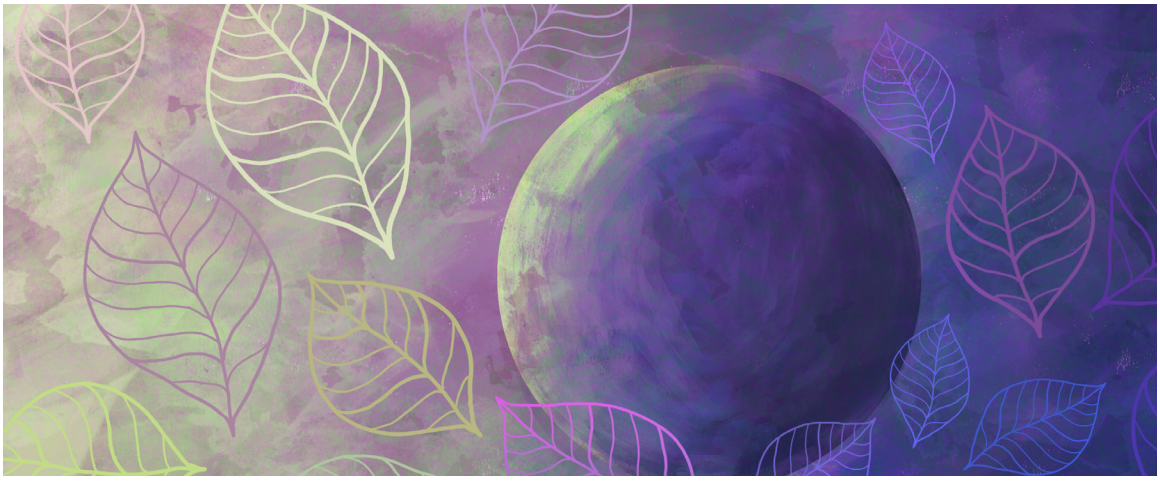
THE PONTIFICAL ACADEMY OF SCIENCES

Statements from the Plenary Session on

BASIC SCIENCE FOR HUMAN DEVELOPMENT, PEACE, AND PLANETARY HEALTH



8-10 September 2022 | Casina Pio IV | Vatican City

"... greater attention should be paid to the values and fundamental goods that are at the basis of the relationship between peoples, society and science. This relationship demands a rethinking aimed at promoting the integral advancement of each human being and of the common good. Open dialogue and attentive discernment are indispensable, especially as science becomes more complex and the horizons that it opens up bring decisive challenges for the future of humanity. For today, both the evolution of society and scientific changes are taking place ever more rapidly, each following the other. It is important that the Pontifical Academy of Sciences consider how these interconnected changes require a wise and responsible commitment on the part of the entire scientific community."

Pope Francis, Address to Participants in the Plenary Session of the Pontifical Academy of Sciences, 12 November 2018
https://www.pas.va/en/magisterium/francis/2018-12-november.html

"Basic science for human development, peace, and planetary health"
Statement of the Plenary Session of the Pontifical Academy of Sciences (Sept 26, 2022)

8-10 Sept 2022 | Casina Pio IV | Vatican City

Abstract
The 2022 Plenary of the Pontifical Academy of Sciences explored and highlighted the driving forces and opportunities related not just to basic science per se, but to basic science for human development, peace and planetary health. The topic is also timely in view of the United Nations' "International Year of Basic Sciences for Sustainable Development".
There are certain key areas where basic science is going to improve human welfare directly, such as medicine, food systems, energy and more. Progress is also happening in interdisciplinary science building on strong basic science, such as: Mathematics and AI; Astronomy; Physics and Biophysics; Climate Science; Chemistry / Bio-Chemistry; Life Sciences and Medical Science.
The fact that important discoveries do not come about because of a goal, but because of curiosity and imagination as a result of wonder and admiration, raises philosophical, ethical, religious, and science policy questions. We thus noted the importance and benefits of long-term perspectives in science, and called for society – including faith-based communities – and policy to recognize and more strongly support basic sciences.
We emphasize that it is ever more important for science to have peace as a goal. As scientists, we must neither neglect the fundamental drivers of conflicts, nor ignore the role of science.
The Pontifical Academy of Sciences remains concerned about neglect or ignorance of science-informed rational arguments and science skepticism in parts of the general public and in conventional and social media.
The abovementioned powerful contributions of basic science and its related capacities need to be shared more equitably – especially by the rich nations – with low-income regions of the world.

1. **First of all, let us clarify the concepts embedded in the Plenary theme *"Basic science for human development, peace, and planetary health"***:
   - *Human development* is understood here as the process of enhancing people's and communities' freedoms, capabilities, and opportunities, improving their physical, mental, and social well-being, so to achieve their aspirations.
   - *Peace* is, first and foremost, the absence of wars and violent conflicts, but there is more to it: it includes overcoming divisiveness, racism, nationalism, and growing inequalities often combined with crime, human trafficking, and marginalization. Promoting justice, cooperation and peace in the world requires a science that seeks the truth, considers potential misuses, and is free from ideologies.
   - *Planetary health* means the health of human civilization and the state of the natural systems which sustain it, recognizing that all life, not just human life, depends on the state of the biosphere and geosphere and their interdependence. Examples of disequilibria are self-destructive lifestyles, pandemics, climate change, loss of biodiversity, devastation of ecosystems and of natural beauty.
   - *Basic research* advances fundamental knowledge and is a source of new scientific ideas and ways of thinking. It is often curiosity-driven, truth-seeking and questioning of established theories.

   At first glance, the three goals – human development, peace, and planetary health – and the values underpinning them, do not seem related to basic science, because that type of science is driven by epistemic interest rather than the need to solve practical problems. Yet, in the long term, basic sciences often become the foundation for applied science and technological innovations. Moreover, there are indications that the transformation of new basic knowledge to societal applications has been progressing more rapidly in recent years.

2. **The 2022 Plenary of the Pontifical Academy of Sciences explored and highlighted the driving forces and opportunities related to *basic science for human development, peace and planetary health*** by addressing the following questions: What are the new and emerging breakthroughs in the sciences? How did these science breakthroughs come about? How can these discoveries instruct new, better and more effective ways to reduce the threats and problems for people, peace, and planet? The first two questions address processes intrinsic to science. The third concerns the translation of knowledge, which is a major challenge that we must also engage in. Emphasis on basic sciences with a human and planetary health perspective is very much in line with the Academy's Statute, "The aim of

the Pontifical Academy of Sciences (PAS) is to promote the progress of the mathematical, physical and natural sciences and the study of epistemological problems related thereto", and the PAS "…promote(s) the progress of sciences and the solution of important scientific-technical problems, which are fundamental for the development of mankind".

