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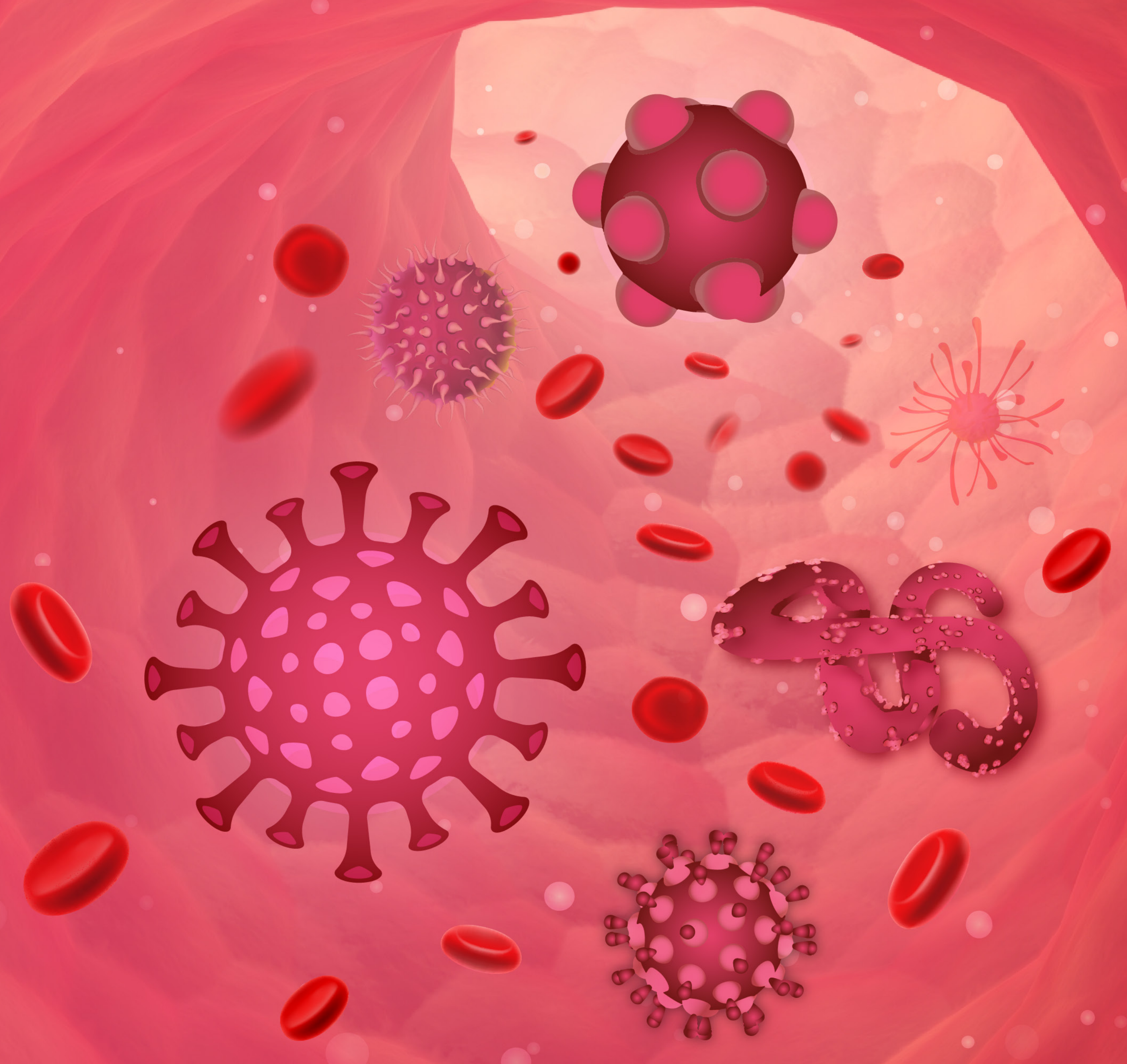

Infectious Diseases

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Trained and equipped to fight animal and zoonotic diseases, pg 18

Combatting malaria, dengue and Zika using nuclear technology, pg 22

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IAEA

The International Atomic Energy Agency's mission is to prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water, industry and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists and criminals, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide a system of fundamental safety principles and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

Pre-empting and preventing infectious disease outbreaks

By Rafael Mariano Grossi, Director General, IAEA

COVID-19 has been a painful reminder of how deadly and disruptive a disease can be. The IAEA has devoted considerable energy and resources to helping countries respond to the pandemic, working closely with key international partners. Our focus has been on the use of nuclear and nuclear-derived techniques for virus detection and diagnosis.

It quickly became clear to me that a piecemeal approach to COVID-19, and to future outbreaks of zoonotic diseases (those transmitted from animals to humans), would be ineffective. That is why, in June 2020, I launched the IAEA ZODIAC — **ZO**onotic **D**isease **I**ntegrated **AC**tion — initiative to strengthen countries' capabilities in early detection, diagnosis, prevention and control of zoonotic disease outbreaks. ZODIAC is about getting all of the capabilities that the IAEA has in zoonotic diseases and related areas and bringing them together in a package to address the deficiencies that many countries face in terms of technical expertise and equipment. This unified platform will help the world pre-empt and prevent zoonotic disease outbreaks and protect the health and well-being of billions of people (page 5). I am inviting key partners such as the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) to join us.

Over 120 countries turned to the IAEA for assistance with the virus, and we responded. Mounting our largest assistance operation ever, we sent hundreds of shipments of vital testing equipment and protective gear all over the world (page 6). The IAEA provided expertise on the diagnosis and detection of COVID-19 using medical imaging (page 12) and one of the fastest and most accurate diagnostic tests available, known as reverse transcription–polymerase chain reaction (RT–PCR) (page 8). The IAEA and its partners have also supported health professionals by providing vetted advice (page 15).

In this edition of the *IAEA Bulletin*, you will learn about infectious diseases more generally (page 4) and how countries work with the IAEA to build their capacity to deal with them (page 18). In Sierra Leone, for example, specialists are drawing on IAEA expertise to test whether bats are infected with the Ebola virus (page 20). In Latin America and the Caribbean, IAEA support is helping countries deal with malaria, dengue and Zika as well as the mosquitoes that spread these devastating illnesses (page 22).

By controlling animal diseases, we can help to protect livestock, communities and entire economies. Nuclear science has already helped countries such as Bulgaria (page 26) and Viet Nam (page 25) to strengthen food security and trade. Thanks to a vaccination campaign involving nuclear-derived techniques, foot-and-mouth disease is now under control in Morocco (page 28). Advances in irradiated animal vaccines are also making a difference in Ethiopia (page 30).

