has traditionally been kept at a minimum level for a superpower, is now gradually on the rise supposedly to counter the United States. North Korea (DPRK) firmly believes that going nuclear was the only way to ensure regime survival. To that end it has tested nuclear weapons on six occasions and has developed both medium range and intercontinental ballistic missiles to threaten the US and its allies in East Asia. The DPRK has tested these technologically mature weapons along provocative routes crossing Japanese and South Korean territory. However, it likely needs more tests to establish strategic MIRV capability.

Under the Communist Party rule, China will continue to be assertive backed by its huge economic, military, and political power. Trends in that region may appear bleak, but the likelihood of two of the most common dire predictions—a nuclear war on the Korean peninsula and an invasion of Taiwan by China (PRC)—are likely exaggerated. Still, there is plenty to worry about. With respect to global security, the most worrisome trends are found in South Korea (ROK) where a robust majority (~70% in a 2022 poll) favors that country acquiring its own nuclear forces as the threat from the North has entered a new dimension. Even Japan, long an advocate of total nuclear disarmament, has sought assurances that it is protected by the U.S. nuclear umbrella. If South Korea, a wealthy, a soft-power superpower, became the 5th member of the illicit nuclear club, it is hard to imagine that others would not follow suit. Ultimately, the US retains veto-power in this region, and presently the US neither wants nor would allow a nuclear South Korea.

The driver of security, including nuclear security, in East Asia is US-China relations. Since 2008, US-China relations entered a period of antagonism. That relationship has been deteriorating and is likely to continue its downward trajectory for at least another decade. The pressure has mounted considerably since 2016. The Trump administration used the language of 'great power competition' and described China as a 'near peer' rival— lowering the US from superpower and elevating the PRC to the same plane, as peer 'great power' competitors. The Biden administration continues that paradigm.

China has expanded its presence in the South China Sea by building artificial islands, establishing a military presence and claiming the surrounding waters as Chinese territory. This expansion creates messy devolutionary effects, and the Korean Peninsula is a case in point. China increasingly threatens Taiwan, the most prolific manufacturer of semiconductor chips in the world. For that reason, any threats to the security of an independent Taiwan are seen in Washington as a direct threat to American power and American security. For its part, US has launched several administrative initiatives to counter growing Chinese technological, economic and military power, by curtailing communication and collaboration between U.S. universities and their Chinese counterparts and by launching a broad and vigorous silicon blockade (in semiconductor technology, devices, and materials) against China that some see as an economic act of war.

Consequently, the spirit of US-China cooperation in place since 1972—a condition of possibility of East Asian peace and numerous East Asian economic miracles—is in jeopardy. Although Beijing is unlikely to launch a full-scale invasion of Taiwan, for example, the increasing risks of lower-level altercations will fuel anxiety and perhaps instability in the region as US-China relations are likely to deteriorate even further in the coming decade.

The security situation in the Middle East and Central Asia had been little better and recently has gotten much worse. India and China confront each other across a tense border. The animosity between the U.S. and Iran has worsened with the abandonment of the Joint Comprehensive Plan of Action (JCPOA) by the Trump Administration. The relations between Iran and Saudi Arabia as well as other the Sunni Arab states remain confrontational as the proxy war between Iran and Saudi Arabia in Yemen continues.
Despite the consensus resolution of the UN General Assembly supporting establishing a nuclear-weapon-free zone in the Middle East, Israel has established a sophisticated, covert nuclear weapons infrastructure and has armed itself with 100 to 200 airplane-deliverable nuclear weapons. Libyan and Iraqi nuclear weapons programs started but were abandoned. Iran—the only likely target of Israeli weapons—initiated and has continued with a determined nuclear technology program (ostensibly for civilian power) including uranium enrichment at Natanz (under IAEA safeguards). It also has developed a credible medium range missile delivery system. Neither the expense of those efforts nor the presence of Israel's nuclear weapons have lessened Iran's funding of regional proxies such as Hamas, Hezbollah, Da'esh in Syria, or Houthi tribes in Yemen.

In July 2015, the JCPOA was signed between Iran and France, Germany, the UK, the European Union, China, Russia, and the U.S. set limits on Iran's nuclear program. Although the IAEA was certifying that Iran was in compliance, the Trump administration denounced the JCPOA in May 2018. In response, Iran started to exceed JCPOA limits and now has several thousand centrifuges enriching uranium up to 60%, under IAEA safeguards. From 23 February 2021 onwards, Iran has stopped the implementation of its commitments, including the Additional Protocol. Moreover, Iran's decision to remove all the IAEA equipment previously installed for surveillance and monitoring activities related to the JCPOA has also had detrimental implications for the Agency's ability to provide assurance of the peaceful nature of Iran's nuclear program.

Israel's fears of the real dangers of an Iranian nuclear weapons capability are shared by Saudi Arabia and other Sunni-dominated states in the region. If an Iranian nuclear weapons capability were to develop fully, we would be looking at a 3rd nuclear age and a sea change in global security. Seen from that perspective, a major step toward devolution of global security took place, when the DPRK joined India, Israel and Pakistan as nuclear-armed states outside the treaty on non-proliferation of nuclear weapons (NPT), which is continually becoming less effective due to the lack of compliance of the nuclear countries within the treaty (U.S., Russia, China, UK and France).

Nuclear-weapon-free zones prohibiting nuclear weapons have been established in Latin America and the Caribbean, the South Pacific, South-East Asia, Africa, and Central Asia; Mongolia has declared itself to have nuclear-weapon free status. While non-nuclear-weapon countries are complying with their obligations by not producing weapons grade fissile material, by submitting to the safeguards regime, and by not developing nuclear weapons, the initial five

nuclear weapons states have made little progress in fulfilling their commitments under NPT Article VI: namely, *"to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control."* On the contrary, ongoing maintenance activity has been occurring at the nuclear test sites in China, DPRK, Russia and the U.S. Accompanying that activity has been the development of new nuclear delivery systems such as hypersonic glide missiles and new or upgraded generations of nuclear weapons and delivery systems in these countries.

In the 1980s the pre-existing relationships and language among top scientists from the superpowers was the foundation of the "Erice process" of stimulating arms control and lessening nuclear risks. Unfortunately, with the devolution of global security such contacts and conversations were discouraged since February 2022. Yet the need for dialogue has never been greater. Hopefully, some highly confidential back channels can be established. However, the number of countries that could act as facilitators is small.
Arms control negotiations involve challenges associated with selection of priorities, choices and positions for negotiation. Challenges are complex, and rapidly changing technological, geostrategic, economic, demographic changes challenge stability of any architecture. Current approaches are largely intuitive and quantifying risk is difficult. Might progress toward arms control and lessening of tensions be helped by applying formal methods of risk analysis of the ongoing developments of nuclear technologies?

The MCR has been investigating whether risk techniques useful in engineered systems such as aerospace or nuclear reactor design could be employed. Although a strictly probabilistic approach is not possible, focusing on fault-tree, event-tree, or decision-tree methodologies could be useful in analyzing non-engineered systems with complex human behaviors, especially when calculating probabilities of potential actions. In particular, they could allow for understanding the implications of the introduction of new weapons and delivery systems into the risk structure. However, formal risk assessments can also lose focus on the real security objectives, by not building strong guardrails into arms control agreements, by focusing on risk management more than risk assessment, by placing excessive confidence in seemingly favorable results, or by excessively increasing the complexity of technical controls.
In January last year, UN Secretary General Guterres noted that, "…. *the end of the Cold War also left us with a dangerous falsehood: that the threat of nuclear war was a thing of the past. Nothing could be more mistaken. These weapons are not yesterday's problem. They remain today's growing threat. The risk that nuclear weapons will be used is higher now than at any point since the duck-and-cover drills and fallout shelters of the Cold War."*

Session 2 Summary
Origins of the Covid-19 Pandemic
Infectious Disease PMP and Session Chairman: Franco Maria Buonaguro

Session 2 included 4 presentations: COVID etiopathogenesis, Franco M Buonaguro (Naples, IT); Unique aspects of African COVID pandemic, Sam Mbulaiteye (Bethesda, US); COVID pandemic in South-East countries, Ishwar Gilada (Mumbai, IN); Post-acute effects of protein misfolding in COVID, Sofie Nyström (Linköping, SE).

The COVID pandemic was unexpected. The scientific community was very concerned about a further flu pandemic, especially those related to the H1N1 virus, the etiological agent of the three major flu pandemics: the 1918–1920 Spanish flu pandemic, the 1977 Russian flu and the 2009/10 Swine flu. The latter H1N1 virus resulted from a previous triple reassortment of bird, swine, and human flu viruses which further combined with a Eurasian pig flu virus,[1] [15] leading to the term "swine flu",[2] the first pandemia of the 21st century. There were 1,632,710 laboratory confirmed swine flu cases and 18,449 deaths[3]. However, some studies estimated that the real number of cases including asymptomatic and mild cases could be 700 million to 1.4 billion people—or 11 to 21 percent of the global population

[1] Trifonov V, Khiabanian H, Rabadan R (July 2009). "Geographic dependence, surveillance, and origins of the 2009 influenza A (H1N1) virus". *The New England J. Medicine*. **361** (2):115-19. doi:10.1056/NEJMp0904572.
[2] Hellerman C (11 June 2009). "Swine flu 'not stoppable,' World Health Organization says". CNN. Archived from the original on 7 March 2010. Retrieved 3 April 2010.
[3] "Pandemic (H1N1) 2009". *World Health Organization (WHO)*. 6 August 2010. Archived from the original on 27 March 2011. Retrieved 8 April 2020.

of 6.8 billion at the time.[4] The lower value of 700 million is more than the 500 million people estimated to be infected by the Spanish flu pandemic.[5] However, at the time the Spanish flu infected about a third of the world's population, a much higher percentage.[6] Excess deaths, reported by WHO-USCDC, were 284,000 (range from 150,000 to 575,000) for the Swine flu/2009, versus over 50,000,000 deaths due to the Spanish Flu. [https://en.wikipedia.org/wiki/2009_swine_flu_pandemic#History]

The previous COVID pandemic in 2003 was mainly limited to China and South-East Asia. For this reason, the scientific community was not sufficiently monitoring the SARS-CoV-2 danger. The 2020 pandemic was much more severe with 6.85 million reported deaths (20 million estimated deaths), 673 million reported infections (5 billion estimated infections) and $28 trillion estimated costs. The disaster was mitigated only by the miraculous production in 10 months of a new mRNA-based vaccine and the rapid production of monoclonal antibodies. The virus is currently endemic worldwide with very limited pathogenicity, except for fragile patients.
The current data officially reported on the Worldometers are 696,406,335 infections with 6,924,844 deaths (https://www.worldometers.info/coronavirus/).

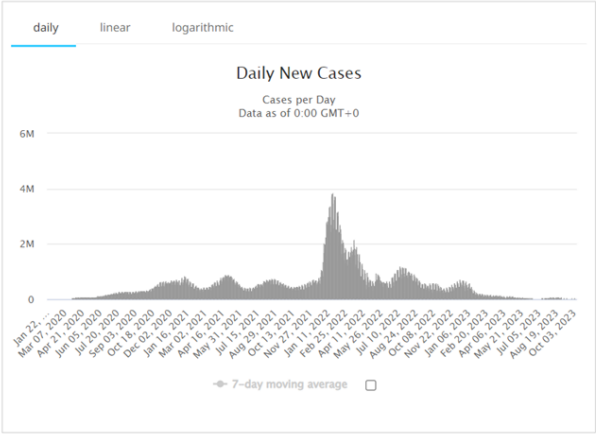
The peculiar aspects of the following table are the modest number of cases and deaths in China, where the epidemic broke out, with 15% of the world population, and the high number of related cases and deaths in Western countries. This disparity could be attributable to the inadequacy of tests and related misdiagnoses of the pandemic. The other possibility would be that previous epidemics of SARS-CoV infections, particularly the 2003 Urbani SARS-CoV epidemic, primed the immune systems of those populations, which became resistant to the virus.

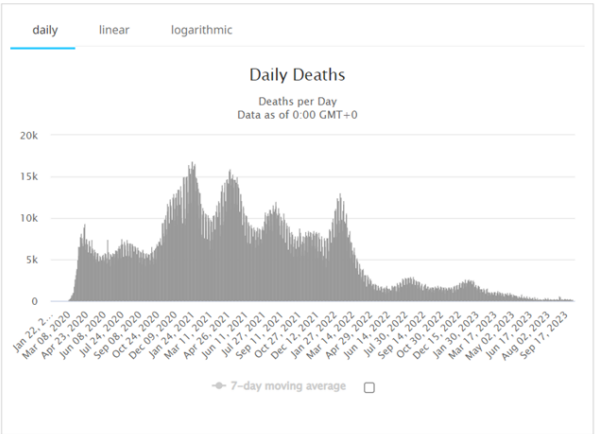
All | Europe | North America | Asia | South America | Africa | Oceania

#	Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	New Recovered	Active Cases	Serious, Critical	Tot Cases/ 1M pop	Deaths/ 1M pop	Total Tests	Tests/ 1M pop	Population
	World	696,406,335	+18,250	6,924,844	+28	668,349,081	+23,024	21,132,410	38,127	89,342	888.4			
1	USA	108,862,996		1,178,436		106,686,109		998,451	1,605	325,153	3,520	1,186,346,810	3,543,393	334,805,269
2	India	44,999,366		531,930		44,466,968		468	N/A	31,991	378	930,797,975	661,721	1,406,631,776
3	France	40,138,560		167,642		*39,970,918*		0	869	612,013	2,556	271,490,188	4,139,547	65,584,518
4	Germany	38,504,530		176,200		38,240,600		87,730	N/A	459,023	2,101	122,332,384	1,458,359	83,883,596
5	Brazil	37,827,912		705,962		36,249,161		872,789	N/A	175,655	3,278	63,776,166	296,146	215,353,593
6	S. Korea	34,571,873		35,934		*34,535,939*		0	231	673,523	700	15,804,065	307,892	51,329,899
7	Japan	33,803,572		74,694		N/A	N/A	N/A	83	269,169	595	100,414,883	799,578	125,584,838
8	Italy	26,126,792		191,852		25,774,213		160,727	48	433,548	3,184	275,228,417	4,567,139	60,262,770
9	UK	24,743,787		229,765		*24,487,796*	+1,246	26,226	N/A	361,234	3,354	522,526,476	7,628,357	68,497,907
10	Russia	23,061,960	+16,127	400,102	+25	22,498,445	+16,297	163,413	N/A	158,169	2,744	273,400,000	1,875,095	145,805,947
11	Turkey	17,232,066		102,174		N/A	N/A	N/A		201,399	1,194	162,743,369	1,902,052	85,561,976
12	Spain	13,914,811		121,760		13,762,417		30,634	231	297,840	2,606	471,036,328	10,082,298	46,719,142
#	Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	New Recovered	Active Cases	Serious, Critical	Tot Cases/ 1M pop	Deaths/ 1M pop	Total Tests	Tests/ 1M pop	Population
86	Palestine	621,008		5,404		615,445		159	17	116,173	1,011	3,078,533	575,907	5,345,541
87	Estonia	620,155	+82	3,001		524,990		92,164		469,136	2,270	3,742,779	2,831,342	1,321,910
88	Venezuela	552,695		5,856		546,537		302	31	18,885	200	3,359,014	114,771	29,266,991
89	Egypt	516,023		24,613		442,182		49,228	122	4,861	232	3,693,367	34,792	106,156,692
90	Qatar	514,524		690		513,687		147	16	172,664	232	4,065,369	1,364,257	2,979,915
91	Libya	507,270		6,437		500,833		0		72,048	914	2,483,848	352,782	7,040,745
92	China	503,302		5,272		379,053		118,977	N/A	347	4	160,000,000	110,461	1,448,471,400
93	Ethiopia	501,032		7,574		488,171		5,287		4,147	63	5,565,340	46,066	120,812,698

[4] Roos R (8 August 2011). "Study puts global 2009 H1N1 infection rate at 11% to 21%". Center for Infectious Disease Research and Policy.
[5] Kelly H, Peck HA, Laurie KL, Wu P, Nishiura H, Cowling BJ (5 August 2011). "The age-specific cumulative incidence of infection with pandemic influenza H1N1 2009 was similar in various countries prior to vaccination". *PLOS ONE*. **6** (8): e21828. Bibcode:2011PLoSO...621828K. doi:10.1371/journal.pone.0021828.
[6] Hagemann H (2 April 2020). "The 1918 Flu Pandemic Was Brutal, Killing More Than 50 Million People Worldwide". *NPR*. Retrieved 24 July 2020.