3. **The theme of the 2022 PAS Plenary, "Basic science for human development, peace, and planetary health", is timely in view of the United Nations' "International Year of Basic Sciences for Sustainable Development"** that has just started on the basis of topics identified as priorities by UNESCO and the United Nations. The PAS is committed to continuing its close cooperation with the UN in fields of science and related policy consultations, as we have done in the recent past on climate, food, biodiversity, pandemic, universal health care, and other issues.

4. **There are certain key areas where basic science is going to improve human welfare directly, such as medicine, food systems, energy and more**. Many of the main disciplines of science are involved in those areas. The progress and prospects of basic science related to those areas are crucial and clearly timely. Moreover, basic science is of intrinsic value. Its insights lead to deeper understanding, knowledge and possibly wisdom. Science's search for the truth remains fundamentally important. The PAS has held conferences and published science-informed statements urging to address issues such as the massive health problems caused by the pandemic and by inadequate health systems, the large-scale destruction of nature and the loss of biodiversity, the climate crisis, the opportunities and risks of artificial intelligence, rising inequalities, hunger and poverty, and increasing local and global conflicts. We were able to identify specific science opportunities to address these problem areas, emphasizing the opportunities of advancing the sciences in each of these fields, as well as the need to expand interdisciplinary research.

5. **We explored patterns in the progress of basic science insights in different disciplines and interdisciplinary linkages.** The conference discourse included voices of scientists on the challenges they faced in order to understand the very basic aspects of a given problem. Examples came from cutting-edge science like genetic modification (CRISPR-cas), quantum and laser physics, atmospheric science, mathematics (new algorithms) and astrophysics. The PAS Plenary 2022 addressed topics at the forefront of science in key areas that change world views and have the *potential to improve human development, peace, and planetary health*. The following are some of these highlights that should not be seen in isolation, but as a growing opportunity for cooperation among disciplines:
   - **Mathematics and AI** addresses intrinsic insights from mathematics as well as the opportunities for new applications, e.g. mathematics of AI, and using AI to accelerate scientific discovery. DeepMind's AlphaFold algorithm has already had a disruptive effect on disciplines that are dependent on protein structure and it will likely have similar transformational effects in diverse fields including weather and climate forecasting, but also on behavioral science. If used responsibly, AI has the potential to help with all of the aims of this Plenary Session – human development, peace, and planetary health. Teaching of mathematics and basic sciences in education systems needs to be intensified to tap these opportunities.
   - **Astronomy** seeks to provide insights into the origin and evolution of stars, planets, galaxies (e.g. via galaxy archeology) and even the Universe itself. As Immanuel Kant wrote: "Two things fill the mind with ever new and increasing admiration and awe, the more often and longer the reflection occupies itself with it: the starry sky above me, and the moral law within me".

   Where do we come from? Are we alone? What is the future of our Sun and its solar system, and of the Milky Way, the galaxy of which we are part, which we now know has a supermassive black hole at its center? Do the known laws of physics hold under extreme conditions? These are some of the biggest questions that humankind can ask, appealing to deep cultural and philosophical yearnings. Society has advanced through the development of new technologies driven in part by astronomy. Because of its broad appeal, astronomy is a gateway science that nurtures inquisitiveness and curiosity in children and students of all ages. The collective body of data sets, often openly accessible to the entire world for study purposes, trains scientists in the use of innovative big data and AI techniques that have their applications elsewhere in society. Astronomers also raise awareness and take actions to protect the dark and quiet skies, important for human culture, heritage and health, which are currently being threatened by urban artificial light pollution and swarms of satellites in space. Being able to view the pristine spectacle of the starry night sky is of fundamental value for every human being. We need technological developments that can serve both night light and satellite services on the one hand, and provide access to the view of the night sky on the other.
   - The **Physics and Biophysics** science on the agenda considered both the large and the small. We saw how large-scale phenomena such as solar activity and its impact on earth need attention in areas such as climate, human health and infrastructure (e.g. electricity grid). As for the small, we examined how microscopy at molecular-scale resolution in fluorescence provides insights into molecules in living cells, offering new ways of disease detection; and we reviewed new pathways from protein folding to understanding viruses such as Covid-19 and designing new types of vaccines. Physics and biophysics have much to add to the understanding of biology and medicine through tools to observe and mechanically perturb molecular systems and, secondly, by developing new theoretical models and simulations for a more quantitative and predictive understanding of these processes.

- **Climate Science** critically relies on atmospheric, planetary, and ecological sciences. We also highlight the growing need to address adaptation and resilience to climate change in conjunction with mitigation, and with integral attention to loss of biodiversity and growing inequalities that make ever larger shares of the population vulnerable to climate stress and related health and food crises. Two of the solutions that came up were nature-based and climate-sensitive: for example, the building sector should adopt nature-positive materials as part of a circular bioeconomy approach; and urban designers should plan for climate change and pay close attention to transforming slum areas.
- **Chemistry / Bio-Chemistry** for human development, peace, and planetary health highlight innovation by evolution, bringing new chemistry to life, such as in food systems; brain organoids, that are stem-cell derived 3D cell culture models for human brain development, offer treatment of neurological disorders. The case of Uruguay exemplifies how science can and did make a huge difference during the pandemic by adopting science-informed approaches and cooperative engagement by health policy. Horizontal gene transfer in the context of a rich biodiversity as part of evolution was explained, in particular in relation to bacteria modification enzymes.
- **Life Sciences and Medical Science** are showcasing new opportunities for regenerating and rejuvenating aged tissues. Organ transplantation remains crucial for many diseases and is enhanced by scientific advances in immunology, organ repair before transplantation, and the emerging use of modified pig organs. Of similar importance are new insights into the causes of dementia from prion strains.