The IAEA does not work in isolation. Cooperation with partners such as the WHO, the FAO and the World Organisation for Animal Health (OIE) is vital. During the COVID-19 pandemic, the IAEA became part of the WHO-led COVID-19 United Nations Crisis Management Team. The IAEA's efforts have also been supported through contributions by countries, as well as from the private sector, Takeda Pharmaceutical Company Limited.

The IAEA is committed to doing everything possible to help the world respond to major challenges to human and animal health, using nuclear science and technology, in the coming years.

"The IAEA is committed to doing everything possible to help the world respond to major challenges to human and animal health, using nuclear science and technology, in the coming years."

— Rafael Mariano Grossi, Director General, IAEA

(Photos: IAEA)

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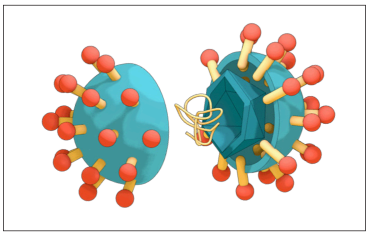

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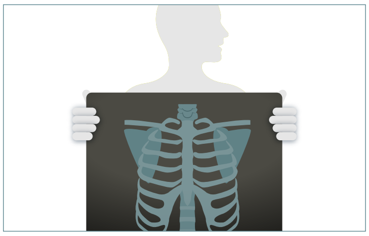

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Infectious diseases and how nuclear science can help

By Nicole Jawerth

Infectious diseases are health conditions caused by pathogens — bacteria, viruses, or other microorganisms, such as parasites or fungi. After invading the body, pathogens multiply and disrupt how the body works.

The types and severity of disease symptoms depend on the pathogens and host, namely a person or animal. In the case of COVID-19, for example, some people show no signs or symptoms or only have mild ones, such as fatigue and body aches, but others have severe and debilitating symptoms that, in some cases, can lead to death.

Infectious diseases are caused by pathogens that can spread from person to person, animal to animal or from an animal to a person. Such diseases can also be spread by vectors — living organisms, such as insects, that carry and spread pathogens.

More than 60% of the infectious diseases now affecting humans originated in animals. Scientists have found that over 75% of new animal diseases are zoonotic — diseases and infections that go from animals to people. Every year around 2.6 billion people suffer from zoonotic illnesses, and almost 3 million die from these diseases. Some of the most widely known zoonotic illnesses are Ebola, severe acute respiratory syndrome (SARS) and COVID-19.

Emerging, re-emerging, spreading

Moving without regard for borders in both people and animals, infectious diseases pose a persistent threat. New diseases or pathogen strains can emerge, and old ones can disappear only to re-emerge later. Some diseases and pathogens have several strains, or variations. As diseases are constantly evolving, science and medicine have to keep evolving too.

When a disease strikes, it impacts human and/or animal health, and can damage livelihoods and hurt economies. The effects are often disproportionately felt by vulnerable groups, such as children, the poor, the elderly and/or people with compromised immune systems. An overwhelming majority of victims of infectious diseases are in developing countries, particularly in impoverished communities.

The likelihood of infectious diseases emerging, re-emerging and spreading among humans is now greater than ever before. Globalization, population growth and urbanization mean that people are moving around more and living closer together, while deforestation, climate change, migration and the livestock industry are shrinking the barriers between people and animals, which is increasing the risk of zoonotic disease outbreaks.

Managing infectious diseases has also become more challenging owing to some pathogens' increased resistance to antibiotics, the re-emergence of vaccine-preventable diseases and new pathogens that have no available vaccines or treatments. Many countries are not readily equipped to

Glossary

Endemic: regularly found in a certain area or among a particular community.

Infectious disease: an illness caused by pathogens, such as bacteria, viruses, parasites or fungi, that can spread from one person to another or from an animal to a person.

Pathogen: a bacterium, virus, or other microorganism, such as a parasite or fungus, that can cause disease.

Vector: a living organism, such as an insect, that carries and spreads pathogens.

Vector-borne: carried and transmitted by vectors.

Zoonotic: diseases and infections that are transmitted from animals to humans.

accurately diagnose these infections early, increasing the risk of their spread.

Prevent, detect, pre-empt

Early detection is key to mitigating the spread of infections and pre-empting the outbreak of epidemics. Nuclear and nuclear-derived techniques are reliable tools that can help investigate, prevent, detect and contain outbreaks of animal and zoonotic diseases.

One of the most widely used and accurate laboratory diagnostic tests is **real time reverse transcription–polymerase chain reaction (real time RT–PCR)**. This nuclear-derived method is used for detecting the presence of specific genetic material of a pathogen, including a virus. A diagnosis can be made by verifying that the pathogen's genetic material is found in a sample from a patient or an animal. Read a step-by-step explanation of how this method works and how it's used for detecting COVID-19 on page 8.

Some diseases show few or no symptoms in their earlier stages and may even be mistaken for other health conditions. **Medical imaging**, such as radiology and nuclear medicine, can be used to quickly and accurately diagnose a disease, as well as to continue monitoring it, increasing the chances of controlling its spread. Learn more about diagnostic imaging and how it is used for COVID-19 on page 12.

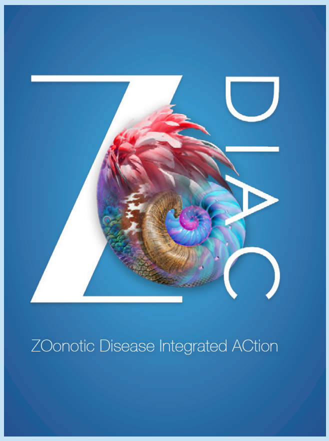
A nuclear-based insect birth control method called the **sterile insect technique (SIT)** can help prevent, control and potentially even stop the spread of certain vector-borne diseases. Research and development are now ongoing on how to use SIT for controlling disease-carrying mosquitoes. Find out more about this on page 22.

Some vaccines contain inactivated versions of a pathogen that, once inside the body, activates the immune system to help prepare it to fight off an infection. **Irradiated vaccines** are now being explored as an option for disease control. Radiation can inactivate a pathogen without affecting its structure. Learn more about irradiated vaccines for fighting animal diseases on page 30.

The IAEA has decades of experience in supporting countries with building their capacity to detect and characterize pathogens early and to rapidly and accurately diagnose, manage and prevent diseases. Often working with partners, such as the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and the World Organisation for Animal Health (OIE), this assistance has made an important contribution to helping to control outbreaks of infectious diseases in both animals and people.