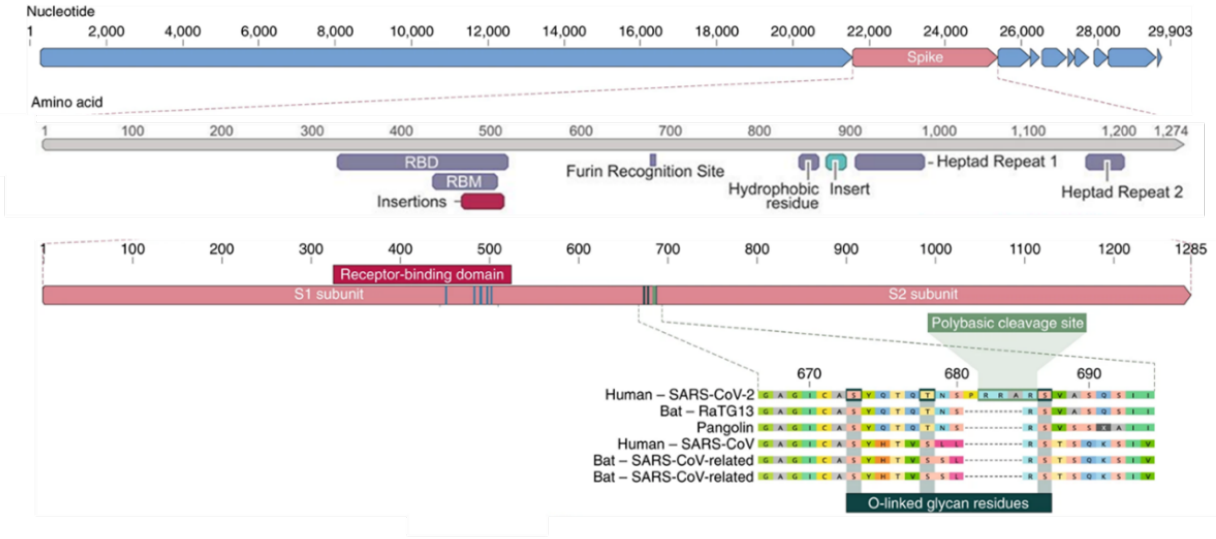
The latter could be a good possibility considering the current global trends of limited numbers of cases and deaths following several rounds of infections with different SARS-CoV-2 variants and multiple vaccine doses.





The first presentation on COVID etiopathogenesis, by Dr. Buonaguro, highlighted the possible origin of the SARS-CoV-2 virus, whose furin recognition sites are not generally identified in the SARS Coronavirus, as suggested by Andersen K.G. et al. report.[7]

Features of the spike protein in human SARS-CoV-2 and related coronaviruses.



Andersen, K.G., Rambaut, A., Lipkin, W.I. *et al.* The proximal origin of SARS-CoV-2. *Nat Med* **26,** 450–452 (2020).

This view was however challenged by a further article by Harrison and Sachs[8]. Moreover, some studies have identified other coronavirus isolates very similar to SARS-CoV-2 with homology >95%, but without the furin

[7] Andersen, K.G., Rambaut, A., Lipkin, W.I. et al. The proximal origin of SARS-CoV-2. Nat Med 26, 450–452 (2020). https://doi.org/10.1038/s41591-020-0820-9.

[8] N. L. Harrison, J. D. Sachs, A call for an independent inquiry into the origin of the SARS-CoV-2 virus. Proc. Natl. Acad. Sci. U.S.A. 119, e2202769119 (2022).

recognition site, which is frequent instead in non-SARS coronavirus. [9] The gain of function issue had previously been reported for the furin site in cystic fibrosis studies,[10] and considered a good target for innovative-targeted therapy.[11]

This very intense debate was based on the possible involvement of the Wuhan virology laboratory in the origin of the SARS-CoV-2 virus, which in any case was not likely to be the product of bacteriological warfare research. The further issue was how well the pandemic was handled considering that most other air-born infections have similar aspects including high transmission frequency, respiratory consequences and even ARDS (Acute Respiratory distress).[12] . Implementing measures to limit airborne transmission, including masks and social distancing, would have limited the peak of transmissions and mitigated the excessive use of intensive care units, the number of which is always limited given the costs. The life-saving therapy developed at the National Cancer Institute of Naples was also reported: the use of Tocilizumab, a monoclonal antibody able to bind and inhibit the IL-6 receptor, a cytokine involved in the Cytokine storm, which cause the severe clinical respiratory distress. Such treatment developed in March 2020 at the Cancer Institute, without the presence of any COVID patients, has been verified in clinical studies and it is still the most relevant therapeutic strategy for clinically severe patients requiring oxygen treatment.

Therapeutic Management of Hospitalized Adults With COVID-19

Last Updated: July 21, 2023

Table 2b. Therapeutic Management of Hospitalized Adults With COVID-19

Disease Severity	Recommendations for Antiviral or Immunomodulator Therapy		Recommendations for Anticoagulant Therapy
	Clinical Scenario	Recommendation	
Hospitalized for Reasons Other Than COVID-19	Patients with mild to moderate COVID-19 who are at high risk of progressing to severe COVID-19[a,b]	See Therapeutic Management of Nonhospitalized Adults With COVID-19.	For patients without an indication for therapeutic anticoagulation: • **Prophylactic dose of heparin**, unless contraindicated **(AI)**; **(BIII)** for pregnant patients
Hospitalized but Does Not Require Oxygen Supplementation	All patients	The Panel **recommends against** the use of **dexamethasone (AIIa)** or other systemic corticosteroids **(AIII)** for the treatment of COVID-19.[c]	
	Patients who are at high risk of progressing to severe COVID-19[a,b]	**Remdesivir**[d] **(BIII)**	
Hospitalized and Requires Conventional Oxygen[e]	Patients who require minimal conventional oxygen	**Remdesivir**[d,f] **(BIIa)**	For nonpregnant patients with D-dimer levels above the ULN who do not have an increased bleeding risk: • **Therapeutic dose of heparin**[h] **(CIIa)** For other patients: • **Prophylactic dose of heparin**, unless contraindicated **(AI)**; **(BIII)** for pregnant patients
	Most patients	Use **dexamethasone plus remdesivir**[f] **(BIIa)**. If remdesivir cannot be obtained, use **dexamethasone (BI)**.	
	Patients who are receiving dexamethasone and who have rapidly increasing oxygen needs and systemic inflammation	Add **PO baricitinib**[g] **(BIIa)** or **IV tocilizumab**[g] **(BIIa)** to 1 of the options above.	
Hospitalized and Requires HFNC Oxygen or NIV	All patients	**Dexamethasone** should be administered to all patients **(AI)**. If the patient has not already received a second immunomodulator, promptly add 1 of the following (listed in order of preference): • **PO baricitinib**[g,i] **(AI)** • **IV tocilizumab**[g,i] **(BIIa)** Add remdesivir to 1 of the options above in certain patients (for examples, see footnote).[i]	For patients without an indication for therapeutic anticoagulation: • **Prophylactic dose of heparin**, unless contraindicated **(AI)**; **(BIII)** for pregnant patients For patients who are started on a therapeutic dose of heparin in a non-ICU setting and then transferred to the ICU, the Panel recommends switching to a **prophylactic dose of heparin**, unless there is another indication for therapeutic anticoagulation **(BIII)**.
Hospitalized and Requires MV or ECMO	All patients	**Dexamethasone** should be administered to all patients **(AI)**. If the patient has not already received a second immunomodulator, promptly add 1 of the following (listed in alphabetical order): • **PO baricitinib**[g,i] **(BIIa)** • **IV tocilizumab**[g,i] **(BIIa)**	
Each recommendation in the Guidelines receives a rating for the strength of the recommendation (A, B, or C) and a rating for the evidence that supports it (I, IIa, IIb, or III). See Guidelines Development for more information.			

The following two presentations [Unique aspects of African COVID pandemic, by Dr Mbulaiteye, and the COVID pandemic in South-East countries, by Dr Gilada, focused on the specific epidemiological, social and clinical features

[9] Cohen J. Close cousins of SARS-CoV-2 found in a cave in Laos yield new clues about pandemic's origins. Sept 2021. Https://doi.org/10.1126/science.acx9257.

[10] Shobair M, Dagliyan O, Kota P et la., , Dang YL, He H, Stutts MJ, Dokholyan NV. Gain-of-Function Mutation W493R in the Epithelial Sodium Channel Allosterically Reconfigures Intersubunit Coupling. J Biol Chem. 2016 Feb 19;291(8):3682-92. doi: 10.1074/jbc.M115.678052.

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of the COVID pandemic in continents with a higher population. Detrimental social effects were reported and the negative impact of lockdown on the lower class with reduced economic power was highlighted.

The final presentation on post-acute effects of Protein misfolding in COVID, by Dr Nyström, focused on a peculiar aspect of the SARS-CoV-2 spike protein. Some fragment of the spike can aggregate in filaments whose deleterious effects are prevalent in the brain tissue as well as in the blood. SARS-CoV-2 infection is associated with a surprising number of morbidities. Uncanny similarities with amyloid-disease associated blood coagulation and fibrinolytic disturbances together with neurologic and cardiac problems led the investigation on the amyloidogenicity of the SARS-CoV-2 spike protein (S-protein). Amyloid fibril assays of peptide library mixtures and theoretical predictions identified seven amyloidogenic sequences within the S-protein. All seven peptides in isolation formed aggregates during incubation at 37 °C. Three 20-amino acid long synthetic spike peptides (sequence 192–211, 601–620, 1166–1185) fulfilled three amyloid fibril criteria: nucleation dependent polymerization kinetics by ThT, Congo red positivity, and ultrastructural fibrillar morphology. Full-length folded S-protein did not form amyloid fibrils, but amyloid-like fibrils with evident branching were formed during 24 h of S-protein coincubation with the protease neutrophil elastase (NE) in vitro. NE efficiently cleaved S-protein, rendering exposure of amyloidogenic segments and accumulation of the amyloidogenic peptide 194–203, part of the most amyloidogenic synthetic spike peptide. NE is overexpressed at inflamed sites of viral infection. Our data propose a molecular mechanism for potential amyloidogenesis of SARS-CoV-2 S-protein in humans facilitated by endoproteolysis. The prospective of S-protein amyloidogenesis in COVID-19 disease associated pathogenesis can be important in understanding the disease and long COVID-19. In particular, such results showed that the spike fragments can contribute to anomalous coagulation, not sensible to heparin treatment, and accelerate the neurological process characterized by fibril formation as in Alzheimer and Parkinson disease.

Session 3 Summary
The Oil Market and the Energy Transition
Energy PMP and Session Chairman: Carmine Difiglio

Since Professor Zichichi expanded the Planetary Emergency agenda to include other threats to humanity, besides nuclear conflict, energy, and energy policies, have been a core topic. In his keynote address, Professor Galbiati showed, with a few basic equations, why understanding energy was the key to 20th century physics and our modern technology. From pre-history through the industrial revolution, human development depended on finding new ways to harness energy - from agriculture, the plow, the domestication of animals, the wheel and smelting metals. The industrial revolution began with the first practical steam engine at the end of the 18th century. Since then, economic progress has rapidly accelerated with vastly expanded power for industry as well as life-changing new technologies. These included railroads, steam ships, products of chemistry, electrical power, electric lighting, many other new technologies powered by electricity, the internal combustion engine, farm tractors, motor vehicles, aircraft, electronics and computers: in essence, our modern world.

Petroleum has been an important part of this story since the first modern oil well in 1859. By the 20th century, modern economies depended on a reliable supply of oil at affordable prices. Between 1935 and 1970, due to ample excess US production capacity, managed by the Texas Railroad Commission, world oil prices remained stable and affordable, encouraging a steady increase in motor-vehicle production, roads, real-estate development and economic progress.[13] That all changed after US excess production capacity was reduced to zero and, in 1973, markets witnessed rapid price spikes followed by a steep plunge. These spikes slashed world GDP growth and pushed the OECD (the Organization for Economic Co-operation and Development) economies into recession.[14] The energy supply problem not only hurt the developed economies that were most dependent on oil, but stalled progress in developing nations who could least afford higher energy prices. Soon after the 1973 "energy crisis", many analysts warned that world oil supplies would soon peak and threaten continued world economic development. This theory did not account for technological progress, as it assumed that certain reserves of oil were too difficult to exploit. Even after deep offshore wells were increasing supply, "peak oil" concerns drove public policies to conserve oil and develop oil alternatives. "Peak oil" was finally abandoned after the US began to produce oil from its shale deposits.[15] After a decade of record-

[13] Robert McNally, *Crude Volatility*, Columbia University Press, 2017.
[14] Carmine Difiglio, "Oil, economic growth and strategic petroleum stocks", *Energy Strategy Reviews*, 2014.
[15] "Peak oil" as understood to be a peak, and subsequent decline, of oil production due to resource limitations despite growing demand. Once it was realized that this was not likely, "peak oil demand" replaced the concept of

breaking year-on-year oil growth, by 2019, the International Energy Agency (IEA) and several major oil companies assumed that the U.S. would, by itself, satisfy increasing world oil demand through 2030.[16] However, since the 2020 pandemic, we've had more net-zero policies, battery electric vehicle (BEV) growth, ESG pressures and greener oil company boards. As a result, there's been a dramatic change in the oil demand outlook by some governments and institutions supported by governments. For example, the IEA's 2022 net-zero scenario has led many to believe that we no longer need to invest in new oil production.[17] Other analysts are not so sure. Depending on one's view on whether net-zero targets would be achieved, there are now wide differences of opinion on the need to continue to invest in oil exploration and production (E&P). Net zero scenarios require a rapid replacement of internal combustion vehicles by BEVs. While China's BEV fleet is rapidly growing, there are questions whether almost all drivers will accept BEVs. It is also uncertain whether the power sector can eliminate fossil fuels and, at the same time, grow sufficiently to replace petroleum in the transport sector. There are also uncertainties about the mineral supply chain needed for BEV batteries and other renewable technologies.