6. **The fact that important discoveries do not come about because of a goal, but because of curiosity and imagination as a result of wonder and admiration, raises philosophical, ethical, religious, and science policy questions.** Emphasizing these perspectives, this PAS Plenary Session featured a session in honor of H.E. Msgr. Marcelo Sánchez Sorondo, our esteemed former Chancellor, on the occasion of his shift to Emeritus, under the theme of science from a philosophical and religious perspective. We can relate to Aristotle, who said "It is through wonder that men now begin and originally began to philosophize; wondering in the first place at obvious perplexities, and then by gradual progression raising questions about the greater matters too, e.g. about the changes of the Moon and of the Sun, about the stars and about the origin of the universe". "… therefore, if it was to escape ignorance that men studied philosophy, it is obvious that they pursued science for the sake of knowledge, and not for any practical utility" (Aristot. Met. 1.982 b 11-20). Aristotle pointed out another essential attribute of disinterested knowledge which is freedom: "Clearly then it is for no extrinsic advantage that we seek this knowledge; for just as we call a man free who exists for himself and not for another, so we call this the only free science, since it alone exists for itself" (Aristot. Met. 1.982b 28-30). The deliberations emphasized the key concepts of hope and the responsibility of the scientist. For sciences to flourish, scientists must enjoy scientific freedom: freedom of association, movement, and expression. This freedom is accompanied by responsibilities: to act with integrity; to uphold the values of science; to combat threats to science and scientific freedom; and to use scientific knowledge to benefit society. This is where ethical consultations between science and faith can be particularly valuable.

7. **We recognize the importance and benefits of long-term perspectives in science, and call for society, including faith-based communities, and policy to recognize and more strongly support basic sciences.** When emphasizing the importance of basic science, we are aware that there are also reasons to criticize the results of curiosity-driven investigations. And science must be transparent to the public at large: for example, it must be explained how it contributes to problem solving. Basic sciences are always at risk of being marginalized when crises, wars, and growing insecurity occupy people's minds and divert resources to the mitigation of day-to-day problems, as is currently the case. However, science operates on long time scales and requires continuity. Certain issues such as climate, biodiversity, genetics, medicine, astrophysics and the analysis of intelligent systems, both natural and artificial, can only be pursued on time scales of decades, if not centuries. Still, science-informed actions on some of these challenges need to be taken now. We realize that the search for solutions to these existential societal challenges can come from advances in science. Therefore, paradoxically, curiosity-driven basic science needs to develop a stronger sense of urgency: we need more opportunity for inquisitiveness in the younger generation, fostered by vibrant educational systems that stimulate imagination. We note that strong support for curiosity-driven science has huge payoffs that often come about in unpredictable ways, mostly in the long term, but increasingly even in the short term. A fine example of what basic science can achieve is the rapid development of the COVID vaccine thanks to developments in the decade-long studies of messenger RNA, which were planned for completely different purposes.

8. **It is ever more important for science to have peace as a goal.** The PAS had already actively engaged in support of this goal at critical junctures in the past, such as addressing threats of nuclear war and, more recently, risks of artificial intelligence and robotics in warfare. The many ongoing armed conflicts, such as the Russian attack on Ukraine, wars in Tigray/Ethiopia and in Yemen and Syria, as well as many other armed conflicts inside and between countries, are of grave concern to us because they cause great suffering for civilian populations, particularly for women and children. We condemn all atrocities against civilians, war crimes and crimes against humanity, and we call for accountability and

independent investigations into these crimes. We also call for unfettered humanitarian aid, access to basic services to civilians and lifting of sieges. As scientists, we must not neglect the fundamental drivers of conflicts, and not ignore the role of science in the arms race. We thus take this opportunity to re-emphasize our recent statement on "Preventing Nuclear War and War Against Civilian Populations: Also a Task for the Sciences".[1] The accelerated – and even global – risks that emerge from threats or actual attacks by powerful countries on their neighbors are putting political order and human civilization at risk. At a time when science is so dominant in culture, all scientific disciplines should consider their potential contributions to peace. Peace is a precondition for human development. Divisiveness, for instance related to ethnicity and race – not just absence of war – undermines both peace and planetary health. This is part of the rationale of our theme "Basic science for human development, peace, and planetary health".

9. **The Pontifical Academy of Sciences remains concerned about neglect of science-informed rational arguments and science skepticism in parts of the general public, and in conventional and social media**.[2] These issues have escalated in recent years. During the Plenary 2022 it became necessary to re-examine the determinants of these tendencies, and the role that religion may play in both adherence to science skepticism and openness to science. The Academy would like to emphasize the importance of science education in the pursuit of truth and in better understanding societal developments. We note, however, that there is also well-informed, important skepticism about sometimes overlooked disconnections between science, technology, and their real-world impact, such as rebound effects of innovations and externalities. These require more attention in the research process. The PAS adheres to transparent science discourse open to the general public, and follows established science ethics. Indeed, PAS Academicians and their narratives on basic sciences can appeal to a broad audience, to show how science is done and what can come out of it, without neglecting risks of misuse. PAS Academicians are encouraged to do more in sharing their diverse narratives on what brought them to a certain invention, what their discovery means, and how curiosity, imagination, and efforts drove their work, including how they connect to the broad issues mentioned above, i.e. human development, peace, and planetary health. Science skepticism can also be channeled into productive discourse by engagement of science with ethicists over the introduction of new technologies. In that context and in general, scientists must work hard on a language that is understood and identified by most of the population to communicate the goods that science delivers.

10. **The abovementioned powerful contributions of basic science and its related capacities need to be shared more equitably – especially by the rich nations – with low-income regions of the world.** Otherwise, the benefits for human development, peace, and planetary health will not come about. Scientific institutions, including Academies of Sciences, need to further strengthen their mechanisms of sharing and engaging with political and societal actors worldwide.[3] Transcending countries, cooperation in science is not only important to facilitate large-scale science programs, but also in terms of inclusiveness: it allows us to understand and welcome cultural differences that are important for peace. Two-way consultations with society are beneficial, for instance between science and faith-based organizations, embracing value and moral issues, as we practice in the PAS.[4]

[1] 8 April 2022 https://www.pas.va/en/events/2022/preventing_nuclear_war.html
[2] https://www.pas.va/en/publications/acta/acta25pas.html
[3] See events and conferences at https://www.pas.va/en/events/plenary-session.html and https://www.pas.va/en/events/workshop.html
[4] See addresses by the Popes from Pope Benedict XV to Pope Francis 1914 – 2022 at https://www.pas.va/en/magisterium/francis/2020-7-october.html. And cf. *Papal Addresses to the Pontifical Academy of Sciences 1917-2000 and the Pontifical Academy of Social Sciences 1994-2000*, ed. Marcelo Sánchez Sorondo, PAS, Vatican City 2003; https://www.pas.va/en/publications/scripta-varia/sv100pas.html

Statement by Joachim von Braun, President of Pontifical Academy of Sciences

At the Papal Audience on September 10th, 2022 on the Occasion of the Plenary Conference "Basic science for human development, peace, and planetary health"

Dear Holy Father,

We are most grateful to You for welcoming us on the occasion of the Plenary Conference of the Pontifical Academy of Sciences.