ZODIAC

The path beyond the COVID-19 pandemic



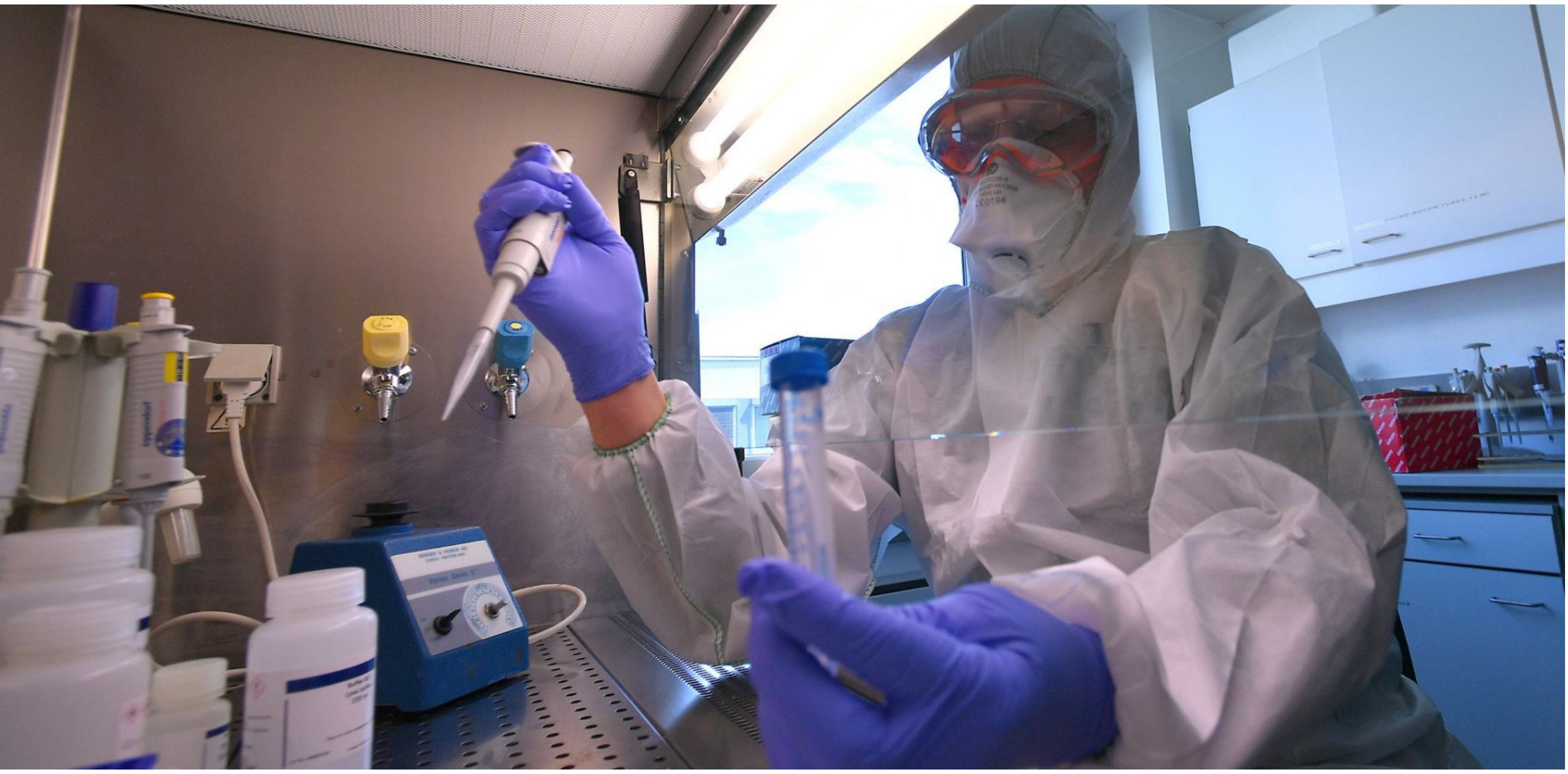
The ZODIAC, or **ZO**onotic **D**isease **I**ntegrated **AC**tion, initiative was launched by the IAEA in June 2020 to strengthen countries' capabilities for early detection, diagnosis, prevention and control of zoonotic disease outbreaks. The initiative is designed as a systematic and holistic approach across sectors and disciplines, and integrates emergency assistance measures, including a response team, for addressing new and existing zoonotic pathogens. ZODIAC aims to help countries prepare for, pre-empt and prevent zoonotic disease outbreaks, as well as protect the wellbeing, livelihood and socio-economic status of billions of people worldwide.

Nuclear and nuclear-derived techniques are proven and reliable tools that play a critical role in investigating, detecting, preventing and containing zoonotic disease outbreaks. As a science-driven organization, the IAEA, in collaboration with its partners, is uniquely placed to undertake, coordinate and efficiently implement ZODIAC and to support countries in strengthening their resilience to zoonotic diseases. It has extensive experience in assisting with tackling animal and zoonotic diseases and has a dedicated laboratory as well as a vast network of veterinary laboratory partners around the world.

ZODIAC will build on the IAEA's cooperation with partners such as the Food and Agriculture Organization of the United Nations, the World Health Organization and the World Organisation for Animal Health.

Vital testing equipment helps countries fight COVID-19

By Luciana Viegas



Preparing a sample to test for COVID-19.
(Photo: D. Calma/IAEA)

Vital equipment for detecting the COVID-19 virus reached countries worldwide in early 2020 through the IAEA's largest ever technical cooperation project. With over 140 countries involved, this assistance has been part of the IAEA's ongoing response to requests from countries for support in controlling the global COVID-19 outbreak. Showing strong support for the initiative, several countries also announced major extrabudgetary funding contributions for the IAEA's efforts in helping to tackle the pandemic.

"The IAEA's timely assistance has been critical to strengthening our capacities for detecting the COVID-19 virus."

— Susana Petrick, Head, Peruvian Institute of Nuclear Energy

"The IAEA's timely assistance has been critical to strengthening our capacities for detecting the COVID-19 virus," said Susana Petrick, Head of the Peruvian Institute of Nuclear Energy (IPEN). "Although we were quick to recognize the threat and take action, we knew that we would have to rapidly increase our capacity for early identification of the virus. The equipment and reagents supplied by the IAEA contributed to enhancing our testing processing capacity and ultimately to protecting people."

COVID-19 is a disease caused by a new coronavirus. The virus was first reported in December 2019, and, after its rapid spread worldwide, the World Health Organization (WHO) characterized the outbreak as a global pandemic in March 2020.