Session 3 provided detailed data documenting the sources of increased oil production and consumption. These data showed that world oil supply flattened from 2005-2009 while non-OECD oil consumption was rapidly increasing. This led to a shift of available supplies from OECD consumers to the developing countries. Comparing economic progress, during this period, the developing countries were experiencing rapid economic growth while the OECD countries had typically stalled. Vast increases in U.S. shale production rapidly expanded world oil supply after 2009, which was especially fortunate due to the loss of Libyan production in 2011 and other outages following the Arab Spring. However, 10 years later, the outlook for a steady US role in expanding oil supply cannot be taken for granted. Measures of US oil shale activity have trended downward even as road and air travel have resumed pre-pandemic growth levels. Drilled-but-uncompleted wells (DUCS) are a measure of ready shale oil reserves. DUCS have rapidly declined since 2020. Even with relatively high world oil prices, US shale oil production growth has slowed.[18] Depending on E&P investments, future oil demand and the decline of oil production from mature wells may leave the world dependent on OPEC+, bringing the world oil market pretty much back to the situation it was in at the beginning of the 1970s energy crisis. Depending on one's view about net-zero, this may or may not be of concern especially if one expects that the pathway to net-zero will rapidly reduce oil demand, causing excess oil production and declining oil prices. However, a more sober estimate of BEV growth requires more oil E&P as billions of people enter the modern energy economy.

The expected increase in per-capita energy consumption in the developing world will spur global energy growth. Chinese and Indian data show that per capita energy consumption increases sharply with per capita income. If this holds, improved living standards in the developing world will require large increases in energy supply. To avoid big increases in developing world fossil fuel demand, a much larger shift to renewable and nuclear power will be necessary than is evidently being developed thus far. While the Chinese growth of BEVs has been impressive, with over half of worldwide BEV sales, climate benefits depend on lowering the carbon footprint of the Chinese grid. While China is geopolitically motivated to reduce its oil consumption, the same does not apply to its reliance on coal. Even if worldwide BEV sales rapidly increase, it takes time to reduce the fleet of internal combustion engine (ICE) vehicles. For example, if BEV sales grow to over half of total sales by 2030, BEVs will still constitute less than 20% of the total fleet. By 2050, reducing the ICE vehicle fleet to one-third of the total will require EV sales grow to 90% of total sales.[19] To achieve this, mineral supplies must increase in lockstep, not only with BEV production but for more renewable technologies in the power sector. Net-zero BEV growth by itself will require a 10-fold increase in lithium supplies between now and 2050.[20]

"peak oil". "Peak oil demand" anticipated a peak and subsequent decline in world oil *consumption* despite adequate oil supplies. This expectation reflected several trends including the saturation of internal combustion vehicle ownership in developed countries, improved vehicle efficiency, and the worldwide uptake of battery electric vehicles. A peak and decline of oil use was projected in most recent energy projections, including the International Energy Agency's *World Energy Outlook*.

[16] *2019 World Energy Outlook*, International Energy Agency.

[17] *2022 World Energy Outlook*, International Energy Agency. It should be noted that the IEA net-zero scenario is one scenario among other scenarios and that the IEA has not represented this scenario as a prediction, absent the significant policies needed to bring it about.

[18] Ibid, Kopits.

[19] Rystad Energy Oil Market Transition Solution, Rystad Energy OilMarketCube.

[20] Ibid, Rystad Energy.

While a large penetration of light-duty BEVs might be possible, electrifying the truck sector is far more challenging. Even lithium batteries are heavy for the power needed to provide enough class-8 truck range between recharges. In a light duty vehicle, while these batteries considerably increase vehicle weight, vehicle performance and load carrying capacity remain satisfactory. This does not hold for heavy trucks. Tractor trailers must typically weigh less than about 70,000 pounds. This provides a load carrying capacity of about 40,000 pounds. About 15,000 pounds of batteries are required to provide acceptable range in a heavy truck.[21] Holding all other factors constant, this reduces maximum load to 25,000 pounds, greatly affecting the economics of road transport. Consequently, net-zero scenarios estimate that hydrogen fuel cell tractors will replace diesel tractors. While technologically possible, the challenges to replace a diesel fleet with expensive hydrogen fuel cell tractors in less-developed countries, and provide the hydrogen refueling infrastructure they would require, are not well represented in the net-zero models that predict significant worldwide uptake of these trucks, especially considering that the majority of truck diesel fuel is consumed outside of the OECD. Plastics are another challenge to reducing oil consumption. Plastics demand is expected to double by 2050 and less than 10% of plastics are recycled.[22] While plastics can be made without using oil or natural gas as a feedstock, these alternatives are unlikely to be competitive or adequate.

If petroleum E&P is abandoned based on optimistic net-zero scenarios, while the resulting oil production is estimated to be nearly adequate in 2050, there would be massive shortfalls of oil supply before then. Realistic estimates show that the 2030 shortfalls would be 50 million to 60 million barrels per day (bpd). Shortfalls by 2040 would be to the tune of 40 million to 80 million bpd. Compare these shortfalls to current oil demand of just over 100 million bpd.[23] Of course, industry and world governments would never allow shortfalls of this magnitude to develop. Consequently, curtailing oil and gas E&P is an unacceptable public policy to achieving net zero. In addition, halting oil and gas E&P would not help to achieve net zero. The economic chaos it would cause, during the transition to net zero, would foreclose the clean energy investments that are needed to achieve net zero.

To understand why the outcomes of recent net-zero policies are so uncertain, it is worth exploring the models that are used to analyze green energy policies. Energy model methodologies have changed little since the 1970s when they came into wide use. A comparison of the predictions made by these early models to reality shows that they were widely off the mark. For example, renewable projections made by the Carter Administration, Amory Lovins and Bent Soerensen predicted that, by 2000, total renewables would reach between 20% to 40% of primary energy demand, mostly due to the growth of wind and solar energy. In fact, less than 10% of primary energy was supplied by renewables, almost all from hydropower and less than 1% from wind and solar. Projections made after 1990 were equally off. The U.S. Department of Energy and the UNFCC projected that, by 2020, renewables would grow to 27% (DOE) or 30% (UNFCC). By 2020, wind and solar energy reached 5% with total renewables achieving 12% of total primary energy supply, again widely off the mark. We have little reason to expect that current energy models will perform any better. First, the models have become considerably more complex, encompassing a wide variety of technologies required to achieve net zero. Many of these technologies have not achieved any commercial success. For example, coal plants with carbon capture are typically projected to be an important technology to achieve net zero. Yet, after over two decades of government support (demonstration plants), there are still no commercial coal plants with carbon capture. Battery electric and hydrogen fuel cell vehicles are estimated to essentially replace internal combustion cars and trucks within the next two decades.[24] These projections are not based on any assessment that the motor vehicle market would naturally evolve in this direction. The estimate comes as the model cannot find any other way to achieve net-zero by 2050. In other words, it is an 'end-driven' projection. To achieve this, governments must essentially ban internal combustion vehicles over time. Given this need, the next question is whether such a policy is sustainable, especially in the less developed world, the largest driver of increased petroleum demand. When confronted with the commonsense observation that poor countries are not likely to forgo cost-effective fossil fuels to achieve net zero, another assumption is made that the OECD countries will subsidize poor countries sufficiently to motivate them to forgo fossil fuels. The energy models have no capability to assess these assumptions. One needs to consider, without relying on models, whether such outcomes are likely. It appears that the outcome of net-zero models will only be achieved if governments completely suppress fossil fuels in every sector of the energy economy and that OECD governments transfer enough wealth to less developed nations to get them

[21] Carmine Difiglio, "Hydrogen Fuel Cell Vehicles: Why do we need them with the rapid uptake of BEVs?", EMFCSC, July 2022.
[22] Ibid. Rystad Energy.
[23] Ibid, Rystad Energy.
[24] International Energy Agency, 2022 Net-Zero Scenario. *2022 World Energy Outlook.*

to do the same thing. While such an outcome might be achieved, the likelihood that it might not explains why, today, the outlook for future petroleum demand is so uncertain with some outlooks assuming net zero and others greatly scaling back what is likely to achieved, especially in less developed countries/regions like India, China, the Middle East and Sub-Saharan Africa. For the oil market, this uncertainty leads to a wide difference of opinion about how much E&P investment must grow, if at all.

Three countries are responsible for over one-third of world oil supply: the US, Saudi Arabia and Russia. As discussed above, the outlook for US shale oil growth has been substantially revised since the pre-pandemic estimates. While the US will continue to be an important oil exporter, several factors make it unlikely that the US will be adding over 1 million bpd of world oil supply every year. Saudi Arabia will likely want to achieve its budget targets with higher prices, not higher production. Since the Ukraine war, the outlook for Russia reflects different assumptions about how restricted Western investments will affect the country's oil sector or how successful Moscow will be in finding new customers. Data shows that while Russian exploratory drilling has declined, this has been offset by increased development drilling.[25] There has also been uncertainty about how the withdrawal of Western services sector support, which was about 20% of the Russian services sector, will affect its future oil production. Nonetheless, the Russian services sector has benefitted from 30 years of learning from Western companies. In addition, the future growth of Russian oil production - with or without Western service companies - is expected to be conventional oil, not "new" oil such as the exploitation of tight oil reserves. This is not only true for Russia, but almost all tight oil reserves outside of North America.[26] Also, increased Russian oil production does not depend on drilling deep offshore wells, something that might be more challenging without Western E&P companies. Regarding finding new customers, there has already been a major shift from pipeline exports to seaborne exports that were necessary to move Russian oil deliveries from Europe to Asia. Russian refining trends in 2022 were also not significantly different than in prior years. Consequently, it does not appear that the pre- and post- pandemic assessment of future Russian oil output has changed very much, especially compared to the revised outlook for the US.

To sum up, a more sober outlook for U.S. shale growth, likely OPEC+ policies, and the likelihood of increasing world oil demand, despite net-zero policies, all imply that oil E&P investments must increase to avoid world-wide economic disruptions.

Session 4 Summary
Engineered Mitigation of Risks to Societal Infrastructures
Session Chairman: William Barletta
Mitigation of Catastrophic Risks PMP Chairmen: William Barletta and Adnan Shihab-Eldin

Societal infrastructures in industrialized and especially in developing countries face catastrophic risks due to natural disasters as well as due to man-made events. Often the consequences of natural events are amplified by poorly designed and sub-standard fabrication of man-made structures, such as buildings, bridges, and dams. During the past thirty years, highly developed countries in earthquake zones have adopted increasingly stringent building codes consistent with best engineering practices that seek to assure that new structures are resilient against collapse in all but the strongest earthquakes, tsunamis, and floods. Even during the past fifty years, poorly engineered large dams built after inadequate characterization of the earthen foundations have collapsed flooding many hundreds of square kilometers and causing hundreds of millions of dollars of damage. The challenge to society is to engineer new infrastructures and retrofit existing infrastructures to provide continuing service to society even in the face of large man-made and natural disasters.

Even the air around us has become a focus of engineering challenges. Regardless of one's opinion about the degree to which added anthropogenic CO_2 will raise global temperatures, many governments have put in place plans aiming at net-zero carbon emissions by 2050. Yet because of the long-time constants that characterized atmospheric chemistry, both governments and entrepreneurs have been investing in technologies with the potential of removing gigatons of CO_2 from the atmosphere and storing it underground. Can such efforts be engineered to be cost-effective? Can subterranean storage of CO_2 at a scale far greater than any previous experience be sustainable for

[25] Vitaly Yermakov, "Russian oil output increase in 2022 amid unprecedented Western sanctions: What's next?", *Oxford Institute for Energy Studies*, July 2023.
[26] Ibid, Difiglio (2014).

millennia? Can storage sites be resilient against earthquakes or other natural disasters? The challenge to engineers, societal planners, and government regulator continues to grow ever greater.

Cost-effective, sustainable resilience offers a strategy for mitigating large-scale risks to societal infrastructures through engineering. Some definition of terms is in order. For example, the U.S. Environmental Protection Agency (EPA) defines *sustainability* as the ability to create and maintain conditions under which humans and nature can exist in productive harmony and that permit fulfilling social, economic, and other requirements of present and future generations. A definition commonly used with regard to energy infrastructures is the ability to maintain or improve standards of living without damaging or depleting natural resources for present and future generations. In the United States, a U. S. Presidential Policy Directive (PPD) defines *resilience* as the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. A definition of resilience by Ayyub is the persistence of a systems functions and performances under uncertainty in the face of disturbances.
The lack of sustainable resilience that motivated this topic was the complete collapse of urban buildings after a moderately strong earthquake in Southeastern Turkey and neighboring Syria on February 6, 2023, leaving millions of people in the region struggling to rebuild their lives. The situation in northwest Syria has worsened since the disaster, with affected communities enduring immense challenges: displacement, hunger and malnutrition, lack of access to healthcare, and fires caused by extreme summer heat.

To apply the concepts of sustainability and resiliency in a useful manner, the engineer needs to assign quantitative metrics. Thus, an underpinning notion in designing, tracking and achieving *sustainable resilience* for a society is performance definition and its measurement in terms of societal well-being. Multi-dimensional measures include economic output (GDP per capita), economic consumption, mortality rates, life expectancy, recovery time, welfare loss, societal resilience defined as the ratio of welfare loss to asset loss, etc.