Today we have an historic audience with You, because of the following two reasons:

1. Our esteemed and beloved former Chancellor, H.E. Bishop Marcelo Sánchez Sorondo has just retired. Yesterday we recognized his tremendous achievements building the Academy for a quarter century with a special session on "Science in Philosophical and Religious Perspectives".
2. We warmly welcomed H.Em. Cardinal Peter Turkson as our new Chancellor. We are grateful to him for now serving the Academy, and grateful to you for this distinguished appointment, which demonstrates your esteem and support of our Academy.

I am pleased to inform you that today, we have eleven new members of the Academy to introduce to you, who are leaders in diverse fields of science from many different countries. We also gave the Pius XI medal to two distinguished of young scientists for their excellent research.

The members of the Academy consider it an honor to offer their precious time to your Academy. They do so because our Academy has an excellent reputation for commitment to scientific truth and its liberating benefits that are open to all people, especially those most in need. PAS also appeals to us because of the autonomy in research that you guard and respect, as well as the international composition of its membership and their excellence in scientific disciplines.

The Academy has an increasing reach and impact through You, especially on issues of climate, protection of human and planetary health, and equity, as demonstrated, inter alia, by the Encyclical *Laudato Si'*.

Our agenda at this Plenary conference was "Basic science for human development, peace, and planetary health". Basic science is essential to improve human welfare, for example by means of improved medicine, food systems, and energy for the poor. Moreover, basic science offers deeper understanding, knowledge of causes and enables a wisdom that is able to respond to the challenges of our time.

We addressed topics at the frontiers of sciences in key areas that change world views and have the potentials to improve human development, peace, and planetary health. We discussed, for example,

1. Climate and atmospheric science and resilience of People and Ecosystems under Climate Stress
2. Reconstructing cities, incl. slums
3. Health of the oceans
4. Life Sciences and Medical science, on healing cancer, and regenerating cells
5. Covid-19 and actions to address the pandemics
6. Mathematics and Artificial Intelligence, using AI to accelerate scientific discovery
7. Astronomy, exploring how our Milky Way was formed.

The fact that important discoveries come about because of curiosity as a result of wonder and admiration of nature raises philosophical, ethical, religious, as well as policy questions. We also integrate philosophy and theology in our work, drawing for instance on Aristotle, Thomas Aquinas and contemporary thinkers that we invite to our meetings. Marcelo has helped us a lot in that over the years, and we also hope to draw on his wisdom also in the future. Our workshop on "Symbols, Myths and Religious Sense" of early humans hundreds of thousands of years ago is an example.

Dear Holy Father,

Basic sciences are at risk of being marginalized or misused by the strong powers of the day. This is especially true when economic crises, wars, and growing risks trouble people, as is currently the case. Therefore, it is ever more important for science to have peace as a goal. A few months ago, the Pontifical Academy of Sciences did again call to attention to the threats of nuclear war, and wars against civilian populations. We also emphasize the fundamental drivers of conflicts: divisiveness, discord, hatred, greed, exploitation, human trafficking and racism, which undermine both peace and planetary health.

In order to address neglect of science-informed rational arguments, the Church can help the understanding of science, for instance through science education in school and university curricula.

We stress, that in view of the well-known powerful contributions of basic science, related knowledge and good practice need to be shared more widely, especially with low-income regions of the world. Otherwise the benefits for human development, peace, and planetary health will not come about. Our Academy therefore is also actively reaching out to scientists in Africa, Latin America and Asia and we are expanding our membership in these hemispheres.

Dear Holy Father,

Thank you for the most thoughtful statements with which you accompany our work, and encourage us. While promoting the freedom of scientific research, you also foster fruitful reflections among science and faith which are important for our work that aims at human development, peace, and planetary health.

We thank you for your prayers, and pray for you.

Best wishes and God bless you.

Address of His Holiness Pope Francis to the Pontifical Academy of Sciences

10 September 2022, Clementine Hall

Your Eminences,

Dear Brother Bishops,

Distinguished Ladies and Gentlemen!

I welcome you on this occasion of the Plenary Session of the Pontifical Academy of Sciences. I thank your President, Professor Joachim von Braun, for his kind words. I likewise express my gratitude to Archbishop Marcelo Sánchez Sorondo, who has worked very hard as Chancellor in service of this Academy and that of the Social Sciences. May the Lord reward him and bestow upon him many blessings. We send him good wishes for his eightieth birthday and for a happy retirement! Now others can take charge. We also welcome the new Chancellor, Cardinal Peter Turkson: thank you for accepting, Your Eminence!

The theme of your Plenary Session, "Basic Science for Human Development, Peace, and Planetary Health", underlines the key issues facing our human family at this moment in history.

Yet first, I would like to answer a question that not a few people are asking: Why did the popes, beginning in 1603, wish to have an Academy of Sciences? As far as I am aware, no other religious institution has such an academy, and many religious leaders have expressed an interest in establishing one. Leaving historical hypotheses to others, I would interpret this decision today in the context of love and care for the common home that God has given us. The Church embraces and encourages a passion for scientific research as an expression of love for the truth and for knowledge about the world on both the macro and microcosmic levels, and about life in all its symphonic splendour. Saint Thomas Aquinas states that "the end of the whole universe is truth" (Summa contra Gentiles, I,1). As part of this universe, we ourselves have a unique responsibility, which stems from our ability to wonder and ask "why?" when faced with reality as it is. At the heart of this, then, lies a contemplative attitude, and the complementary task of caring for creation. Dear friends, the theme of your Plenary Session is situated in this same perspective.