"IAEA staff are working hard to ensure that this critical equipment is delivered as quickly as possible where it is most needed," said IAEA Director General Rafael Mariano Grossi in March 2020, shortly after the COVID-19 pandemic was announced. "Providing this assistance to countries is an absolute priority for the IAEA."

In support of efforts to fight the disease, shipments to dozens of laboratories in Africa, Asia, Europe, and Latin America and the Caribbean contained diagnostic machines and kits, as well as reagents and laboratory consumables, in order to speed up national testing, which is a crucial part of containing the outbreak. The shipments also included biosafety supplies, such as personal protective equipment and laboratory cabinets for the safe analysis of collected samples.

"This equipment improves and speeds up our existing work processes, especially testing for the COVID-19 virus," said Maja Travar, Head of the Department of Clinical Microbiology at the University Clinical Centre of the Republic of Srpska in Banja Luka, Bosnia and Herzegovina. "Given that the country's largest number of positive cases are hospitalized at our institution, this shipment is of great importance. We can now also increase our testing capacity as well as our biosafety level, which is extremely important for providing our patients with a range of services while also protecting our staff."

Diagnostic testing

Many of the supplies have been for using a nuclear-derived technique called real time reverse transcription–polymerase chain reaction (real time RT–PCR) (see page 8), which can help to accurately detect and identify the novel coronavirus in humans, as well as in animals that may also host it, within hours. Techniques like real time RT–PCR are an important tool in the rapid detection and characterization of viruses like the one causing COVID-19. "Such tools are the only means to have certainty," said Enrique Estrada Lobato, a nuclear medicine physician at the IAEA.

The IAEA, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), has also provided guidance to countries on the detection of the COVID-19 virus through the Veterinary Diagnostic Laboratory Network, or VETLAB Network, a network of veterinary laboratories in Africa and Asia (see page 19). The support has included the provision of standard operating procedures to identify the virus in line with WHO recommendations.

The IAEA has also taken part in the WHO-led COVID-19 United Nations Crisis Management Team (CMT), which was launched in February 2020 following the activation of the United Nations crisis management policy. Comprising high-level representatives from 23 agencies and organizations within the United Nations system, the CMT has met on a weekly basis to communicate key information and analyze and prioritize emerging issues, as well as to coordinate strategies, policy decisions and plans and agree on joint action to optimize the United Nations' response to the COVID-19 global pandemic. In addition to regular meetings and communication, the CMT works with existing coordination efforts for the outbreak and has dedicated workstreams related to the pandemic, including health, travel and trade, national action planning, critical supply chain management and external communication.

The assistance provided to countries by the IAEA in tackling COVID-19 has been delivered through the IAEA's technical cooperation programme, which supports the peaceful application of nuclear technology in areas such as human and animal health.

In addition to its own resources, the IAEA has used extrabudgetary funding for its emergency COVID-19 assistance. Donor countries continue to make extrabudgetary financial contributions to the IAEA for this purpose, and, as of early May 2020, more than €15.5 million in contributions had been made. Funding has also been provided through the IAEA's Peaceful Uses Initiative.

"The IAEA takes pride in its ability to respond quickly to crises, as we did in the recent past with the Ebola, Zika and African swine flu viruses," said Mr Grossi in a statement to the IAEA Board of Governors in early March 2020. "Contributing to international efforts to deal with the coronavirus will remain a priority for me as long as the outbreak persists."

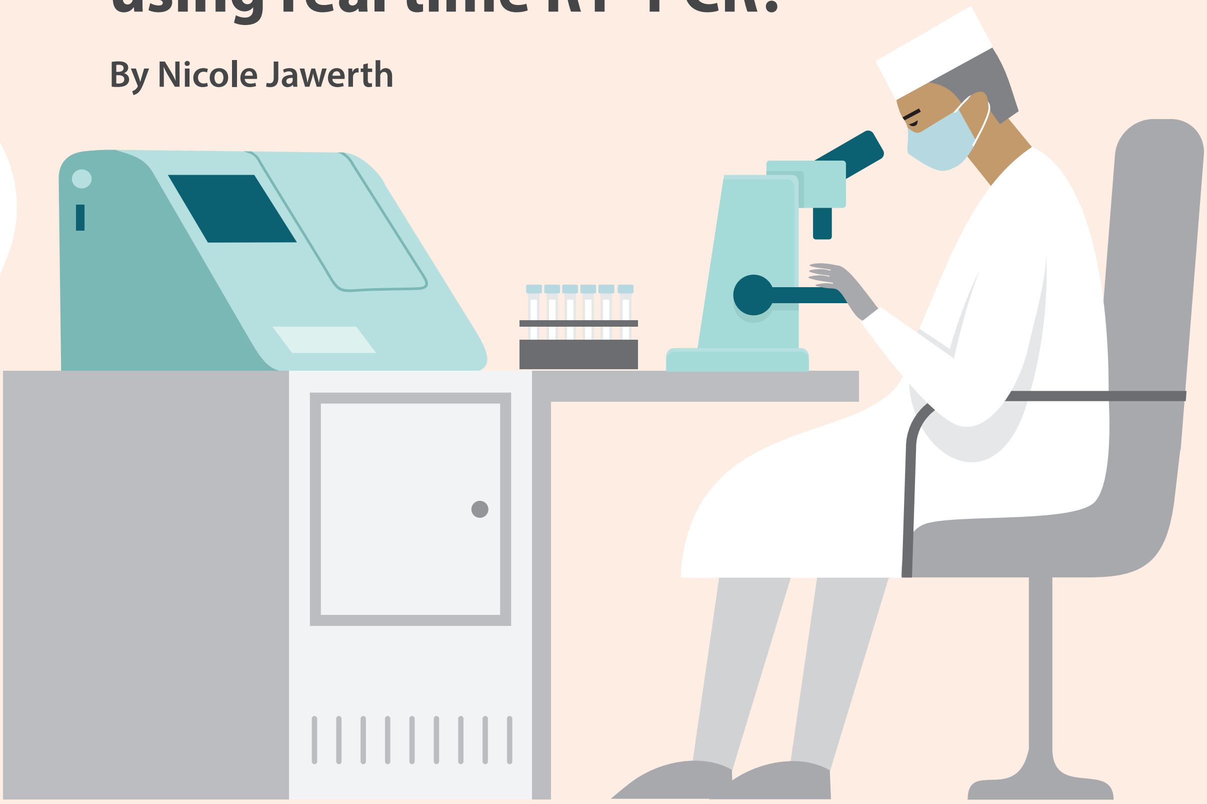
The testing infrastructure developed through the IAEA's emergency assistance to address COVID-19 will also help countries deal with other animal and zoonotic diseases in the future. This is part of the IAEA's broader efforts to support countries in preventing, handling and pre-empting disease outbreaks worldwide.