Quantifying the attributes of performance of a societal infrastructure requires the engineer to identify and analyze all applicable hazards and also to apply economic valuation that accounts for the society's attitudes toward the various risks. Quantification of uncertainties both for economic valuation of the infrastructure and for analysis of tradeoffs is central in planning, operation and maintenance. The temporal time profiles for these performance attributes can then be estimated and enhanced with the considerations of sustainability and cost-efficiency.
Societal planners and engineers should also examine the components of resilience. These include robustness, redundancy, rapidity of repair, adaptability and efficiency. Each component should be monitored and regularly treated for enhancement considering sustainability and economic efficiency. Achieving sustainable resilience in developing countries starts with human capacity building and cultural changes including changes in leadership and attitudes for becoming resourceful and purposeful with knowhow. Planners and leaders also need familiarity with available technologies for achieving sustainable resilience.

As an example of these concepts, consider complicated, extensive system in which sustainable resilience is in order. Local and region water systems are combination of natural and nature-based (so-called green) infrastructure combined with engineered gray infrastructure (structures). The resulting green-gray infrastructure is composed of the physical and operational structures (such as reservoirs, dams, seawalls, pipes or water treatment plants) and protocols for managing and controlling water. The physical structures are used to: (a) manage and control water supplies; (b) deliver water to users; and/or to (c) remove and treat wastewater. The challenge of resilience is engineering and operating the constituent water systems and sub-systems to meet society's needs now and, in the future, to enhance sustainability and quality of life.
As discussed above, designing and operating of water systems is not simply engineers and planners choosing the lowest cost solution that satisfies local and national codes and the relevant environmental and public health regulations. Rather the engineer must consider and balance a multiplicity of factors such as controlling physical risks and vulnerabilities, minimizing negative environmental impacts, assuring physical security, advancing long-term policy and development goals, providing sound governance with an eye toward aesthetics, and assuring resilience with respect to fluctuating supply and demand.

The risks associated with the water infrastructure may be succinctly summarized as: controlling too much water; coping with too little water in the system; confining and cleaning polluted water; and preventing disruption to safe water supplies from either natural or man-made events. Protecting the water infrastructure is especially difficult because it is extensive, spatially distributed, and diverse in its physical characteristics. Consequently, both the range of events that could impact a water infrastructure and the costs and financing of adequate protection are crucial to

assess as completely and accurately as possible. Specifically, large-scale risks may be associated with natural events such as floods/tsunamis, severe storms, volcanoes, droughts, and earthquakes. But they may also be associated with anthropogenic events: accidents, mismanagement, and malicious actions such as cyber-attacks or physical attacks including the purposeful contamination of water supplies.

Managing and mitigating of the risks associated with a water infrastructure must address both the traditional natural and anthropogenic risks described above. As was discussed in Session 1 of this year's Seminars, in an ever-expanding global, technical and politically complex world, the likelihood of a nuclear-related event cannot be discounted. Unfortunately, the potential impacts of a nuclear-related event on water infrastructures have not been adequately addressed. The nuclear-related risks could arise due to use of nuclear or radiological weapons, nuclear accidents, nuclear terrorism, or mismanagement of nuclear facilities. They might even be due to naturally occurring radioactive materials present in surface and groundwater. With respect to nuclear-related risks, questions to be addressed include: (a) Are the managers of water systems prepared to handle a nuclear-related events?; (b) Are current actions aimed at making water systems more resilient to natural disruption also applicable to nuclear-related events?; and (c) How can the scientific and engineering professionals help steer the managers of water systems towards modifying those systems for resilient sustainability even in the face of nuclear-related events?

An even larger challenge to engineers that has been posed by policy makers and some scientists is the control of the amount of CO_2 in the atmosphere. Increasing levels of CO_2 (~2 ppm/yr.) are projected by the IPCC to have the potential for large enough changes in the biosphere that many nations are actively targeting energy policies of "net-zero by 2050." These policies include decarbonizing the energy sector by switching to renewable energy, nuclear energy, and reducing carbon emissions relative to coal generation by switching to natural gas coupled with carbon capture at the source followed by subterranean sequestration. However, given the large residence time of CO_2 in the atmosphere (~700 years) and the guided by a roughly logarithmic correlation of global temperature increase on the concentration of carbon dioxide, many people advocate for direct air-capture of carbon dioxide.

To have an appreciable benefit by the end of the present century, direct capture would have to reach a level of ~1-2 ppm/yr. Are the costs in money, land, and energy commensurate with that or greater rates of capture? Cyclical CO_2 removal technologies, such as direct air capture incurs costs due to capital investment, the cost of capture (energy for operating the process), the cost of CO_2 release and regeneration of the sorbent material or process, and sorbent losses and maintenance of equipment. In direct air capture systems, there is a thermodynamic minimum energy required for separating the 420 ppm concentration of CO_2. Once-through systems such enhance rock weathering require moving massive amounts of material and energy costs for breaking the rock into small pieces that can more rapidly absorb CO_2 in air. Depending on intended fate of captured CO_2, the following requirements may be necessary: CO_2 compression, transportation of pressurized CO_2 to storage sites, geological sequestration, and monitoring of leakage and other unintended environmental impacts. If the world could afford capturing a few hundred gigatons of carbon dioxide, could that amount—far beyond actual engineering experience—be properly measured and stored safely? What are the risks of a catastrophic sudden release of even 0.1% of the stored CO_2? Could those consequences be mitigated to an acceptable level?

It is difficult and costly for technology to do as well as the Earth's natural processes in absorbing CO_2. With present technologies the most optimistic projects indicate that DAC costs *might be* at the edge of practicality**.** This estimate has not been demonstrated at any large-scale facility. Moreover, choosing to pursue carbon dioxide reduction will be hugely expensive. It may be more economical to decarbonize an existing energy source, and such a large expenditure must be weighed against competing needs for fiscal resources, such as that providing energy for nations which are in extreme energy poverty.
Much more research is worthwhile**,** but how much can and should be debated in the context of forms of examining a variety of geo-engineering concepts to reduce greenhouse gas concentrations. Such a broader examination is planned for next year's Seminars.
In response to the dramatic incidence of severe wildfires this summer, the MCR PMP has formed a new sub-panel focused on global risks of wildfires and strategies to reduce their severity and the damages they cause. A central activity will be a pilot project to detect and characterize potentially dangerous wildfires in urban, exurban and transboundary zones and to identify means for their control before they can threaten population centers.

Countermeasures involve distributed sensors, computational intelligence, advanced firefighting materials and methods, and automatic and semi-autonomous responses. Earlier prototype experiments in Italy have employed

fire-detection drones. In the past using satellites to track wildfires once they have spread has not been especially effective in distinguishing controlled burns and other heat sources from incipient wildfires. Infra-red detection is thought to be at least as useful as smoke detection, as embers can spread miles ahead of the flame fronts with high winds.

The initial systems analysis of the stages of the wildfire mitigation begins with identifying the global data that can be used to prioritize regions for pilot projects. Possible regions for detailed study include Sicily and California. Of particular interest for those two regions are the roles of hot winds—Scirocco winds in Sicily and Santa Ana winds of California. Regional-scale models will permit matching the characteristics of lifecycle stages of wildfires against a portfolio of detection technologies and policy countermeasures. A key aim is to formulate and seek third-party support for a local pilot project.

Session 5 Summary
The Future of Cyber Security
The Future of Cyber Security PMP and Session Chairman: Axel Lehmann

The PMP on The Future of Cyber Security, founded by Prof. Antinino Zichichi in 2001 as the PMP on Information Security, was always addressing permanent increasing security risks and counter measures of data and information fraud in the digital age. These included data theft, manipulation or corruption, violation of privacy, distribution of fake data and information, or denial of services - just to mention a few of those risks. Regarding the "Digital World" of today, a major challenge of increasing importance concerns the exponentially increasing complexity of digital systems, their increasing interconnectivity which results in increasingly emergent behavior of "Systems-of Systems". This challenge requires fundamental research, e.g., on advanced information and communication (ICT) architectures, design concepts for resilient systems design, just to mention two basic research directions, but which are not subject of this PMP.
During the 2023 Seminars, cyber security panel members held meetings and gave presentations at the Plenary Session including discussions on recent advancements of ICT, computing, sensor technologies, communication networks and software technologies. These enable rapid innovations, such as development of new AI tools and applications for so-called "smart systems". Examples for these innovations are advanced robotics capabilities, smart energy and e-health systems, or autonomous systems enabled by advanced AI. These opportunities also create new challenges - last but not least - for information and cyber security.
Besides technological aspects, status-quo of international normative and legal regulations of ICT developments and applications were also presented and analyzed during several panel meetings. In this regard, major attention was given arising regulatory deficits for recent advancements of AI tools and applications. Besides all benefits of AI, the panel considers as a major challenge the recent "tsunami" of increasing opportunities and risks of generative AI technologies and their consequences for our public, private and social life. As almost all AI applications depend on the availability and quality of data, the PMP also emphasizes these important risk and security factors for AI applications and the necessity to generate global public awareness. Regarding potential future developments of AI, the panel points to a recent statement of Sam Altman, Demis Hassabis, Geoffrey Hinton, *et. al.* (in Fortune, May 30, 2023) that "… A.I. poses a "risk of extinction" on par with pandemics and nuclear warfare …".

Summary of Presentations in Plenary Session 5
During the Plenary Session, Cyber Security Challenges in Conjunction with the Current Crises, PMP members provided 4 presentations:

Information technologies – Quo Vadis? Starting with a brief historical review of ICT developments over the past 50 years, the presentation reminded the audience of the continuing increased performance of computing devices and of communication networks while at the same time IT innovation cycles for new products are decreasing. These developments have led to the vastly increased complexity of smart systems and System-of-Systems - a fundamental scientific research challenge to master this complexity.
Special attention was given to rapidly evolving developments of AI technologies, tools and applications. As a recent and prominent example, developments of generative AI tools were mentioned, especially of Large Language Models (LLM) like ChatGPT, which open new sources of data and information fraud as well as of security risks.
Besides significant potential benefits of AI tools and applications, the panel also mentioned arising risk factors and new challenges for data, information and cyber security. Besides correctness and validity of applied AI methods and tools, sources, context and quality of applied data, information or knowledge has to be carefully considered. It was

also cautioned overestimating expected AI benefits with allusion to the two past so-called “AI winters”, where high expectations on performance of AI tools and applications could not be achieved.
The presentation also summarized future potentials and benefits of advanced IT-developments based on classical physics, quantum technologies, advanced computing architecture principles like parallel, distributed, cloud or edge computing, inductive and deductive reasoning methods applied in AI applications, and of the necessity for future resilient systems design principles.

Technological Challenges – AI and Quantum Computing: Nowadays almost everybody in politics, business or in public and private life is talking about AI or even using it. But according to a poll in 2018, among 1,500 senior business leaders in USA, only 17 percent were familiar with AI. Especially starting with the first release of ChatGPT in November 2022, a wider audience and a rapidly increasing user community became aware of an AI capability known as generative AI. Therefore, we summarized important development steps and keystones of AI: basic methods, algorithms and their applications, e.g., in expert systems (in the 80s), as well as of machine learning (in the 90s, based on artificial neural networks, genetic algorithms and statistical approaches), as well as deep learning (in the 2000s, with multilayer neural nets). These ground-breaking developments were enabled by advances in microelectronics and nanotechnology, by permanent increasing computing performance and storage capacities, by advancing sensor technologies for collecting huge amounts of data (big data), and by the ubiquitous nature of communication networks and the internet. Besides rapid advancements for businesses and industries, these innovations also pushed and increased demand for social networks, smart systems and innovative AI tools, such as for generation of text (e.g., ChatGPT), images (e.g., DAL-E 2), natural language processing (e.g., Transformer) or platforms for creating multi-lingual chatbots (like BotStar). But these advancing AI technologies are also sources for increased vulnerabilities. security risks, and criminal activities. These developments are opening new challenges regarding ethical and social behavior of developers and users, e.g., in context of developments of smart systems, such as autonomous vehicles or application of AI-based decision supporting systems. Especially the development and use of generative AI tools open new sources for information and knowledge fraud, e.g., by bot nets, in social networks, just to mention some examples. With the achievement of physical limits of today´s classical semiconductor chip production, quantum physics and technologies are getting more importance for next generation communication and computing. Especially for cryptography communication based on quantum technology will play an important role. While still subject of basic research with many open challenges for practical use, quantum computing and AI have the potential to interact and complement each other. As such, quantum computers could speedup machine learning capabilities or natural language processing. But still challenges like hardware constraints and appropriate algorithms have to be solved.
In summary, besides major beneficial achievements of current AI technologies, resulting new security and safety risks as well as missing normative and legal frameworks require intensive research and rapid action.

Common Code of Conduct, Normative and Legal Rules**:** This presentation started with a brief review of recent cases that demonstrated missing national and international code of conducts, norms or legal basis for AI applications. With the rapid growth of generative AI tools and applications, e.g., based on Large Language Models (LLM) for automatic text generation, especially starting since November 2022 with Chat GPT, leading meanwhile to an exponential wave of worldwide used automatic generation of content without a normative or legal basis. A majority of IPR and copyright regulations throughout the world do not explicitly address AI-generated content – text, pictures, audio, etc. With generative AI, it is not always clear who the creator is or how much involvement a human has had in the creation of the work as chatbots are extensively used by all kind of actors.
Corresponding consequences and deficits are becoming obvious: Missing measures to ensure legality, correctness, validity and authenticity of AI tools, applications and results.
A global legal basis is required to ensure legal responsibility of AI tool developers and users, as well as warrantee of data protection and data privacy just to mention some of these open questions. Otherwise, AI and cybersecurity have an intrinsic connection with each other. AI is being rapidly used to bolster cybersecurity and offer more protections against sophisticated hackers. It helps by automating complex processes for detecting attacks and reacting to breaches.
With the exponential increase of AI applications and availability of generative AI tools especially, the AI ecosystem of tools and applications must be secure and resilient from cybersecurity attacks. Besides missing legal regulations or normative rules, codes-of-conduct are urgently required considering ethical and social consequences. The presentation also mentioned some examples of already existing national regulations or policies concerning AI, but points to the necessity for global approaches which are urgently required to solve at least some of the addressed deficits and problems.

***Data Ethics*:** As volumes of measured and collected data, information and knowledge is exponentially increasing - the well-known, big data "problem". Along with this development also problems of data and information fraud, theft and violations of privacy, transparency, accountability and fairness are increasing, so that guiding principles for data ethics are urgently required.

The presentation defines and explains the importance of data ethics. OECD Recommendations state that ''Private data may only be used and shared with definite boundaries''. ''Public data should be open, inclusive and clear". The UN Development Group (UNDG) has developed a "Data Privacy, Ethics and Protection Guidance Note on Big Data for Achievement of the 2030 Agenda". According to US-Federal Data Structure, data ethics is "…the norm of behavior that promote appropriate judgments and accountability when acquiring, managing, or using data". The European Commission states more general that "…. data ethics is about responsible and sustainable use of data". In accordance with the OECD and the UN, data ethics' frameworks have to include measures of transparency, accountability and fairness of data.