Looking back on recent years, I gratefully recall PAS's declarations in the face of various emergencies, whether concerning food crises and the fight against hunger – in cooperation with the UN Food Summit – or to do with the health of the oceans and seas, or indeed with strengthening the resilience of the poor in the case of climate shocks. Important too were your efforts to help rebuild poor neighbourhoods in a sustainable way making use of the bioeconomy, as well as an equitable response to health problems caused by the Covid pandemic. No less relevant is the work to establish international standards for organ donation and organ transplants in the fight against human trafficking, as well as undertakings to promote a new science of medical rehabilitation for the elderly and the poor. Moreover, I particularly appreciate your efforts to engage science and politics in order to prevent nuclear war and war crimes against civilian populations. I congratulate all those who have actively participated in this, especially you, Professor von Braun, for the wisdom and commitment with which you have brought fresh ideas into the life of the Academy. You have taken up today's challenges as concrete scientific opportunities, in order to address them by working with scientists who can help to resolve problems.

In this Plenary Session, you emphasize "basic science," which makes available a great deal of new knowledge about the Earth, the universe and the place of human beings within it. I congratulate you because you maintain the goal of connecting basic science with resolving current challenges, of connecting astronomy, physics, mathematics, biochemistry and climate sciences with philosophy in the service of human development, peace and the health of our planet. This interconnected approach is very important because, as scientific achievements increase our awe at the beauty and complexity of nature, there is a growing need for interdisciplinary studies, linked to philosophical reflection, that can lead to new syntheses. This interdisciplinary vision, if it also takes stock of Revelation and theology, can help provide answers to humanity's ultimate questions, which are also being asked by new, and sometimes disoriented, generations.

Indeed, this century's scientific achievements must always be directed to the needs of fraternity, justice and peace, and help meet the great challenges facing our human family and our environment. In this sense, too, the Pontifical Academy of Sciences has a unique structure, composition and set of goals, which are always aimed at sharing the benefits of science and technology with the greatest number of people, especially those most disadvantaged and in need. In this way, it also strives to liberate people from various forms of slavery, such as forced labour, prostitution and organ trafficking. These crimes against humanity, which go hand in hand with poverty, also occur in developed countries, in our own cities. The

human body, whether in part or in its entirety, can never be an object of trade! I am pleased that PAS is actively engaged in supporting these goals, and I trust it will continue to do so with ever greater intensity commensurate with growing needs.

In short, the positive results of science in the twenty-first century will depend, to a great extent, on the ability of scientists to seek the truth and apply discoveries in a way that develops in tandem with the search for what is right, noble, good and beautiful. I look forward to the results of your work, which will also be important for educational institutions and younger generations.

Dear Members of the Academy, at this moment in history, I ask you to promote knowledge with the aim of building peace. After two tragic world wars, it seemed that the world had learned to move progressively towards respect for human rights, international law and various forms of cooperation. Unfortunately, history shows signs of regression. Not only are anachronistic conflicts intensifying, but instances of a myopic, extremist, resentful and aggressive nationalism are re-emerging (cf. Fratelli Tutti, 11), and new wars of domination, affecting civilians, the elderly, children and the sick are causing destruction everywhere. The many ongoing armed conflicts are of serious concern. I have said that it was a third world war being fought "piecemeal" – perhaps we can now say that it is "all out" – putting people and the planet at ever greater risk. Saint John Paul II gave thanks to God that, through Mary's intercession, the world had been preserved from atomic war. Unfortunately, we must continue to pray for protection against this danger, which should have been averted long ago.

All knowledge based on science and experience must be utilized to avoid wars and overcome suffering, poverty and new forms of slavery. By rejecting research that in the past has been destined for deadly ends, scientists around the world can unite in a common readiness to disarm science and thus become a force for peace. In the name of God, who created all human beings for a common destiny of happiness, we are called today to bear witness to our fraternal vocation to freedom, justice, dialogue, mutual encounter, love and peace, and avoid nurturing hatred, resentment, division, violence and war. In the name of the God, who gave us the planet to safeguard and develop, we are called today to ecological conversion, to save our common home and life, and that of future generations, rather than increasing inequality, exploitation and destruction.

Dear Members of the Academy, dear friends, I encourage you to continue working for truth, freedom, dialogue, justice and peace. Today more than ever – also thanks to you! – the Catholic Church is an ally of scientists who follow this aspiration. I assure you of my prayers and, respecting each one's beliefs, I invoke upon you God's blessing. And please, in your own way, also pray for me. Thank you!

Program

https://www.youtube.com/playlist?list=PLPHLdH2gKE0fC_OqHQwVO4MvowQtzN6DQ

THURSDAY, SEPTEMBER 8th 2022	
9:00	**Chair: Joachim von Braun** *PAS President, Bonn University* **Joachim von Braun** *PAS President* | Welcome and Concept of the Plenary **Card. Peter Turkson** *PAS Chancellor* | Words of Welcome
SESSION I – Astronomy for human development, peace, and planetary health	
9:15	**Co-Chairs: Ewine van Dishoeck** *PAS Academician, Professor of Molecular Astrophysics, Leiden University, The Netherlands* and **Martin Rees** *PAS Academician, University of Cambridge, Institute of Astronomy, UK* by Zoom • **Reinhard Genzel** *PAS Academician, Director, Max Planck Institute for Extraterrestrial Physics, Germany* *Black hole at galactic center* by Zoom • **Michael Kramer** *Director, Max Planck Institute for Radio Astronomy, Germany* *Testing relativistic gravity with radio astronomy* • **Amina Helmi** *Full Professor, Kapteyn Astronomical Institute, University of Groningen, The Netherlands* *How was our Milky Way formed?* • **Karin Öberg** *Professor of Astronomy, Harvard University, USA* *How to make a habitable planet*
10:15	**Discussion of the presentations (30 minutes)**
10:45	**Coffee Break**
SESSION II – Physics and biophysics for human development, peace, and planetary health	
11:15	**Co-Chairs: Fabiola Gianotti** *PAS Academician, Director-General at CERN (European Organization for Nuclear Research), Switzerland* and **William D. Phillips** *PAS Academician, Distinguished University Professor & College Park Professor of Physics, University of Maryland, USA* by Zoom • **Francisca Nneka Okeke** *Professor of Physics, University of Nigeria, Nsukka* *Solar activity and earth phenomena* by Zoom • **Stefan W. Hell** *PAS Academician, Director, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany* *Molecular-scale resolution in fluorescence* • **José Nelson Onuchic** *PAS Academician, Professor of Physics, Co-Director, Center for Theoretical Biological Physics, Rice University, USA* *Using physics to improve human health: From protein folding to understanding Covid-19 and designing new vaccines*
12:15	**Discussion of the presentations (30 minutes)**
12:45	**Lunch at the Casina Pio IV**