Evaluating the results of an RT-PCR diagnostic test for COVID-19.

(Photo: D. Calma/IAEA)

How is the COVID-19 virus detected using real time RT–PCR?

By Nicole Jawerth



As the coronavirus that causes the COVID-19 disease spreads across the world, the IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO), is offering its support and expertise to help countries use real time reverse transcription–polymerase chain reaction (real time RT–PCR), one of the fastest and most accurate laboratory methods for detecting, tracking and studying the COVID-19 virus.

But what is real time RT–PCR? How does it work? How is it different from PCR? And what does this have to do with nuclear technology? Here's a handy overview of the technique, how it works and a few refresher details on viruses and genetics.

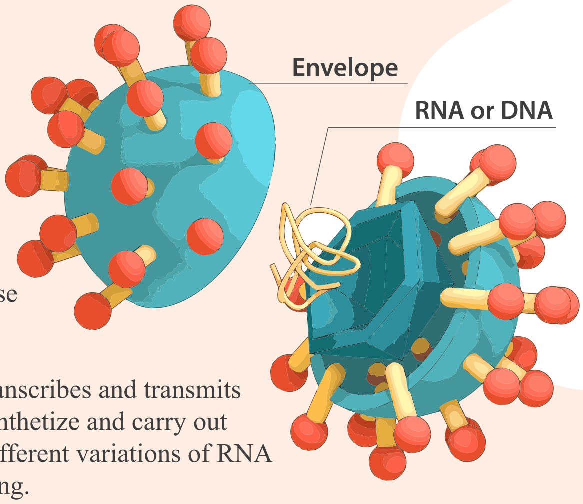
What is real time RT–PCR?

Real time RT–PCR is a nuclear-derived method for detecting the presence of specific genetic material in any pathogen, including a virus. Originally, the method used radioactive isotope markers to detect targeted genetic materials, but subsequent refining has led to the replacement of isotopic labelling with special markers, most frequently fluorescent dyes. This technique allows scientists to see the results almost immediately while the process is still ongoing, whereas conventional RT–PCR only provides results at the end of the process.

Real time RT–PCR is one of the most widely used laboratory methods for detecting the COVID-19 virus. While many countries have used real time RT–PCR for diagnosing other diseases, such as the Ebola virus and Zika virus, many need support in adapting this method for the COVID-19 virus, as well as in increasing their national testing capacities.

What is a virus? What is genetic material?

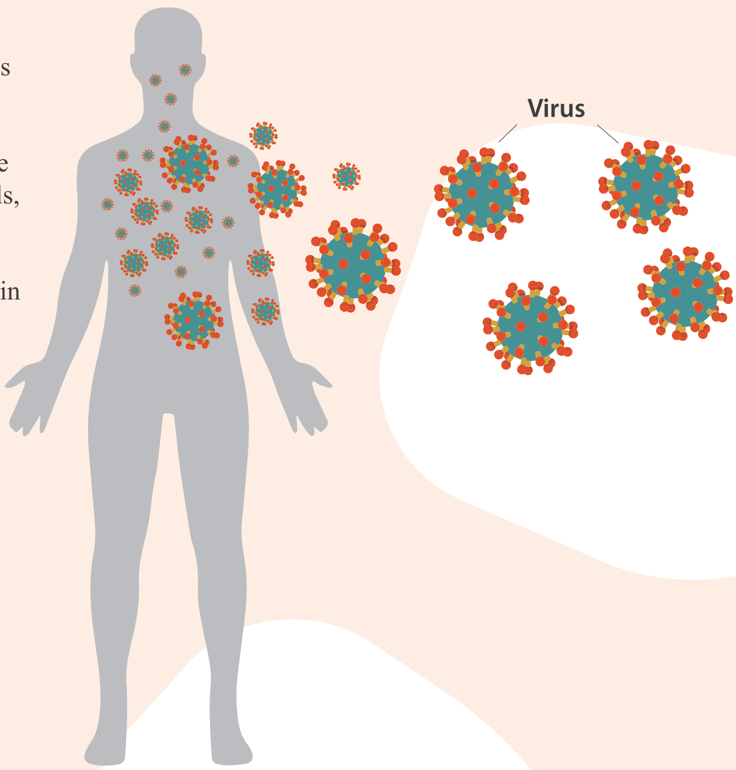
A virus is a microscopic package of genetic material surrounded by a molecular envelope. This genetic material can be either deoxyribonucleic acid (DNA) or ribonucleic acid (RNA).



DNA is a two-strand molecule that is found in all organisms, such as animals, plants and viruses, and which holds the genetic code, or blueprint, for how these organisms are made and develop.

RNA is generally a one-strand molecule that copies, transcribes and transmits parts of the genetic code to proteins so that they can synthetize and carry out functions that keep organisms alive and developing. Different variations of RNA are responsible for copying, transcribing and transmitting.

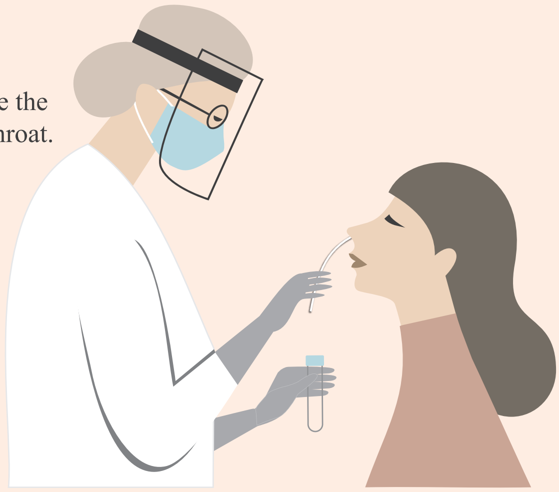
Some viruses such as the SARS-CoV-2 coronavirus, which causes COVID-19, only contain RNA, which means that they rely on infiltrating healthy cells to multiply and survive. Once inside the cell, the virus uses its own genetic code — RNA in the case of the COVID-19 virus — to take control of and ‘reprogramme’ the cells, turning them into virus-making factories.



In order for a virus like the COVID-19 virus to be detected early in the body using real time RT–PCR, scientists need to convert the RNA to DNA. This is a process called ‘reverse transcription’. They do this because only DNA can be copied — or amplified — which is a key part of the real time RT–PCR process for detecting viruses.