Especially in context of AI applications, compliance with ethical guiding principles or norms plays an important role. These principles or norms have to be related to quality, validity and trustworthiness of data, information and knowledge and their sources. Such codes of conduct and even more legality have to be met in the context of personalized content creation (e.g., messages, text, sound, photos, video), as well as for scientific measurements and observations. Furthermore, there are other important ethical questions that may be attributed to AI, such as legal liability for autonomous systems, trustability of AI judgements in court, responsibility of AI-led medical operations or medical prescriptions, or liability for dynamic behavior of robots. AI ethics should be prepared to answer those questions.

Session 6 Summary[27]
Progress on Small Modular (Nuclear) Reactors
Session Chairman: Adnan Shihab-Eldin
Energy PMP Chairman: Carmine Difiglio

In recent years, a major change has occurred in the global nuclear-power industry. After decades in which almost all nuclear power reactors worldwide have been large units, each generating about 1,000 megawatts (MW) or more of electricity, the industry has turned its attention to designing an entirely new generation of reactors called 'small modular reactors,' or SMRs. There are now over 75 new SMR designs being developed around the world, and almost every company, institute, or government agency working on new-reactor technology is concentrating on one or more of them. A couple of SMRs are actually in operation now; perhaps a dozen or more are in the early stages of construction; and another few dozen are in the 'talking stage' during which the reactor designer-developer is negotiating with a host electric utility or company about the terms for starting an actual deployment project.
The reactor technologies under development today also span an enormous range of coolant types (water, gas, liquid metal, molten salt, etc.), neutron-spectrum types (thermal neutrons, fast neutrons), moderators (water, heavy water, various other liquids, graphite), sizes (from as small as a few megawatts-electric to a few hundred MWe) and other characteristics. What is common about them, or at least most of them, is their smaller size, their promise of much improved safety, their expected lower capital cost (per unit), and the broad idea that a nuclear-power site might consist of many individual small factory-manufactured modules rather than one or only a few of the gigawatt reactors deployed now.
What are the drivers that have motivated so many companies, institutes and government agencies to be working on the many SMR designs now under development or in early stages pointing toward deployment? The drivers vary worldwide, but two common factors seem to be economics - the potential for electricity or other energy services at lower costs – coupled with the fact that nuclear reactors do not release significant carbon dioxide that affects the climate. Other drivers are that the SMRs mostly promise much improved safety, offer siting flexibility, require capital investments in smaller increments, and can assist in electricity-grid stability. Also, they can be factory-fabricated, making manufacturing, construction and installation potentially simpler and faster. Not every new SMR design potentially offers all of these benefits, but most of the SMRs offer most of them, and some of them also seem to be aiming for non-electricity markets such as industrial process heat, hydrogen production, or sea water desalination.
Despite the many important potential benefits, it is not at all clear that, in the end, the SMRs as a class will end up dominating the nuclear-power market in decades to come, nor that the overall nuclear market will grow in a way

[27] Drafted by Robert J. Budnitz. Lawrence Berkeley National Laboratory (ret.), Energy Geosciences Division.

that will be able to absorb a large number of SMRs. Also unknown, even if the growth occurs, is which of the many different SMR reactor technologies and designers-vendors will win out in the end, and how quickly, and where and why. In addition, it is not clear whether SMR deployment, if it happens, will occur in parallel with continuing deployment of a significant number of large reactors that are similar in size to today's deployed reactors, or will occur almost entirely at the expense of a diminished deployment of those larger designs, even if the large new reactors will themselves embed many advanced features.
There has always been opposition to nuclear-power deployment in some parts of society worldwide, and in some governments, based on a variety of concerns (including the potential for large accidents, radioactive-waste disposal, security, and weapons proliferation). The opposition's importance and intensity have varied over the past many decades and may now have entered a less influential period. Whether it will prevail, and where, is again unknown. This will all evolve in the next several years. The remainder of this report will outline the most important factors affecting how this future will play out.

Economics: The economics aspect will likely be the most important determinant of whether SMRs as a class, or any individual SMR design, will succeed in being widely deployed. Today, gigawatt scale reactors are widely viewed as uneconomic in many electricity markets. They seem unlikely to compete with either natural gas or renewables (solar, wind), with a few exceptions in places where today's electricity is extremely expensive or where government subsidies to nuclear energy distort the true market costs.
This cost problem with the larger reactor designs, in particular the high up-front capital needed, provides the opportunity window for SMRs. But what is not known today and won't be known for several years (or more) into the future, is whether the costs of any of the SMRs will be able to compete successfully - in terms of both the capital required and the cost of electricity or other energy generated. This cannot be known now in part because it will depend a lot on whether series production of Nth-of-a-kind SMRs will make them cheap enough – the first ones probably won't be. Only time will tell whether economies due to factory-manufacturing efficiencies and other economies of SMR deployment will be sufficient. Delays in licensing of these new reactor types may also affect costs. Another aspect is whether the complexities of obtaining regulatory approval to proceed with a given SMR at a given site will hurt the investment structure intolerably, or not. Again, only time will tell.

Safety: There is a broad consensus that most of the new SMR designs offer significantly enhanced safety compared to today's deployed large reactors. There are four principal reasons for this: First, significant advances have been made over the past decades in engineering, in materials, in software used for control, in the effectiveness of human-influenced operations and in equipment reliability. They have made today's operating fleet much safer than 20-30 years ago, and these advances are all reflected in the new SMR designs. This means, for example, that the abnormal conditions that could lead to a potential accident sequence are far less likely to occur in most SMRs. Second, the SMRs' smaller size means less heat to cope with in abnormal conditions, more time before accident conditions can get out-of-hand, and less radioactivity to be potentially released if an actual release were to occur. Third, the new SMR designs all strive to take advantage of numerous insights learned in operating today's larger reactors, leading, for example, to the incorporation into the SMRs of many new passive features that involve less need for active human intervention or functioning of active equipment. Finally, there have been improvements in regulations, in safety culture, and in analysis and monitoring of reactor designs to detect problems. Together with an international sharing of best operating practices, these advances mean that if a reactor starts showing signs of problems, it is much more likely that intervention will occur before things get out-of-hand in a way that could lead to an accident. For all of these reasons, these new SMRs will almost surely have a much smaller risk profile - less frequent upset conditions, less frequent actual accidents, and less severe consequences if an accident were to occur.

Safety regulations worldwide: The regulation of the safety of any reactor worldwide is the responsibility of the country in which it based, and is universally assigned to a national regulatory agency, each of which has its own regulations, inspectors, enforcement procedures, and the like. The International Atomic Energy Agency (IAEA) has had a program for decades under which it has developed model safety regulations, analysis methods and inspection protocols, and has provided assistance when requested from any member state to help assure that the regulatory agency is doing a competent job. The IAEA also offers various inspection services in many technical areas and in many procedural and administrative areas too. There are also international treaties that provide a framework for assuring that the safety of a nuclear power program in each member state meets IAEA standards.
However, the IAEA has no enforcement authority; it merely provides guidance, inspection services when requested, and the power of outside peer pressure when appropriate. This will be true for the new SMRs just as it is for the several hundred existing operating power reactors worldwide. Although strengthening the IAEA's mandate,

capabilities, or both seems highly desirable, it is unlikely to happen soon. A more immediate challenge for the IAEA arises because the new SMRs will, in some cases, be using novel technologies. Hence, its guidance documents and inspection protocols will need to be revised, updated and tested. This revision and updating process is now under way but will not be fully in place for at least a few years. The importance of this IAEA role in coordinating activities across many countries cannot be overemphasized. Also, in most countries with reactors operating today, the safety regulations are tailored to the technology deployed in that country. If SMR deployment using a different technology is contemplated, these safety regulations need to be modified or new ones developed to cover the specific technical issues that arise. This regulatory-revision work is under way now worldwide, including an effort to make the new regulations adopted in different countries compatible so that an approval granted in one country may be easily accepted in others.

SMR deployment internationally: It is likely that the potential advantages of SMR technology will lead to greater deployment of nuclear power, including countries that have not had nuclear power before. However, challenges and barriers also exist when developing a new nuclear-power program: it can require a significant investment in infrastructure, beginning with the establishment of a national regulatory agency (akin to the Nuclear Regulatory Commission in the US) empowered by legislation to license and regulate the SMRs as they are built and operated. Establishing such an agency is difficult, and although there is detailed guidance on how to do this in IAEA documents or programs, even the most successful recent newcomer-country regulatory programs have taken a decade or so to reach maturity.

Achieving an acceptable safety culture can also be problematic. Some countries are widely known as suffering from disturbing corruption at various levels in the society. In these cases, it is essential to ensure that this corruption does not affect the effectiveness of the nuclear-power program. Some countries have a culture in which calling attention to an error or other failure by a colleague is deeply frowned upon, especially if the colleague has higher social or managerial rank or is much older. And some countries have a sufficiently weak or ineffective central government that many of the new SMR vendors might decide simply not to allow their new SMRs to be installed in that country.

The worldwide nuclear-power industry is diligently working now on approaches to ensure that the regulatory issues mentioned will not become a barrier to widespread SMR deployment.

Security and safeguards: Today there is an international safeguards regime under the Non-Proliferation Treaty, administered by the IAEA and participated in by almost all countries. Existing and newcomer countries with SMRs will have to fulfil the requirements of this regime, but this is unlikely to be a major barrier in the end to widespread SMR deployment. However, because SMRs represent many novel reactor and fuel-cycle technologies, it will take time for the IAEA regime to adjust effectively to these new SMR technologies and the industries that support them. This could delay SMR deployment in some countries. One positive attribute of many of the new SMRs is that their design has attempted to incorporate both more secure features and more difficult-to-compromise attributes than is true of many of today's existing large power reactors. This is so because one can incorporate certain features in the design stage that simply were not considered important when the existing fleet was originally designed.

Front-end fuel-cycle issues: Some of the new SMR designs require fuel with novel designs, either untested or with limited test data. This limitation may delay the deployment of some of these designs. Also, some of the new SMR designers plan to use uranium-235 enriched to 15% to 20%, much higher than the 5% range that most of today's light water reactors use. There is currently a shortage of certain types of enrichment capacity worldwide that could hold up the initial deployment of some of the SMRs. The worldwide marketplace is currently trying to bridge this short-term gap, but it might take several years, which could delay some of the first SMRs.

Back-end fuel-cycle issues: All nuclear power reactors produce radioactive spent fuel as the chain reaction proceeds, and all of the fission products that have not radioactively decayed are basically a 'waste' that needs to be both stored safely at first and then ultimately disposed of safely. Other non-fission-product radioactive species are also produced, from actinide activation, activation of metals in the facility, and other processes. Storing these radioactive wastes can be done safely today using widely deployed technologies, and at a cost that does not drastically affect the life-cycle costs of nuclear power. However, implementing the technically preferred solution of final disposal deep underground has been a major impediment to reactor deployment in some countries.

There is a broad consensus worldwide among technical experts that disposal in a deep repository, for hundreds of thousands of years, is both safe and not expensive, amounting perhaps to a cost of a few percent of the total value of the electricity produced. For decades the preferred disposal technology has been using a mined facility. In recent years, disposal in deep boreholes has also been advanced as an alternative and might offer a much less expensive

option. However, public acceptance of the siting for a deep repository has been a major problem almost everywhere worldwide and remains an impediment. Whether this issue will impede the deployment of SMRs is not known now but is important. No country contemplating the deployment of SMRs should take the decision without giving consideration up-front as to what will be the fate of these radioactive materials that will ultimately require deep disposal.

One example of a new SMR: Session 6 included a presentation on a particular reactor design now under development by Ultra Safe Nuclear ("Modular Micro-Reactor"). This reactor is quite small, below 50 megawatts-thermal, and intended to provide energy directly to factories and communities, rather than typical power grid applications. It would employ 10%-enriched uranium fuel encased in ceramic beads, helium as the coolant, graphite as the moderator, very low power density, no moving parts, and an entirely autonomous operating mode. As an example, it exemplifies the wide range of alternative technological possibilities beyond the light-water-reactor technology that dominates today. The presentation emphasized both the very safe characteristics and the many applications in industry and commerce of this new design, which is but one of a number of tiny SMRs now under development.

Outlook: In brief, there are a very large number of new SMR designs being developed around the world, and the first few of them are operating or under construction now, although in a niche market or in a heavily subsidized environment. Many other new SMR designs are being actively considered for near-term deployment worldwide. The promise that these new reactors offer is that the cost and other barriers standing in the way of widespread deployment of large reactors could be overcome by these smaller SMR designs. Whether the various barriers and other factors affecting the outcome can be overcome is unknown, and hence it is unknown whether or not the SMR reactors, as a class, will make an important contribution worldwide. Only time (and hard work) will tell.

Session 7 Summary
Pollution and Water Crisis
Pollution and Water Crisis PMP and Session Chairman: Lorne Everett

Session 7 of the World Federation of Scientists 2023 Symposia focused on three serious planetary emergencies: inadequate and polluted groundwater, draught and childhood lead exposure. Drinking water sources are threatened by lead toxicity and "Forever Chemicals," otherwise known as PFAS (Per-and Polyfluoroalkyl Substances). Many world regions are threatened by drought, in particular, the most populated country in the world, India. These themes followed the ideas presented in our proposed World Water Crisis Center in Erice and Paris. According to the British medical journal Lancet, pollution kills more people than any other source. Many great civilizations collapsed because of drought.

The Global Planetary Emergency: Groundwater, Food and Poverty

Our civilization depends on five pillars for its existence:
1) Food: enough water, productive soil and energy to grow food
2) Energy: oil for transportation including food distribution and electricity for other essential needs
3) Pollutant content: low enough in water, air and food for human health and reproduction
4) Climate: not too cold and not too hot
5) Governance: effective enough to solve problems before they become insolvable
Each of these pillars is in trouble and in combination they represent the primary planetary emergency along with the threat of nuclear war. Amongst the essentials for human survival, the most urgent in need of correction is disappearing freshwater. According to the World Bank (2015), "Water is reaching a tipping point" and the World Economic Forum (2021), "Water insecurity risks triggering a global food crisis." What goes unacknowledged by these, and other global policy bureaucracies, is that the global water crisis has groundwater at its heart because groundwater makes up 99 % of all liquid freshwater. It supplies half the global population with drinking water and supports 70 % of irrigation agriculture. Eight of the 17 UN Sustainability Goals are dependent on groundwater (UNESCO 2020). With drought, as the rivers and lakes go dry, groundwater is the only available water for food production in many countries and many drinking-water wells go dry. The global water crisis has a paradox: there are billions of people dependent on food from unsustainable groundwater irrigation as many aquifers have been drained and others nearly so. Soon, the global food supply will have to be produced using much less water (less irrigation).