SESSION III – Mathematics and AI for human development, peace, and planetary health	
14:30	**Co-Chairs: Mohamed H.A. Hassan** *PAS Academician, President of The World Academy of Sciences, Sudan* and **Stanislas Dehaene** *PAS Academician, Professor, Experimental Cognitive Psychology, Collège de France, Cognitive Neuroimaging Unit, CEA, INSERM, Université Paris-Sud, Université Paris-Saclay, NeuroSpin Center, Gif/Yvette, France* • **Demis Hassabis** *Founder and CEO of DeepMind (Pius XI Medalist 2020)* *Using AI to accelerate scientific discovery.* Followed by presentation of the Medal • **Peter Scholze** *Managing Director, Max Planck Institute for Mathematics (Pius XI Medalist 2020)* *On Platonism in Mathematics*. Followed by presentation of the Medal by Zoom • **Batmanathan Dayanand Reddy** *Professor Emeritus of Applied Mathematics University of Cape Town, South Africa* *Africa's brightest young minds: The African Institute for Mathematical Sciences (AIMS) and its impact on development on the continent* • **Mérouane Debbah** *Chief, Research at the Technology Innovation Institute, Abu Dhabi, Professor at CentraleSupélec, Paris, France* *Mathematics at heart of technological breakthroughs* by Zoom
15:30	**Discussion of the presentations (30 minutes)**
16:00	**Coffee Break**
SESSION IV – Chemistry / Bio-Chemistry for human development, peace, and planetary health	
16:30	**Co-Chairs: Edward M. De Robertis** *PAS Academician, Norman Sprague Professor of Biological Chemistry, David Geffen School of Medicine, University of California Los Angeles (UCLA), USA* and **Ada E. Yonath** *PAS Academician, Martin S. and Helen Kimmel Professor of Structural Biology and Director, The Helen and Milton A. Kimmelman Center for Biomolecular Structure and Assembly, Weitzmann Institute, Israel* by Zoom • **Frances Hamilton Arnold** *PAS Academician, Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry, California Institute of Technology. Pasadena, California, USA* *Innovation by evolution: bringing new chemistry to life* • **Jürgen A. Knoblich** *PAS Academician, Scientific Director, Institute of Molecular Biotechnology (IMBA), Vienna, Austria* *Brain organoids: Stem cell derived 3D cell culture models for human brain development and neurological disorders* • **Rafael Radi** *Professor and Chair, Department of Biochemistry, Faculty of Medicine and Director of the Center for Biomedical Research (CEINBIO), Universidad de la República, Uruguay* *Science during the pandemic: a journey from basic redox biochemistry to Covid-19 national public health advice* • **Werner Arber** *Emeritus President for Life, Pontifical Academy of Sciences and Emeritus Professor of Molecular Microbiology, Biozentrum, University of Basel, Switzerland* *Horizontal gene transfer in the context of a rich biodiversity* by Zoom
18:30	**Discussion of the presentations (30 minutes)**
19:00	**Dinner at the Casina Pio IV**

FRIDAY SEPTEMBER 9th 2022	
SESSION V – Life Sciences and Medical science for human development, peace, and planetary health	
9:00	**Co-Chairs: Chien-Jen Chen** *PAS Academician, Professor, Graduate Institute of Epidemiology, National Taiwan University College of Public Health* and **Francis L. Delmonico** *PAS Academician, Professor of Surgery, Harvard Medical School, Massachusetts General Hospital, Chief Medical Officer, New England Donor Services, USA* • **Helen M. Blau** *PAS Academician, Donald E. and Delia B. Baxter Foundation Professor and Director of the Baxter Laboratory for Stem Cell Biology at Stanford University School of Medicine, USA* *Regenerating and rejuvenating aged tissues by targeting gerogenes* • **James F. Markmann MD, PhD** *Chief of the Division of Transplant Surgery and Director of Clinical Operations at the Transplant Center at Massachusetts General Hospital, and the Claude Welch Professor of Surgery at the Harvard Medical School, USA* *The current state of organ transplantation and the science of immunity* • **Stanley B. Prusiner** *PAS Academician, Director of the Institute for Neurodegenerative Diseases and Professor of Neurology and Biochemistry at the University of California San Francisco (UCSF), USA* *α-synuclein prion strains as the causes of dementia with Lewy bodies and multiple system atrophy* (incl. 5 min. self-presentation) by Zoom
10:00	**Discussion of the presentations (30 minutes)**
10:30	**Coffee Break**
SESSION VI – Atmospheric Science, and Climate Science for human development, peace, and planetary health	
11:00	**Chair: Jane Lubchenco** *Distinguished University Professor, Oregon State University, Corvallis OR, and Deputy Director for Climate and Environment at the White House Office of Science and Technology Policy, USA. PAS Academician* • **Susan Solomon** *PAS Academician, Lee and Geraldine Martin Professor of Environmental Studies, Department of Earth, Atmospheric and Planetary Sciences, MIT, USA* *Variability and prediction related to climate change* by Zoom • **Hans J. Schellnhuber** *PAS Academician, Director Emeritus of the Potsdam Institute for Climate Impact Research (PIK), Germany* *Climate sensitive construction and building sectors* by Zoom
12:00	**Discussion of the presentations (30 minutes)**
12:30	**Lunch at the Casina Pio IV**

SESSION VII – Session for commemoration of deceased Academicians and self-presentations of new Academicians	
14:00	**Co-Chairs: Joachim von Braun** *PAS President*
	Commemorations • **Yves Coppens** (by Zeresenay Alemseged) • **Paul Crutzen** (by Veerabhadran Ramanathan) by Zoom • **Beatriz Mintz** (by Helen Blau) • **Enrico Berti** (by Marcelo Sánchez Sorondo) • **Michael Sela** (by Aaron Ciechanover) by Zoom
	Self-Presentations of new Academicians (5 minutes each) • **Zeresenay Alemseged** *Donald N. Pritzker Professor of Organismal Biology and Anatomy, University of Chicago, USA* • **Chien-Jen Chen** *Professor, Graduate Institute of Epidemiology, National Taiwan University College of Public Health* • **Ewine F. van Dishoeck** *Professor of Molecular Astrophysics, Leiden University, The Netherlands* • **Jennifer A. Doudna** *Professor of Biochemistry, Biophysics and Structural Biology, Dept. of Chemistry, University of California, Berkeley, USA* by Zoom • **Elaine Fuchs** *Investigator of the Howard Hughes Medical Institute and Rebecca C. Lancefield Professor of the Rockefeller University, USA* • **Edith Heard** *Director General of European Molecular Biology Laboratory (EMBL), Heidelberg, Germany and Professor at Collège de France* by Zoom • **Jane Lubchenco** *Distinguished University Professor, Oregon State University, Corvallis OR, and Deputy Director for Climate and Environment at the White House Office of Science and Technology Policy, USA* • **Susan Solomon** *Lee and Geraldine Martin Professor of Environmental Studies, Department of Earth, Atmospheric and Planetary Sciences, MIT, USA* by Zoom
15:30	**Coffee Break**