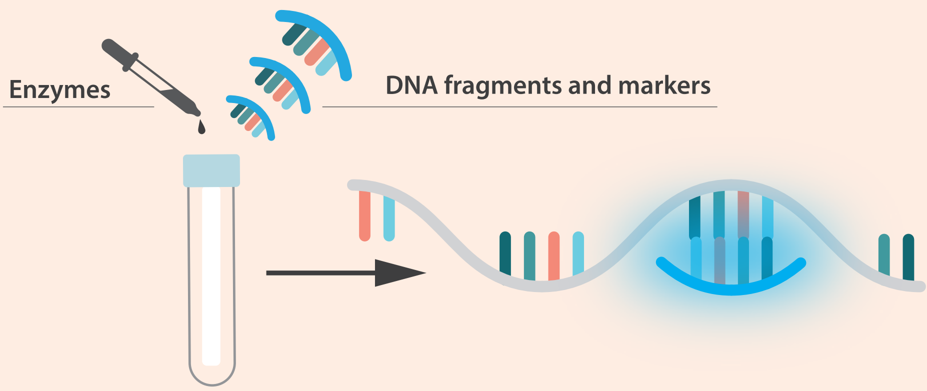
Scientists amplify a specific part of the transcribed viral DNA hundreds of thousands of times. Amplification is important so that, instead of trying to spot a minuscule amount of the virus among millions of strands of genetic information, scientists have a large enough quantity of the target sections of viral DNA to accurately confirm that the virus is present.

How does real time RT–PCR work with the COVID-19 virus?



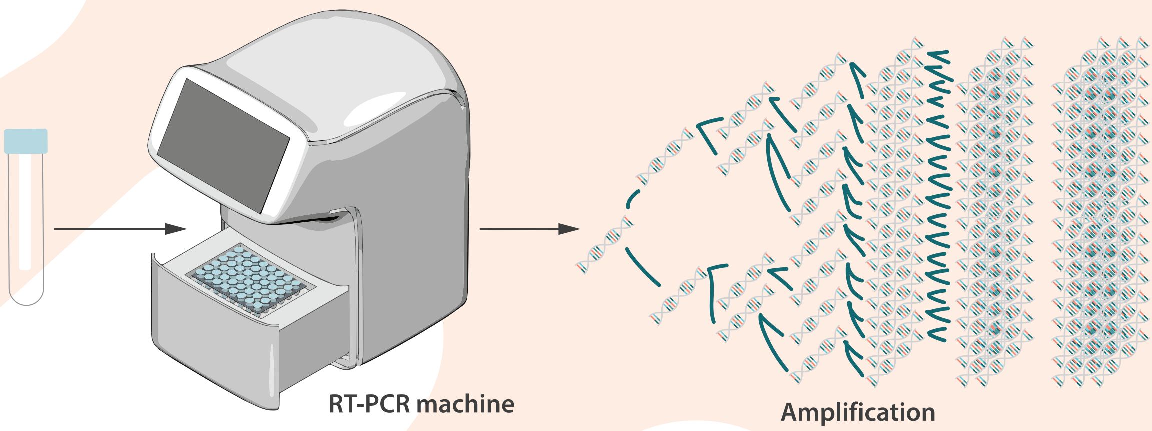
A sample is collected from the parts of the body where the COVID-19 virus gathers, such as a person's nose or throat. The sample is treated with several chemical solutions that remove substances such as proteins and fats and that extract only the RNA present in the sample. This extracted RNA is a mix of the person's own genetic material and, if present, the virus' RNA.

The RNA is reverse transcribed to DNA using a specific enzyme. Scientists then add additional short fragments of DNA that are complementary to specific parts of the transcribed viral DNA. If the virus is present in a sample, these fragments attach themselves to target sections of the viral DNA. Some of the added genetic fragments are used for building DNA strands during amplification, while the others are used for building the DNA and adding marker labels to the strands, which are then used to detect the virus.



The mixture is then placed in an RT–PCR machine. The machine cycles through temperatures that heat and cool the mixture to trigger specific chemical reactions that create new, identical copies of the target sections of viral DNA. The cycle is repeated over and over to continue copying the target sections of viral DNA. Each cycle doubles the previous number: two copies become four, four copies become eight, and so on. A standard real time RT–PCR set-up usually goes through 35 cycles, which means that, by the end of the process, around 35 billion new copies of the sections of viral DNA are created from each strand of the virus present in the sample.

As new copies of the viral DNA sections are built, the marker labels attach to the DNA strands and then release a fluorescent dye, which is measured by the machine's computer and presented in real time on the screen. The computer tracks the amount of fluorescence in the sample after each cycle. When a certain level of fluorescence is surpassed, this confirms that the virus is present. Scientists also monitor how many cycles it takes to reach this level in order to estimate the severity of the infection: the fewer the cycles, the more severe the viral infection is.



Why use real time RT–PCR?

The real time RT–PCR technique is highly sensitive and specific and can deliver a reliable diagnosis in as little as three hours, though laboratories take on average between six and eight hours. Compared to other available virus isolation methods, real time RT–PCR is significantly faster and has a lower potential for contamination or errors, as the entire process can be carried out within a closed tube. It continues to be the most accurate method available for the detection of the COVID-19 virus.

However, real time RT–PCR cannot be used to detect past infections, which is important for understanding the development and spread of the virus, as viruses are only present in the body for a specific window of time. Other methods are necessary to detect, track and study past infections, particularly those which may have developed and spread without symptoms.

What is PCR and how is it different from real time RT–PCR?

RT–PCR is a variation of PCR, or polymerase chain reaction. The two techniques use the same process except that RT–PCR has an added step of reverse transcription of RNA to DNA, or RT, to allow for amplification. This means PCR is used for pathogens, such as viruses and bacteria, that already contain DNA for amplification, while RT–PCR is used for those containing RNA that needs to be transcribed to DNA for amplification. Both techniques can be performed in 'real time', which means results are visible almost immediately, while when used 'conventionally', results are only visible at the end of the reaction.