But there are a few billion, mostly rural people, for whom escape from extreme water poverty requires more, not less water use, through creation of tens of millions of small low- yield wells for family water supply (drinking, food preparation and hygiene). Less groundwater pumping of many aquifers and more pumping of others is essential, hence the paradox. The global water crisis comes at a bad time because it coincides with diminishing productive soil due to erosion and salinization, diminishing ocean food productivity, increasing contamination of water and food with extreme groundwater contamination in many areas.

Poor governance is causing this looming catastrophe. During the past 70 years, we have chosen the wrong technologies and management strategies for energy, water, soil and food and with climate change, our society is increasingly fragile. In the 1960s, we chose chemical industrial agriculture (fertilizers and pesticides) tied to large-scale largely unmonitored irrigation using groundwater with no attention to long-term sustainability of water and soil. Soil deterioration has been a major contributor of carbon dioxide to the atmosphere.
The primary result of the abandonment of growth of nuclear has been the continuing use of coal and a squandering of global conventional oil, which is one of humanity's most precious natural resources. Since 1990, we have been putting immense subsidies on wind and solar that are intermittent energy. We chose to construct a hundred thousand dams, nearly all in the northern hemisphere (nearly 9,000 in the USA and nearly as many in China) to store water for hydroelectric power, irrigation, flood control and recreation while during long drought, this water evaporates. While allocating immense resources to dam construction, we chose to drain our aquifers for irrigation and now many aquifers, which should be our sustaining water, are overdrawn (excessively depleted) and cannot provide the water resilience that only aquifers can. Globalization of the world's food supply system has greatly increased the complexity and lack of transparency of where the instabilities lie. Many countries that were more or less self-sufficient in their basic diet before globalization are now vulnerable to factors beyond their control or even beyond their awareness, such as far-away drought. The IPCC definition of climate change includes change due to both natural and human causes but the fact that the paleoclimate record shows large natural changes in the past 10,000 years that caused some civilizations to collapse due to drought went unrecognized and we as a society did not prepare for climate change. Without drastic improvements in water-food governance and clean baseload, energy expansion, the future looks bleak. The current policy is focused only on reduction in human-produced greenhouse gasses without an equal or greater effort directed at the most immediate planetary emergency, which is the linked combination of water, food, diet and poverty that puts humanity at most risk.

Our Global War on Childhood Lead Exposure-The Risk of Creating a New Generation of Victims

The mean blood lead level (BLL) in the United States in the 1930s−1940s was 27−58 μg/dL, and the geometric mean (GM) BLLs in U.S. children have decreased by ∼95% (from 15.2 to 0.83 μg/dL) in the past half-century as a result of policies banning lead in gasoline, food, paint, plumbing, and industrial emissions. The dramatic reduction has been considered amongst the most prominent public health achievements of the last three decades. Despite that success, public health messaging about the dangers of low-level lead exposure, has become increasingly hyperbolic. Children whose blood lead levels were once considered below detection, are often labeled "lead poisoned" by the media and public health professionals. This labeling is based on a CDC threshold of concern that has steadily decreased from 60 to 3.5 ug/dL, in near lockstep with the dramatic reductions in blood lead. In fact, the CDC threshold is now reset every few years, so that about 2.5% of children will always be above it, regardless of societal progress in reducing blood lead. No other environmental contaminant has ever had a health-implied "poisoning" threshold that is lowered just as fast as societal progress in reducing the hazard.

We became concerned about serious adverse effects of hyperbolic messaging associated with lead exposure, in the aftermath of helping to reveal government corruption associated with the 2014-2016 Flint Water Crisis. Ironically, for decades, the U.S. Centers for Disease Control has downplayed, and even covered up, cases of elevated blood lead from exposure to lead in drinking water. But the Flint Water Crisis created a national and international media sensation associated with health risks from elevated lead in water, in part, because of a false claim that the blood lead of children had been elevated to unprecedented levels by the water lead exposure.

We recently showed that during the Flint Water Crisis, the blood lead of Flint children rose to the average for the State of Michigan and was always less than half of the blood lead in nearby Detroit--but the false narrative of horrific childhood lead-poisoning continued. This narrative was created in a well-intentioned effort to raise money to assist the victims, but it may have created the unanticipated consequence of a self-fulfilling prophecy, because many Flint children believed the stories they were told about their brain damage by parents, teachers, politicians and activists.

The skyrocketing special education enrollment rates that were previously attributed to lead exposure, may have been due to the false messaging and a powerful placebo effect. In other words, the well-intentioned effort to raise funding to help Flint children may have inadvertently damaged them permanently.
Several years ago, we argued that the scientific climate in America and in many Western Democracies was becoming increasingly politicized and corrupted, partly due to increasingly perverse incentives of academia. The false narrative of harm from elevated lead during the Flint Water Crisis, and the possible human health harm associated with it, is a cautionary tale highlighting the difficulties of maintaining scientific integrity in such a climate. Academic freedom is increasingly under attack, inconvenient truths are sometimes repressed, and professors who are willing to exercise true moral courage to expose false narratives are often retaliated against. Courage will be necessary, to prevent science from becoming increasingly politicized from either the left or the right, in order to avoid perverted science such as eugenics that, in the extreme, encouraged the Holocaust.

Politicized and corrupted science pose direct risks to civilization and the planet. If not reversed, a tipping point is possible, in which trust in science has declined to a point, that citizenry will more frequently turn to other and less accurate sources of information. This may already be occurring in many countries. A standing committee is recommended on scientific freedom and responsibility to address this threat, which undermines the ability of science to identify and address future planetary emergencies.

Groundwater for People and the Environment: A Globally Threatened Resource

The intensity of global groundwater use rose from 124 m3 per capita in 1950 to 152 m3 in 2021, for a 22.6 % rise in the annual per capita use (Figure 1).

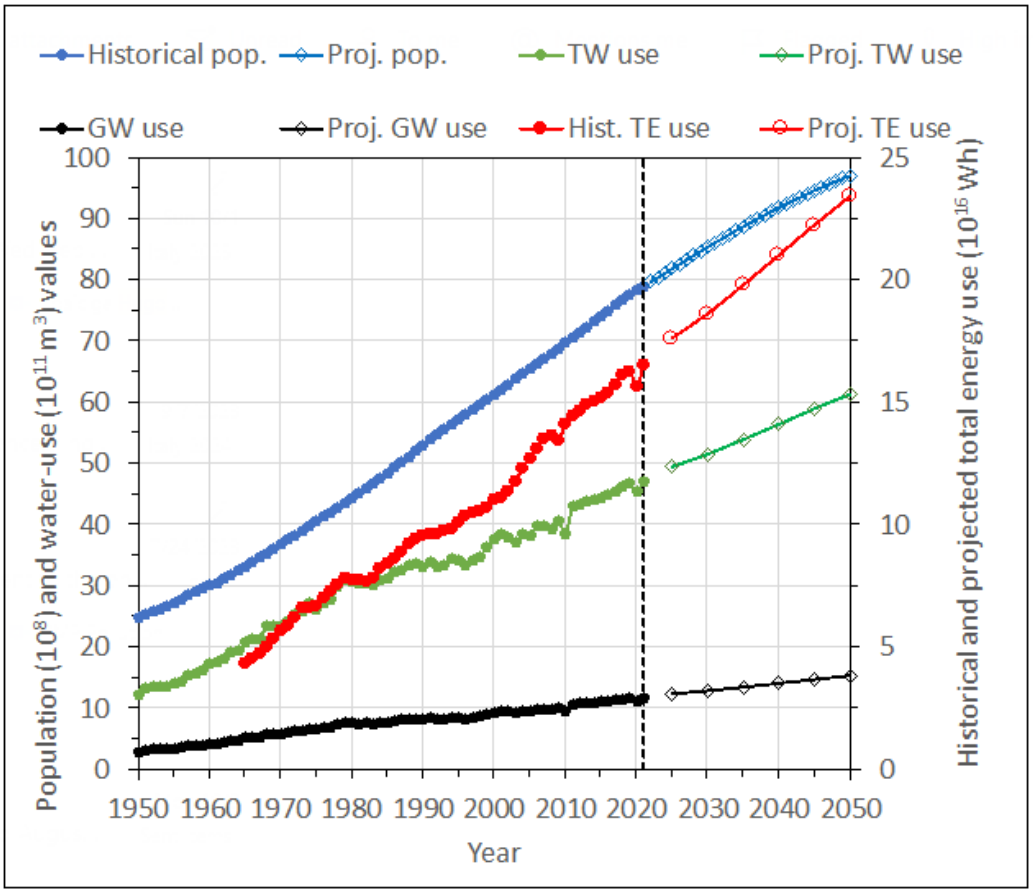

Figure 1. Historical (1950-2021) and projected (2025-2050) world population, and total energy, total water, and groundwater uses.

Reference.

Loaiciga, H. and R. Doh. 2023. Groundwater for people and the environment: a globally threatened resource. Groundwater. In press.

This rise in global per capita water use reflects a rising consumption pattern. Global groundwater use, which provides between 21% and 30% of total freshwater use, will continue to rise due to the sustained population growth projected through most of the 21st century and to the important role that groundwater plays in the water- ood-energy nexus. The rise in groundwater use, on the other hand, has inflicted adverse impacts in many aquifers, such as land subsidence, seawater intrusion, stream depletion and deterioration of groundwater-dependent ecosystems, groundwater-quality degradation, and aridification. This paper projects global groundwater uses between 2025 and 2050. The projected global annual groundwater withdrawal in 2050 is 1,535 km^3 (or 811,000 acre feet). The projected global groundwater depletion, i.e., the excess of withdrawal over recharge, in 2050 equals 887 km^3 , 61% larger than in 2021. This projection of groundwater depletion signals probable exacerbation of adverse groundwater-withdrawal impacts in view of climatic trends and the environmental requirement of groundwater flow unless concerted national and international efforts achieve groundwater sustainability.

Figure 1 depicts the annual, historical, and worldwide annual consumptions of total freshwater (i.e., surface water plus groundwater uses) and groundwater from 1950 through 2021, in addition to total energy use in the period 1965-2021 for which data were available. Moreover, Figure 1 shows the world population in the period 1950-2021, and projections of (a) population, (ii) global total water use, (iii) global groundwater use, and (iv) global energy use from 2025 through 2050. Measures that counter groundwater overdraft are urgently needed, which from the water-demand perspective involves reducing the groundwater-use intensity by improving the water-use efficiency in the municipal, industrial and agricultural sectors, and by increasing water recycling or reuse coupled with managed aquifer recharge (MAR). A glimpse of the extent to which water is wasted is revealed by data reported by Mexico's Comisión Nacional del Agua, which estimated that 40 to 60% of the water produced for irrigation use in Mexico is lost during conveyance or as runoff. Conveyance losses in Mexico's municipal sector range between 30 and 50% of the produced water. Cohen (1995) estimated that 42% of the total water used globally is discharged after being used (i.e., as sewage and agricultural runoff). If that water were recycled or reused the water supply would be augmented by 72% (Loaiciga, 2015). The recharge of treated sewage, stormwater, and diverted surplus streamflow into aquifers for subsequent use by means of managed aquifer recharge constitutes an active effort to achieve sustainable groundwater use by means of managed aquifer recharge (Dillon, *et. al.,* 2019).

Drought: A Regular Visitor in India

Draughts usually occur annually in one or more Indian regions. Conceptually, drought is defined by a decrease in water availability over a particular area for a particular period. Operationally, it is defined as an event that falls short of climatologically normal conditions. Drought is quantified by its duration, severity, intensity, inter-arrival time, and areal extent.
Droughts are of different types, including meteorological, snow, agricultural, hydrological, groundwater, reservoir, and socioeconomic. Impacts of droughts are linked with their type and have been very serious. The 1942 drought in Kolkata and Bengal caused 1,500,000 deaths. The 1972-73 drought in central India affected 100,000,000 people and was responsible for economic losses of US$50,000,000. The 1987 drought affected 300,000,000 people and caused 410 deaths. The 1993 drought affected 1,175,000 people. The 2000-2001 drought affected 90,000,000 people and caused 20 deaths and economic losses of US$588,000,000. The 2002 drought affected nearly 300,000,000 people and caused economic losses of US$910,721,000.

In order to mitigate the impact of drought, timely management, including crisis management, risk management, vulnerability assessment, and a proactive mitigation plan, is needed. To that end, better monitoring, improved drought indices, and more accurate and reliable forecasting are essential, which will facilitate integrated drought management. Thus, it is vital that more observations, location specific forecasting technology, records of drought impacts, and well-oiled governmental machinery are developed, and a proactive drought management plan needs to be prepared.

Session 8
Environmental Contaminants and Children Health
Session Chairman: Stefano Parmigiani
Children Welfare & Sustainability PMP Chairman: Stefano Parmigiani and Frederick vom Saal

Many chemicals present in the environment, in food and water, as well as in common household products that have been reported to disrupt normal endocrine function, referred to as endocrine disrupting chemicals (EDCs) (1). These

manmade substances mimic, block, or interfere with natural hormones in the body. Like hormones, they act at exceedingly low concentrations, and because of their disrupting activity on the endocrine system, they have the potential to harm the health of wildlife and humans. The International Seminars on Planetary Emergencies began its exploration of the health dangers of man-made environmental EDC contaminants in 2002 when, after the workshop "*Impact of Endocrine Disrupting Chemicals on Brain development and Behavior*" held in Erice in the International School of Ethology, the President of the World Federation of Scientists and International Seminars on Planetary Emergencies, Prof. Antonino Zichichi, invited the organizers Prof. Stefano Parmigiani and Prof. Frederick vom Saal to participate in the Seminars and report on the danger to health posed by EDCs. At that time almost none of the scientists attending the Seminars knew about EDCs, and the report generated an intense debate (especially with chemical scientists) on experimental scientific evidence.

Now there is an overwhelming confirmation that EDCs used as insecticides, herbicides and fungicides, components of plastic and resins, personal care products, and in a wide variety of other products, bind to hormone receptors, disrupt enzymes, disrupt hormone transport in blood, and alter gene activity and thus disrupt the action of endogenous hormones. Substances subsumed under the term EDCs comprise a heterogeneous group of perhaps as many as 1,000 substances, and include DDT, polychlorinated biphenyls (PCBs), bisphenol A (BPA), other bisphenols, and phthalates. The most well-known EDC is bisphenol A (BPA), used mostly as the fundamental unit (monomer) of polycarbonate plastic, a transparent and rigid type of plastic used to make glass substitutes, water dispensers, food storage containers and reusable beverage bottles. BPA is also used to make resins that line cans, as well as in many different products.