SESSION VIII – Science in philosophical and religious perspectives Session in Honor of H.E. Msgr. Marcelo Sánchez Sorondo, Former Chancellor, The Pontifical Academy of Sciences	
16:00	**Co-Chairs: Jürgen Mittelstraß** *PAS Academician, Director, Konstanzer Wissenschaftsforum, University of Constance, Germany* and **Joachim von Braun** *PAS President* • **Jürgen Mittelstraß** *PAS Academician, Director, Konstanzer Wissenschaftsforum, University of Constance, Germany* *Introductory remarks* • **Flavia Marcacci** *Professor of History of Scientific Thought, Pontifical Lateran University, Rome, Italy* *Beyond Galileo: facts, values, and historical joints* • **H.E. Bishop Robert Barron** *Diocese of Winona-Rochester, Minnesota, USA* *Three philosophical paths beyond scientism* • **Rev. Antje Jackelén** *The Lutheran Archbishop of Uppsala in Sweden and Primate, Church of Sweden* *Science in philosophical and religious perspectives* • **Address: H.E. Archbishop Paul Richard Gallagher** *Secretary for Relations with States within the Holy See's Secretariat of State* | *On sciences for human development, peace, and planetary health – Perspectives from the Holy See* • **H.Em. Cardinal Giovanni Battista Re** *Dean of the College of Cardinals* **Reflections by Academicians**
17:30	**Reflections by H.E. Msgr. Marcelo Sánchez Sorondo**
18:00	Closing session **Chair: Joachim von Braun** *PAS President* *Introduction of draft conference statement: initial comments by conference participants*
19:00	**Dinner at the Casina Pio IV**

SATURDAY, SEPTEMBER 10th 2022	
9:30	**Papal Audience for PAS Academicians and Guests**

List of Participants

Zeresenay Alemseged
Donald N. Pritzker Professor of Organismal Biology and Anatomy, University of Chicago, USA.
PAS Academician

by Zoom

Werner Arber
Microbiology, Biological Evolution. Emeritus Professor, Biozentrum, University of Basel, Switzerland. Nobel laureate in Physiology or Medicine.
PAS Emeritus President for Life

Frances Hamilton Arnold
Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry, California Institute of Technology. Pasadena, California, USA. Nobel laureate in Chemistry.
PAS Academician

Vanderlei S. Bagnato
University of Sao Paulo, Department IFSC - Physics, Brazil.
PAS Academician

by Zoom

David Baltimore
California Institute of Technology Pasadena, CA, USA
Nobel laureate in Physiology or Medicine.
PAS Academician

H.E. Bishop Robert Barron
Diocese of Winona-Rochester, Minnesota, USA

by Zoom

Antonio Battro
Academia Nacional de Educación, Buenos Aires, Argentina.
PAS Academician

David Baulcombe
University of Cambridge, Department Plant Sciences, UK.
PAS Academician

Helen M. Blau
Donald E. and Delia B. Baxter Foundation Professor and Director of the Baxter Laboratory for Stem Cell Biology at Stanford University School of Medicine, USA. PAS Academician

Joachim von Braun
Food, Nutrition and Agricultural Research, Development and Poverty. Distinguished Professor, Economic and Technological Change, University of Bonn, Germany. PAS President

Chien-Jen Chen
Professor, Graduate Institute of Epidemiology, National Taiwan University College of Public Health.
PAS Academician

by Zoom

Aaron Ciechanover
Principal Investigator, Distinguished Technion Research Professor, The Rappaport Family Technion Integrated Cancer Center (R-TICC), The Rappaport Faculty of Medicine and Research Institute, Israel. Nobel laureate in Chemistry. PAS Academician

Brother Guy Joseph Consolmagno SJ
Director of the Vatican Observatory, Vatican City.
PAS Academician "Perdurante Munere"

by Zoom

Mérouane Debbah
Chief, Research at the Technology Innovation Institute, Abu Dhabi, Professor at CentraleSupélec, Paris, France

Stanislas Dehaene
Professor, Experimental Cognitive Psychology, Collège de France, Cognitive Neuroimaging Unit, CEA, INSERM, Université Paris-Sud, Université Paris-Saclay, NeuroSpin Center, Gif/Yvette, France. PAS Academician

Francis L. Delmonico
Professor of Surgery, Harvard Medical School, Massachusetts General Hospital, Chief Medical Officer, New England Donor Services, USA. PAS Academician

Edward M. De Robertis
Norman Sprague Professor of Biological Chemistry, David Geffen School of Medicine, University of California Los Angeles (UCLA), USA. PAS Academician

Ewine F. van Dishoeck
Professor of Molecular Astrophysics, Leiden University, The Netherlands. PAS Academician

by Zoom

Jennifer A. Doudna
Professor of Biochemistry, Biophysics and Structural Biology, Dept. of Chemistry, University of California, Berkeley, USA. Nobel laureate in Chemistry. PAS Academician

Elaine Fuchs
Investigator of the Howard Hughes Medical Institute and Rebecca C. Lancefield Professor of the Rockefeller University, USA. PAS Academician

H.E. Archbishop Paul Richard Gallagher
Secretary for Relations with States within the Holy See's Secretariat of State

by Zoom

Reinhard Genzel
Director, Max Planck Institute for Extraterrestrial Physics, Germany. Nobel laureate in Physics. PAS Academician