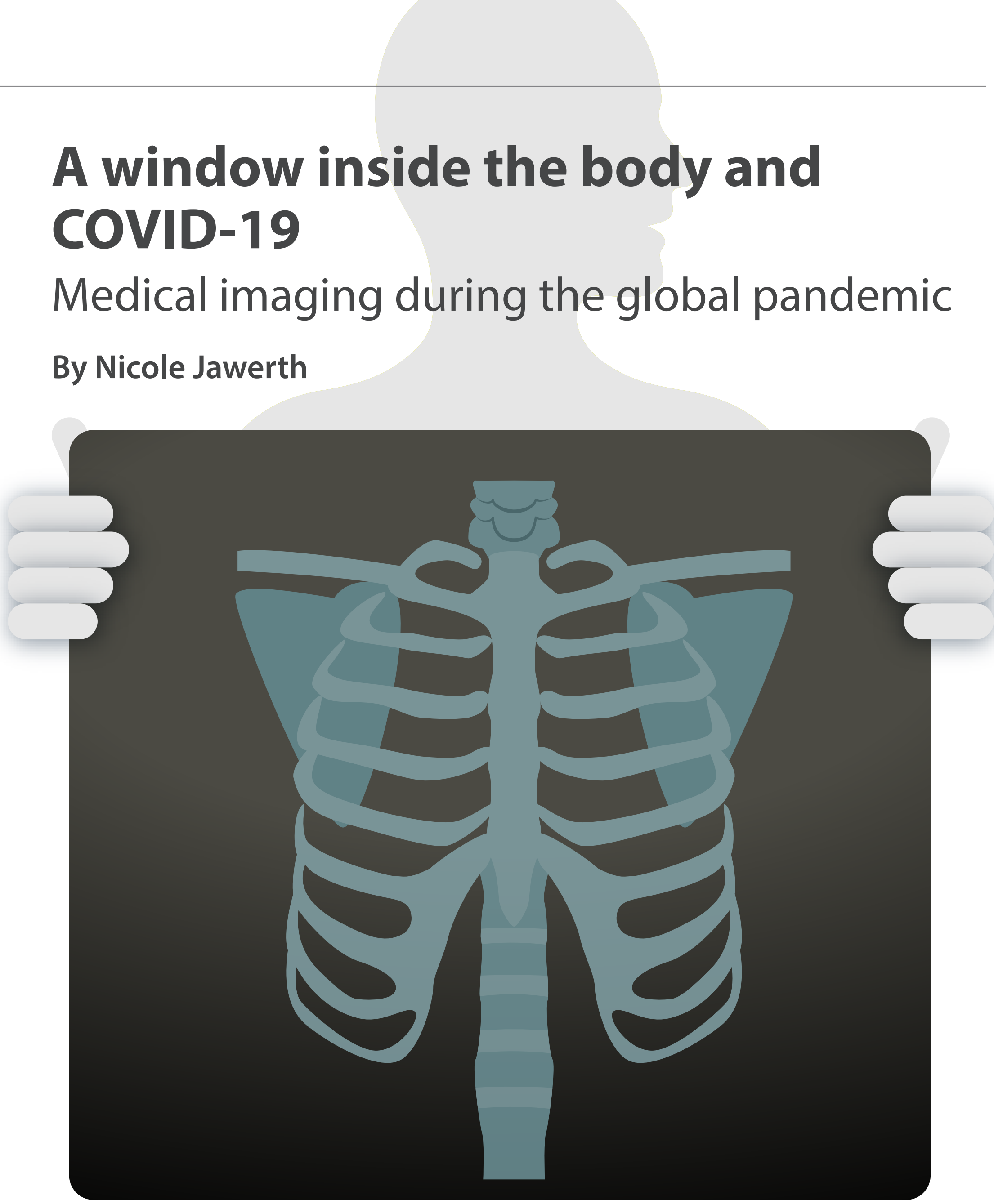
PCR is one of the most widely used diagnostic tests for detecting pathogens, including viruses, that cause diseases such as Ebola, African swine fever and foot-and-mouth disease. Since the COVID-19 virus only contains RNA, real time or conventional RT–PCR is used to detect it.

For over 20 years, the IAEA, in partnership with the FAO, has trained and equipped experts from all over the world to use the real time RT–PCR method, particularly through its VETLAB Network of veterinary diagnostic laboratories. Recently, this technique has also been employed to diagnose other diseases, such as Ebola, Zika, Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS), as well as other major animal diseases. It has also been used to detect major zoonotic diseases: animal diseases that can also infect humans.

A window inside the body and COVID-19

Medical imaging during the global pandemic

By Nicole Jawerth



Getting images of what's happening inside of people's bodies is helping health professionals to evaluate and better understand the COVID-19 disease, which is caused by a newly discovered coronavirus.

"Diagnostic imaging is a window into the body," said Olivier Pellet, a radiologist at the IAEA. "It has allowed us to uncover complications, such as lesions, pneumonia or blood clots in the lungs. Every day we learn about the virus and its impact on the human body, while discovering new COVID-19-related signs and symptoms we have not seen before, even when a person may otherwise appear asymptomatic."

"Every day we learn about the virus and its impact on the human body, while discovering new COVID-19-related signs and symptoms we have not seen before, even when a person may otherwise appear asymptomatic."

— Olivier Pellet, radiologist, IAEA

Medical imaging has been used worldwide for over a hundred years to diagnose, monitor and assist in the treatment of many health conditions, such as cancer, infectious diseases, heart disease and neurological disorders. Many countries have been working with the IAEA for decades to build up and maintain their radiation medicine services, including diagnostic imaging.

While there are a range of imaging techniques available, the three most widely used methods for evaluating COVID-19 patients are chest X-rays, chest computed tomography (CT) and lung ultrasound (learn more about each technique on page 13 and 14).

"These three techniques are complementary and offer options for evaluating how COVID-19 affects different organs at different stages," said Pellet. "The reason they are used on the lung and chest area is because respiratory symptoms have been known to be among the first signs of COVID-19."

Although diagnosing COVID-19 relies on identifying the virus using laboratory tests such as reverse transcription–polymerase chain reaction (see page 8), medical imaging is widely used to evaluate patients at various stages of the disease, particularly for those with moderate, severe or critical cases.

Refining and adapting

Since the global spread of COVID-19 began in early 2020, health professionals have had to adapt and improve how they use these techniques to ensure that they are justified, appropriate and safe for diagnosing the disease.

"Radiologists and other imaging specialists have had to figure out which procedures to use for COVID-19 and when, how to accurately analyze and identify the disease's symptoms in medical images, and how to adapt their work to protect staff and patients from infection while continuing to provide other essential and critical health services," Pellet said.

They have also had to stay vigilant about striking the right balance: using too little radiation makes the images unclear, but too much puts the patient at risk of receiving an unnecessary dose of radiation. Similarly, taking more scans than needed means unnecessary exposure, while too few could mean missing out on critical information to help a patient.