EDCs have been associated with diverse human health outcomes, including alterations in sperm and oocyte quantity and quality, fertility, abnormalities in sex organs, endometriosis, early puberty, altered nervous system function, immune function, certain cancers and disruption of metabolic systems**.** There is now a much broader focus on the contribution of EDCs to chronic non-communicable diseases, such as obesity, diabetes, liver disease, cardiovascular disease, as well as neural-behavioral and reproductive dysfunction.

The most critical time in life when exposure to EDCs can cause permanent injuries is during early development (e.g., involving exposure during both prenatal life and during the infant period when nutrition is obtained via lactation). Maternal exposure to EDCs can lead to EDCs being concentrated in breast milk and transported to a nursing baby, with potentially permanent adverse effects. Exposure to EDCs during development not only can directly harm the exposed individual, but also the individual's offspring and future generations. The worldwide increase in neurodevelopmental disabilities, including autism, ADHD, infant/childhood depression, social disorders and dyslexia, have been related to EDCs acting as neurotoxicants in the developing brain.

Research on maternal EDC exposure and child neurodevelopmental outcomes have recently found significant associations between gestational levels of BPA or phthalates with alterations of emotional behavior, aggressive behavior, cognitive impairment, and ADHD in children. After more than three decades of experimental research, animal studies have shown that maternal exposure to BPA during gestation and/or lactation induces long-term alterations in offspring behavior, including mainly three behavioral categories: (1) anxiety and exploration; (2) learning and memory; and (3) socio-sexual behaviors across mammalian species. We therefore concentrated the attention on the impact of EDCs on children's health and on the urgent need for effective and sustainable solutions. The session was therefore divided in two parts with 5 presentations:

Part I - Impact of Endocrine Disrupting Chemicals on Children's Health

The Life-Milch European Project 1: Environmental endocrine disruptors, breast milk and infant neurobehavioral development

Professor Paola Palanza (University of Parma, Italy) described the ongoing European LIFE-MILCH project (www.lifemilch.eu) that she leads, and its preliminary results. The Life MilCh project is a longitudinal study that aims to determine the association between levels of maternal milk exposure to EDCs and infants' physiological and neurobehavioral development in the first year of life in two Italian regions, Emilia Romagna and Sardinia. The objective is to establish a risk assessment model of maternal nutritional and life habits, EDC levels in breastmilk, and their effects on infant health and development. The project aims to establish safety guidelines to reduce maternal and infant exposure to EDCs. All recruited women filled out questionnaires related to life and nutritional habits at enrolment, birth, 1, 3, 6, and 12 months after delivery. The duration and type of lactation was registered. At the

different time-points, infants were evaluated for growth and anthropometric measurements, anogenital distance (AGD), subcutaneous adiposity; neurobehavioral development was assessed by different tests: Visual Preference Paradigm (1mo), Face-to-Face-Still-Face (3mo), Fagan Test (6mo), Barrier Task (12 mo.), and the Bayley III Scale (6 and 12 mo.). At any time-point, biological samples (maternal and infant urine and breastmilk) were obtained and then analyzed for EDCs levels.
A preliminary analysis on a subset of data showed significant interaction effects between pre- and post- natal Bisphenols (BPs) and Parabens (PBs) concentration levels in breastmilk and maternal urine with infant growth and neurodevelopment parameters. More specifically, effects on anogenital distance, body weight, socioemotional stress response, and specific neurodevelopmental areas were found. These preliminary results suggest that infant early physiological and neurobehavioral outcomes may be affected by exposure to EDCs, and these measurements may provide early biomarkers of effects in relation to maternal lifestyle and nutritional habits.

The Life-Milch Project 2: Endocrine disruptors and longitudinal infant growth, metabolism, bone health and epigenetics
Professor Maria Elisabeth Street (University of Parma) illustrated how the Exposure to EDCs during prenatal life is responsible for epigenetic changes, modifying gene expression, and potentially leading to an increase in non-communicable diseases. Breast milk is the gold standard for nutrition in early life. The quality of breastfeeding and breast milk are due to a complex interplay among mother and infant behavior, the infant's feeding style, the features of mother's milk including nutrients, water, immune factors, exogenous contaminants leading to effects on the bonding between mother and infant, on the infant's neurodevelopment and cognitive dialog in general, on his/her capacity to develop smell and taste, and finally on the microbiome and future metabolism features.

Preliminary data have shown that breast milk samples collected from mothers living in Northern Italy, collected at birth, and subsequently until breast feeding was continued up to a maximum period of observation of 12 months of age, contained large amounts of phthalates and derived metabolites. Similar findings hold true also for bisphenol A and S, for glufosinate and glyphosate. Some Polycyclic aromatic hydrocarbons (PAHs) were detectable in up to 6% of samples, parabens in up to 4%, and pyrethroids in 2-4% of samples. Formula milk was analyzed in 20 different products on the market, among those more commonly used. Some phthalate metabolites were detected in up to 100% of samples. In 4 different formulas bisphenols were found. Parabens were found in 3-5% of samples, Indeno (1,2,3-cd) pyrene IND was found in one sample. Packaging of formula milk and baby bottles was also considered. In the urine samples from the newborns, bisphenols could be detected in 4-14% of samples, some paraben metabolites in up to 69% of samples, PAH in 8-14% of samples, glyphosate in 8% of samples, pyrethroids in 2-8% of samples currently analyzed.

In all newborns and infants, length, weight, BMI and biceps, triceps, subscapular and suprailiac skinfold thicknesses, head circumference, ano-genital distances, pubertal stages and any genital malformations were recorded at birth, 1,3,6 and 12 months of age. Males and females showed different growth trajectories as expected. Associations with EDC exposure is under analyses. Among the data recorded were also data related with food category intake of mothers during pregnancy and after delivery up to 6 months of age of their offspring. Interestingly, we observed after delivery a reduction in the intake of cereals, fruit and vegetables, and an increase in the intake of fatty foods, whereas the consumption of eggs, meat and dairy products was quite variable and overall constant. A statistically significant reduction in the intake of cereals was observed with the end of breastfeeding. These changes are not generally considered but could have direct and indirect consequences throughout life, related with exposure to EDCs and/or other food contaminants besides nutrient composition per se. A risk model is currently under study.

Part II - Chemicals Strategy for Sustainability

An international perspective on the European Council (EC) "Chemicals Strategy for Sustainability"
Dr. Pete Myers (*Carnegie Mellon University in Pittsburgh, Pennsylvania-USA)* Illustrated the danger posed by EDCs that are common additives in plastic to human health and especially to children. Plastic pollution has become so widespread that microscopic flecks of plastic can be found in snow, soil, drinking water, and even human blood. (https://doi.org/10.1016/j.envres.2008.03.008). Endocrine disruptors in plastic are associated with a 50% decline in adult male sperm counts over the past five decades and are implicated in the enormous leap in rates of autism and ADHD among children. Approximately 42% of plastic materials currently under production is used for packaging, much of which is discarded as soon as it is used. It is critical that plastic reduction and safer, healthier alternatives become mandated by law. The global production of EDCs has increased dramatically, thus leading to large increases

in exposure. Plastic containing EDCs have become a global scourge, with the increase in plastic production and waste dramatically exceeding any reasonable expectation that recycling can solve the problem. Plastic acts as a vector carrying EDCs to virtually every place in the world. Despite these disturbing trends, several solutions have begun to emerge that have the potential to reverse these challenges:

The European Commission announced in 2020 its "Chemical Strategy for Sustainability." The Chemicals Strategy also contains important commitments to Safe and Sustainable Chemistry, a new field the EU Commission envisions to be guided by endocrine science. New methods of water treatment have been invented that remove micropollutants (chemicals that elicit adverse effects at low concentrations in water such as many pesticides, pharmaceuticals and personal care products) from drinking and treated water. These technologies can dramatically reduce EDC exposures of the general public. Important advances in European approaches to regulating food packaging materials are underway that can reduce if not largely eliminate many human exposures to hazardous EDCs. These emerging solutions hold great promise to: 1) reduce the health burden of many chronic diseases, 2) lower the economic costs imposed by EDC exposures (estimated conservatively to exceed €150 billion per year in the EU), 3) stimulate a new wave of chemical innovation that leads to a next generation of inherently safer materials (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6469444/).

The EC Chemicals Strategy for Sustainability and food contact chemicals

Dr. Jane Munke, Managing Director and Chief Scientific Officer at the charitable Food Packaging Forum Foundation (FPF) in Zurich, Switzerland, reported about the risk associated with food packaging. Food contact chemicals transfer from all types of food contact materials and articles into food and, consequently, are taken up by humans. Current safety assessment of food contact chemicals for the prevention of associated chronic diseases in the human population is ineffective at protecting human health. In addition, society is striving for waste reduction with a focus on food packaging. As a result, solutions are being developed toward reuse, recycling or alternative (non-plastic) materials. However, the critical aspect of chemical safety is often ignored. Developing solutions for improving the safety of food contact chemicals and for tackling the circular economy (i.e., recycling waste hazardous polluting materials) must include current scientific knowledge. It is necessary to initiate a broader discussion involving scientists with relevant expertise and decision makers and influencers addressing single-use food packaging due to environmental concerns. Ultimately, the aim is to support science-based decision making in the interest of improving public health.

The new field of Sustainable Ultra-dilute Oxidation Catalysis (SUDOC) as a tool for removing endocrine disruptors in water treatment and other applications

Professor Terry Collins, the Teresa Heinz Professor of Green Chemistry and the Director of the Institute for Green Science at Carnegie Mellon University, USA, reported on powerful new methods for removing EDCs from water to address a major route of environmental exposures. He began by reflecting on why the chemical enterprise is in such disturbing trouble over EDCs. All chemical products and processes to date have been commercialized principally because of high *technical and cost performances* (e.g., BPA can be used to produce polycarbonate and epoxy plastics that yield immense profits). However, all EDCs also have *health, environmental and fairness performances* that have not been integrated into the value proposition at the times of commercialization. Thus, BPA is the EDC known today to activate the greatest numbers of assays capable of detecting endocrine disruption activity leading to immense health and environmental harm treated as externalized costs, all while BPA makes a fortune in traditional near-term income.

Dr. Collins went on to describe the invention of TAML® activators, widely patented, small molecule catalysts that in infinitesimal concentrations activate hydrogen peroxide in tiny concentrations to remove micropollutants from urban, industrial, and environmental waters. TAMLs were produced over decades in an extensively documented program to be mimics of the peroxidase enzymes which they outperform, thereby succeeding beyond any early expectations in delivering by far the most powerful peroxide-activating catalysts across both chemistry and biology and giving new powers for removing chemicals from water for the protection of the environment and human health. The design program for TAML activators was described focusing on ridding water of EDCs. It was shown how commercialized examples have passed numerous cellular and animal assays such that, thus far, TAMLs do not elicit either high or low dose toxicity. This clearly show how green chemistry is certainly a possible solution to cope with the environmental contaminants that are threatening wildlife and human health.

Conclusions

The European Commission announced in 2020 its “Chemical Strategy for Sustainability” based on a strong commitment to use the best available science. The speakers of this session have advocated for the full support of the World Federation of Scientists to the European Commission’s effort. It has been also pointed out the pivotal scientific role of the Ettore Majorana Foundation and Centre for Scientific Culture-EMFCSC- for the advancement of the culture of sustainability (especially through the International Seminars on Planetary Emergencies). It is evident that the global emergency posed by man-made environmental contaminants acting as EDCs is a complex one, and to cope and find solution to this problem it is necessary to have a multidisciplinary approach with experts from different fields, such as behavioral biology, ecology, endocrinology, environmental sciences, psychology, psychiatry, ethics, chemistry, economics, political science and philosophy. This multidisciplinary approach is needed because the problems and solutions are multidimensional. An urgent change of mentality (a metanoia) is required along with a cultural revolution that homo sapiens can no longer afford to postpone.

Appendix 1

Plenary Program of the 2023 Planetary Emergency Seminars

Welcome and Introductory Remarks:
- Fabrizio Zichichi (introducing Antonino Zichichi)
- Antonino Zichichi (via video)

Keynote Address: Cristian Galbiati

Session 1: Nuclear Weapons: Arms Control – Devolution of Global Security
Session Chairmen: William Barletta and Adnan Shihab-Eldin, *Chairmen Mitigation of Catastrophic Risks*
Francesca Giovannini: *The West*
Tariq Rauf: *The Middle East & Central Asia*
John Delury: East *Asia*

Session 2: Origins of the Covid-19 Pandemic
Session Chairman: Franco Maria Buonaguro, *Chairman Infectious Disease PMP*
Franco M. Buonaguro: *The European pandemic*
Ishwar Gilada: *The Eastern pandemic*
Sofie Nyström: *The U.S.A. pandemic*
Sofie Nyström: *The SARS-Cov-2 variants*

Session 3: The Oil Market and the Energy Transition
Session Chairman: Carmine Difiglio, *Chairman Energy PMP*
Carmine Difiglio: *Oil Market Volatility and Net-Zero Transition Policies*
Steven Kopits: *The Energy Transition, Looking at Scenarios*
Lucian Pugliaresi: *IEA's Net-Zero Pathway and Petroleum: Rocky Road?*
Claudio Galimberti: *Sustaining Investments with Declining OECD Oil Demand*
Vitaly Yermakov: *New Global Oil Map: Implications for Producers and Consumers*

Session 4: Critical Infrastructure
Session Chairmen: William Barletta & Adnan Shihab-Eldin, *Chairmen Mitigation of Catastrophic Risks*
Walter Grayman: *Vulnerabilities of Water Infrastructure*
Jonathan Wurtele: *Carbon capture from the air: At what cost?*
Bilal Ayyub: *Building resiliency in developing countries*

Session 5: Cyber Security Challenges in Conjunction with the Current Crises
Session Chairman: Axel Lehmann. *Chairman, Future of Information Security PMP*
Axel Lehmann: *Information technologies – Quo Vadis?*
Hamadoun Touré and Alex Ntoko: *Technological Challenges - AI, Machine Learning, Quantum Computing*
Pavan Duggal and Henning Wegener: *Common Code of Conduct, Normative and Legal Rules*
Sun Kun Oh: *Data Ethics*

Session 6: Progress on Small Modular (Nuclear) Reactors, SMRs
Session Chairman: Adnan Shihab-Eldin, *Energy PMP*
Adnan Shihab-Eldin: *Introduction*
Hans-Holger Rogner: *Is there an economic rationale for SMRs?*
Robert Budnitz: *How much safer and more secure are SMRs?*
Charles McCombie: *Will SMRs simplify or complicate solutions to waste disposal?*
Noura Mansouri: *How can SMRs improve the energy security in developing nations?*
Riccardo DeSalvo: *The Ultra Safe Reactor: an example of an innovative advanced micro modular reactor (MMR)*

Session 7: Pollution and Water Crisis
Session Chairman: Lorne Everett, *Chairman Pollution and Water Crisis PMP*
John Cherry: *The Global Groundwater Crisis- a Perfect Storm from Three Directions: Poverty, Depletion and Pollution*

Marc Edwards: *Our Global War on Childhood Lead Exposure: The Risk of Creating a New Generation of Victims*
Hugo A. Loaiciga: *Groundwater for People and the Environment: a Globally Threatened Resource*
Vijay P. Singh: *Drought: A Regular Visitor in India*

Session 8: Environmental Contaminants and Children Health
Session Chairmen: Stefano Parmigiani, *Chairman Children Welfare/Sustainability PMP and Frederick vom Saal*

Part I - Impact of Endocrine Disrupting Chemicals on Children's Health
Paola Palanza: *The Life-Milch Project 1: Environmental endocrine disruptors, breast milk and infant neurobehavioral development*
Maria Elisabeth Street: *The Life-Milch Project 2: Endocrine disruptors and longitudinal infant growth, metabolism, bone health and epigenetics*

Part II - Chemicals Strategy for Sustainability
John Peterson Myers: *An international perspective on the European Council's "Chemicals Strategy for Sustainability"*
Jane Muncke: The EC Chemicals Strategy for Sustainability and food contact chemicals
Terry Collins: *Sustainability dispositions key to successful implementation of the Chemicals Strategy for Sustainability*

Appendix 2
Bibliography for Session 2, Origins of the Covid-19 Pandemic

- Buonaguro FM, Ascierto PA, Morse GD, Buonaguro L, Puzanov I, Tornesello ML, Bréchot C, Gallo RC.Rev Med Virol. 2020 Sep;30(5):e2134. doi: 10.1002/rmv.2134.
- Anti-IL6R role in treatment of COVID-19-related ARDS.