Fabiola Gianotti
Director-General at CERN (European Organization for Nuclear Research), Switzerland. PAS Academician

by Zoom

Takashi Gojobori
King Abdullah University of Science and Technology, Kingdom of Saudi Arabia. PAS Academician

by Zoom

Theodor W. Hänsch
Max-Planck-Institut für Quantenoptik, Garching, Germany. PAS Academician

Demis Hassabis
Founder and CEO of DeepMind (Pius XI Medalist 2020)

Mohamed H.A. Hassan
President of The World Academy of Sciences, Sudan. PAS Academician

by Zoom

Edith Heard
Director General of European Molecular Biology Laboratory (EMBL), Heidelberg, Germany and Professor at Collège de France. PAS Academician

Stefan W. Hell
Director, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany. Nobel laureate in Chemistry. PAS Academician

Amina Helmi
Full Professor, Kapteyn Astronomical Institute, University of Groningen, The Netherlands

Rev. Antje Jackelén
The Lutheran Archbishop of Uppsala in Sweden and Primate, Church of Sweden

by Zoom

Klaus von Klitzing
Max-Planck-Institute for Solid State Research, Stuttgart, Germany. Nobel laureate in Physics. PAS Academician

Jürgen A. Knoblich
Scientific Director, Institute of Molecular Biotechnology (IMBA), Vienna, Austria. PAS Academician

Michael Kramer
Director, Max Planck Institute for Radio Astronomy, Germany

Pierre J. Léna
Université Paris VII Denis Diderot, Observatoire de Paris, Département de Recherche Spatiale, Meudon, France. PAS Academician

Jane Lubchenco
Distinguished University Professor, Oregon State University, Corvallis OR, and Deputy Director for Climate and Environment at the White House Office of Science and Technology Policy, USA. PAS Academician

Flavia Marcacci
Professor of History of Scientific Thought, Pontifical Lateran University, Rome, Italy

James F. Markmann
MD, PhD Chief of the Division of Transplant Surgery and Director of Clinical Operations at the Transplant Center at Massachusetts General Hospital, and the Claude Welch Professor of Surgery at the Harvard Medical School, USA

Jürgen Mittelstraß
Director, Konstanzer Wissenschaftsforum, University of Constance, Germany. PAS Academician

Salvador Moncada
Research Domain Director Faculty of Biology, Medicine and Health, University of Manchester, UK. PAS Academician

Karin Öberg
Professor of Astronomy, Harvard University, USA

by Zoom

Francisca Nneka Okeke
Professor of Physics, University of Nigeria, Nsukka

José Nelson Onuchic
Professor of Physics, Co-Director, Center for Theoretical Biological Physics, Rice University, USA. PAS Academician

by Zoom

William D. Phillips
Distinguished University Professor & College Park Professor of Physics, University of Maryland, USA. Nobel laureate in Physics. PAS Academician

Stefano Piccolo
Dipartimento di Medicina Molecolare Università di Padova, Italy. PAS Academician

by Zoom

Ingo Potrykus
Professor emeritus
ETH, Zürich, Switzerland.
PAS Academician

by Zoom

Stanley B. Prusiner
Director of the Institute for Neurodegenerative Diseases and Professor of Neurology and Biochemistry at the University of California San Francisco (UCSF), USA. Nobel laureate in Physiology or Medicine. PAS Academician

Didier Patrick Queloz
Jacksonian Professor of Natural Philosophy at the University of Cambridge, and professor at the University of Geneva. Nobel Laureate

Yves Quéré
Académie des sciences,
Paris, France. PAS Academician

Rafael Radi
Professor and Chair, Department of Biochemistry, Faculty of Medicine and Director of the Center for Biomedical Research (CEINBIO), Universidad de la República, Uruguay

by Zoom

Veerabhadran Ramanathan
Distinguished Professor Emeritus, Scripps Institution of Oceanography, University of California at San Diego, USA; Climate Solutions Scholar, Cornell University, Ithaca, NY, USA.
PAS Academician

by Zoom

Chintamani N.R. Rao
Jawaharlal Nehru Centre for Advanced Scientific Reseach,
Bangalore, India. PAS Academician

Batmanathan Dayanand Reddy
Professor Emeritus of Applied Mathematics University of Cape Town, South Africa

H.Em. Cardinal
Giovanni Battista Re
Dean of the College of Cardinals
Vatican City

by Zoom

Martin Rees
University of Cambridge, Institute of Astronomy, UK. PAS Academician

H.E. Bishop Marcelo Sánchez Sorondo
Former PAS Chancellor,
Vatican City

Hans J. Schellnhuber
Director Emeritus of the Potsdam Institute for Climate Impact Research (PIK), Germany. PAS Academician

by Zoom

Peter Scholze
Managing Director, Max Planck Institute for Mathematics (Pius XI Medalist 2020)

Laurent Simons
Ph.D. student
Physics department
Ludwig-Maximilians-Universität Münich, Germany

Wolf J. Singer
Max-Planck-Institute for Brain Research, Frankfurt am Main, Germany. PAS Academician

by Zoom

Susan Solomon
Lee and Geraldine Martin Professor of Environmental Studies, Department of Earth, Atmospheric and Planetary Sciences, MIT, USA. PAS Academician

by Zoom

Donna T. Strickland
University of Waterloo, Department of Physics, Waterloo, ON, USA.
PAS Academician

H.Em. Cardinal Peter K.A. Turkson
PAS Chancellor
Vatican City

Refael Vicuña
Pontificia Universidad Católica de Chile, Facultad de Ciencias Biológicas, Departamento de Génetica Molecular y Microbiología, Santiago, Chile.
PAS Academician

Msgr. Dario Edoardo Viganò
PAS Vice Chancellor
Vatican City

by Zoom

Maryanne Wolf
University of California, Los Angeles School of Education and Information Studies, Los Angeles, CA, USA.
PAS Academician

by Zoom

Ada E. Yonath
Martin S. and Helen Kimmel Professor of Structural Biology and Director, The Helen and Milton A. Kimmelman Center for Biomolecular Structure and Assembly, Weitzmann Institute, Israel. Nobel laureate in Chemistry.
PAS Academician

For the biographies of PAS Academicians, please see www.pas.va

Wi-Fi Network: Academy-Guest
Password: G@rdens1936

THE PONTIFICAL ACADEMY OF SCIENCES | CASINA PIO IV | V-00120 VATICAN CITY
Tel: +39 0669883195 | Fax: +39 0669885218 | Email: pas@pas.va
For further information please visit: www.pas.va

@casinapioiv