Buonaguro FM, Puzanov I, Ascierto PA.J Transl Med. 2020 Apr 14;18(1):165. doi: 10.1186/s12967-020-02333-9.PMID: 32290847

- SARS-CoV-2 RNA polymerase as target for antiviral therapy.

Buonaguro L, Tagliamonte M, Tornesello ML, Buonaguro FM.J Transl Med. 2020 May 5;18(1):185. doi: 10.1186/s12967-020-02355-3.PMID: 32370758

A new human coronavirus named SARS-CoV-2 was identified in several cases of acute respiratory syndrome in Wuhan, China in December 2019. On March 11 2020, WHO declared the SARS-CoV-2 infection to be a pandemic, based on the involvement of …

- Lung histopathological findings in COVID-19 disease - a systematic review.

Pannone G, Caponio VCA, De Stefano IS, Ramunno MA, Meccariello M, Agostinone A, Pedicillo MC, Troiano G, Zhurakivska K, Cassano T, Bizzoca ME, Papagerakis S, Buonaguro FM, Advani S, Muzio LL.Infect Agent Cancer. 2021 May 17;16(1):34. doi: 10.1186/s13027-021-00369-0.PMID: 34001199

Since December 2019, the global burden of the COVID-19 pandemic has increased rapidly and has impacted nearly every country in the world, affecting those who are elderly or with underlying comorbidities or immunocompromised states. Aim of this systematic review is t …

- Knowledge-based repositioning of the anti-HCV direct antiviral agent Sofosbuvir as SARS-CoV-2 treatment.

Buonaguro L, Buonaguro FM.Infect Agent Cancer. 2020 May 12;15:32. doi: 10.1186/s13027-020-00302-x. eCollection 2020.PMID: 32419838

The new human coronavirus named SARS-CoV-2 is a positive-sense RNA virus for which no specific drugs are currently available. ...Such a repositioning would allow the containment of the SARS-CoV-2 pandemic and limit the progression of disease …

- Proceedings of the Online Conference “Vaccines and Vaccination during and Post COVID Pandemics” (7-9 December 2022).

Sokolovska L, Isaguliants M, Buonaguro FM.Vaccines (Basel). 2023 Jun 29;11(7):1175. doi: 10.3390/vaccines11071175.PMID: 37514990

The COVID-19 pandemic put focus on various aspects of vaccine research and development. ...This report summarizes conference presentations and their discussion. Sessions covered the topics of (1) COVID-19 vaccine development, evaluation, and attitude t …

- HLA Does Not Impact on Short-Medium-Term Antibody Response to Preventive Anti-SARS-Cov-2 Vaccine.

Ragone C, Meola S, Fiorillo PC, Penta R, Auriemma L, Tornesello ML, Miscio L, Cavalcanti E, Botti G, Buonaguro FM, Bianchi A, Buonaguro L, Tagliamonte M.Front Immunol. 2021 Jul 27;12:734689. doi: 10.3389/fimmu.2021.734689. eCollection 2021.PMID: 34386018

The response to anti-SARS-Cov-2 preventive vaccine shows high interpersonal variability at short and medium term. ...Such vaccine is based on the entire spike protein of the SARS-CoV-2. Ab titers have been evaluated 2 weeks after the …

- Evaluation of the diagnostic accuracy of a new point-of-care rapid test for SARS-CoV-2 virus detection.

Miscio L, Olivieri A, Labonia F, De Feo G, Chiodini P, Portella G, Atripaldi L, Parrella R, Conenna R, Buonaguro FM, Cavalcanti E, Ascierto P, Botti G, Bianchi A.J Transl Med. 2020 Dec 21;18(1):488. doi: 10.1186/s12967-020-02651-y.PMID: 33349261

BACKGROUND: The easy access to a quick diagnosis of coronavirus disease 2019 (COVID-19) is a key point to improve the management of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and to contain its spread. ...METHODS: In the …

- Immune profiling of SARS-CoV-2 epitopes in asymptomatic and symptomatic pediatric and adult patients.

Tornesello AL, Botti C, Micillo A, Labonia F, Arpino S, Isgrò MA, Meola S, Russo L, Cavalcanti E, Sale S, Nicastro C, Atripaldi L, Starita N, Cerasuolo A, Reimer U, Holenya P, Buonaguro L, Buonaguro FM, Tornesello ML.J Transl Med. 2023 Feb 14;21(1):123. doi: 10.1186/s12967-023-03963-5.PMID: 36788606

BACKGROUND: The infection with severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has unpredictable manifestations of coronavirus disease (COVID-19) and variable clinical course with some patients being asymptomatic whereas other …

- The clinical and translational research activities at the INT - IRCCS “Fondazione Pascale” cancer center (Naples, Italy) during the COVID-19 pandemic.

Buonaguro FM, Botti G, Ascierto PA, Pignata S, Ionna F, Delrio P, Petrillo A, Cavalcanti E, Di Bonito M, Perdonà S, De Laurentiis M, Fiore F, Palaia R, Izzo F, D'Auria S, Rossi V, Menegozzo S, Piccirillo M, Celentano E, Cuomo A, Normanno N, Tornesello ML, Saviano R, Barberio D, Buonaguro L, Giannoni G, Muto P, Miscio L, Bianchi AAM; and the INT-Pascale COVID-19 Crisis Unit.Infect Agent Cancer. 2020 Nov 23;15(1):69. doi: 10.1186/s13027-020-00330-7.PMID: 33292365

COVID-19 pandemic following the outbreak in China and Western Europe, where it finally lost the momentum, is now devastating North and South America. Although very few (n = 3) patients developed a symptomatic COVID-19 and required the transfer to a …

- Vaccination strategy and anti - SARS-CoV-2 S titers in healthcare workers of the INT - IRCCS “Fondazione Pascale” Cancer Center (Naples, Italy).

Cavalcanti E, Isgrò MA, Rea D, Di Capua L, Trillò G, Russo L, Botti G, Miscio L, Buonaguro FM, Bianchi AAM.Infect Agent Cancer. 2021 May 12;16(1):32. doi: 10.1186/s13027-021-00375-2.PMID: 33980271

BACKGROUND: Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection and the resulting disease, coronavirus disease 2019 (COVID-19), have spread to millions of people globally, requiring the development of billions of differ …

- Bimodal antibody-titer decline following BNT162b2 mRNA anti-SARS-CoV-2 vaccination in healthcare workers of the INT - IRCCS “Fondazione Pascale” Cancer Center (Naples, Italy).

Isgrò MA, Trillò G, Russo L, Tornesello AL, Buonaguro L, Tornesello ML, Miscio L, Normanno N, Bianchi AAM, Buonaguro FM, Cavalcanti E; anti-COVID-19 INT Task Force.Infect Agent Cancer. 2022 Jul 28;17(1):40. doi: 10.1186/s13027-022-00451-1.PMID: 35902961

BACKGROUND: Both SARS-CoV-2 mRNA-based vaccines [BNT162b2 (Pfizer-BioNTech) and mRNA-1273 (Moderna)] have shown high efficacy, with very modest side effects in limiting transmission of SARS-CoV-2 and in preventing the severe COVID- …

- Amyloidogenesis of SARS-CoV-2 Spike Protein.

Nyström S, Hammarström P.J Am Chem Soc. 2022 May 25;144(20):8945-8950. doi: 10.1021/jacs.2c03925. Epub 2022 May 17.PMID: 35579205

SARS-CoV-2 infection is associated with a surprising number of morbidities. ...Our data propose a molecular mechanism for potential amyloidogenesis of SARS-CoV-2 S-protein in humans facilitated by endoproteolysis. The prospective of S-pro …

- Viruses and amyloids - a vicious liaison.

Hammarström P, Nyström S.Prion. 2023 Dec;17(1):82-104. doi: 10.1080/19336896.2023.2194212.PMID: 36998202

Post-acute sequalae (PAS) of viral infections is known for several viruses. SARS-CoV-2 and COVID-19 implicate connections between amyloid formation and severe outcomes in the acute infection, PAS and neurodegenerative diseases. ...Not only do hu …

- Emerging Viral Infections and the Potential Impact on Hypertension, Cardiovascular Disease, and Kidney Disease.

Savedchuk S, Raslan R, Nystrom S, Sparks MA.Circ Res. 2022 May 13;130(10):1618-1641. doi: 10.1161/CIRCRESAHA.122.320873. Epub 2022 May 12.PMID: 35549373

This is because the entry point for SARS-CoV-2 is the ACE2 (angiotensin-converting enzyme 2) protein. ...This review will highlight several emerging viruses and their potential unique tropisms for the kidney and cardiovascular system. We focus on SA …

- T cell perturbations persist for at least 6 months following hospitalization for COVID-19.

Govender M, Hopkins FR, Göransson R, Svanberg C, Shankar EM, Hjorth M, Nilsdotter-Augustinsson Å, Sjöwall J, Nyström S, Larsson M.Front Immunol. 2022 Aug 8;13:931039. doi: 10.3389/fimmu.2022.931039. eCollection 2022.PMID: 36003367

COVID-19 is being extensively studied, and much remains unknown regarding the long-term consequences of the disease on immune cells. ...Within 2-3 weeks after symptom onset, all COVID-19 patients developed anti-nucleocapsid IgG and spike-neutral …

- JAK inhibitor blocks COVID-19 cytokine-induced JAK/STAT/APOL1 signaling in glomerular cells and podocytopathy in human kidney organoids.

Nystrom SE, Li G, Datta S, Soldano KL, Silas D, Weins A, Hall G, Thomas DB, Olabisi OA.JCI Insight. 2022 Jun 8;7(11):e157432. doi: 10.1172/jci.insight.157432.PMID: 35472001 Free PMC article.

COVID-19 infection causes collapse of glomerular capillaries and loss of podocytes, culminating in a severe kidney disease called COVID-19-associated nephropathy (COVAN). ...Here, based on 9 biopsy-proven COVAN cases, we demonstrated for the first time …

- SARS-CoV-2 Specific Antibody Response and T Cell-Immunity in Immunocompromised Patients up to Six Months Post COVID: A Pilot Study.

Sjöwall J, Hjorth M, Gustafsson A, Göransson R, Larsson M, Waller H, Nordgren J, Nilsdotter-Augustinsson Å, Nyström S.J Clin Med. 2022 Jun 20;11(12):3535. doi: 10.3390/jcm11123535.PMID: 35743605

COVID-19 generates SARS-CoV-2-specific antibodies in immunocompetent individuals. ...All patients showed IgG levels above or within reference limits. At six months, all patients had detectable SARS-CoV-2 anti-spike antibody …

- Specific T-cell responses for guiding treatment with convalescent plasma in severe COVID-19 and humoral immunodeficiency: a case report.

Nyström K, Hjorth M, Fust R, Nilsdotter-Augustinsson Å, Larsson M, Niward K, Nyström S.BMC Infect Dis. 2022 Apr 11;22(1):362. doi: 10.1186/s12879-022-07323-4.PMID: 35410137

BACKGROUND: The immune response to SARS-CoV-2 virus, the cause of COVID-19, is complex. Antibody mediated responses are important for viral clearance but may also drive hyperinflammation in severe COVID-19. ...In addition, the case …

- Pentameric C-reactive protein is a better prognostic biomarker and remains elevated for longer than monomeric CRP in hospitalized patients with COVID-19.

Hopkins FR, Nordgren J, Fernandez-Botran R, Enocsson H, Govender M, Svanberg C, Svensson L, Hagbom M, Nilsdotter-Augustinsson Å, Nyström S, Sjöwall C, Sjöwall J, Larsson M.Front Immunol. 2023 Sep 1;14:1259005. doi: 10.3389/fimmu.2023.1259005. eCollection 2023.PMID: 37724104

The differing roles of the pentameric (p) and monomeric (m) C-reactive protein (CRP) isoforms in viral diseases are not fully understood, which was apparent during the COVID-19 pandemic regarding the clinical course of severe acute respiratory syndrome coronavirus …

- Major alterations to monocyte and dendritic cell subsets lasting more than 6 months after hospitalization for COVID-19.

Hopkins FR, Govender M, Svanberg C, Nordgren J, Waller H, Nilsdotter-Augustinsson Å, Henningsson AJ, Hagbom M, Sjöwall J, Nyström S, Larsson M.Front Immunol. 2023 Jan 4;13:1082912. doi: 10.3389/fimmu.2022.1082912. eCollection 2022.PMID: 36685582 Free PMC article.

Impaired levels and responses of monocytes and DC to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is likely to be a driving force behind the immune dysregulation that characterizes severe COVID-19. METHODS: Here, we follow …

Reference: *Cancer Challenges during COVID-19 Pandemic.* Franco M. Buonaguro and Attilio AM Bianchi, Eds.Published: September 2023. (This book is a reprint of the Special Issue Cancer Challenges during COVID-19 Pandemic that was published in Journal of Personalized Medicine
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