"Any time radiation is used in medicine, it needs to be justified and optimized to ensure that the procedures are effective, while also keeping patients and workers safe," said Miroslav Pinak, Head of the Radiation Safety and Monitoring Section at the IAEA. "During a pandemic situation, when normal procedures and workflows are interrupted, attention must be paid to continuing to maintain high standards of radiation protection while also integrating measures required to minimize the spread and impact of COVID-19."

To support these efforts, the IAEA has provided health professionals with a wide range of resources, such as webinars, articles and technical guidance documents, related to COVID-19 and radiology, nuclear medicine and radiation protection. Learn more about this on page 15.

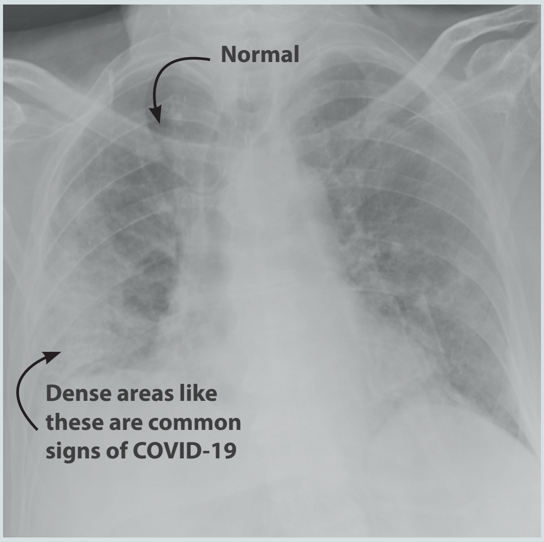
Chest X-rays

X-rays are a type of radiation. Many people are most familiar with them for their use in diagnosing a broken bone or examining teeth.

Health care professionals can harness X-ray radiation using an X-ray machine. When a patient is placed in the machine, a carefully selected dose of X-rays passes through the targeted area of the body. The thicker and denser parts of the body, such as bone, let fewer X-rays through, while softer, thinner parts let more through. As the X-rays come out on the other side of the body, a specialized detector captures their pattern. This creates an image of the structures inside the body and their changes.

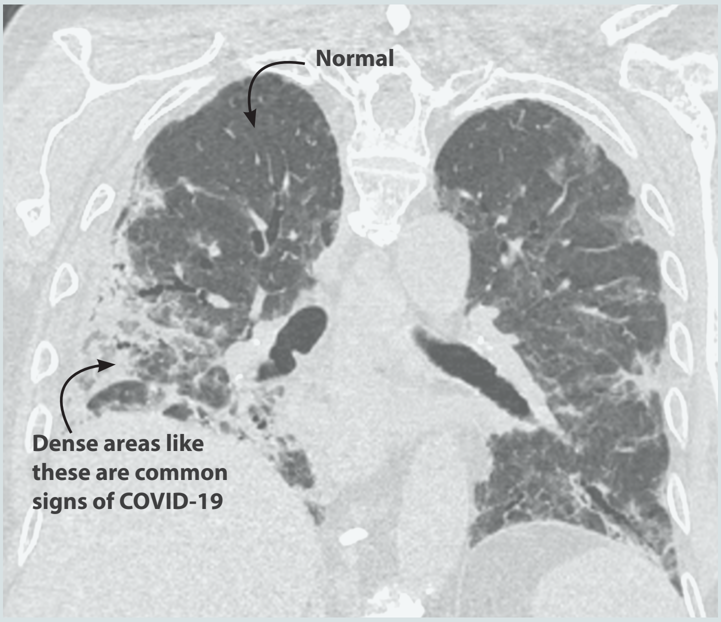
For evaluating COVID-19, X-rays are taken of a person's chest to get a look at the lung tissue. This is used for patients with respiratory symptoms of COVID-19. X-rays are also used for monitoring the evolution of the disease and making treatment and follow-up decisions, such as whether to admit a patient to the hospital or send a patient with severe symptoms for a CT scan.

"Given that X-ray machines are often readily available in care centres, many health care professionals already have access to these tools to help their countries deal with COVID-19," Pellet said. "Some X-ray machines are also portable, lightweight, and easy to handle and decontaminate, which is critical in a pandemic, particularly in medical triage areas or makeshift hospital environments."



Chest X-ray of a patient with COVID-19 pneumonia. Both lungs are showing signs, particularly the right.

(Photo: L. Zanoni/Nuclear Medicine Division, Bologna University Hospital Authority St. Orsola-Malpighi Polyclinic)



Chest CT of a patient with COVID-19 pneumonia. Both lungs are affected, particularly the right.

(Photo: L. Zanoni/Nuclear Medicine Division, Bologna University Hospital Authority St. Orsola-Malpighi Polyclinic)

Chest CT

A computed tomography (CT) scan is a set of multiple X-ray images. A CT machine rotates around the patient and rapidly sends X-rays through the body from multiple angles. A ring of hundreds of specialized detectors around the body track the pattern of the X-rays. This is then processed by the machine's powerful computer to create detailed images constructed out of very thin slices of the body, up to 0.3 mm wide, often in 3D. For a CT scan of the chest, which is the area of the body typically scanned when evaluating COVID-19, hundreds of images are generated to cover the whole chest area.

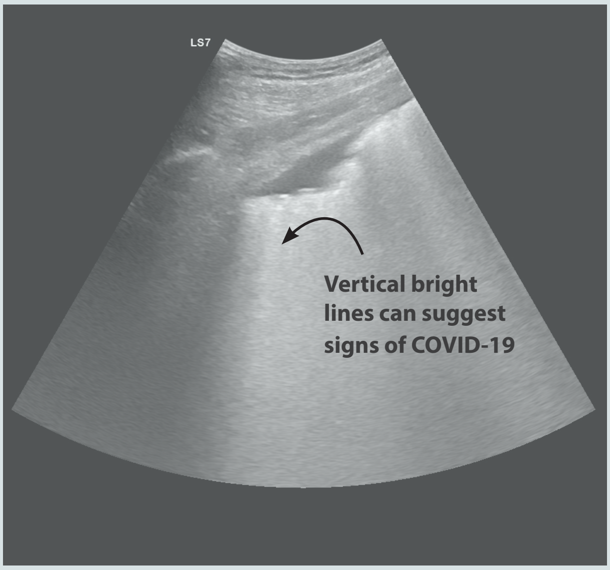
CT machines are more sophisticated, more expensive and not as widely available as X-ray machines. They are also harder to decontaminate, which can take more than 20 minutes, said Pellet. "CT scans provide highly detailed information and to do that they use more radiation than an X-ray machine. They should therefore only be used when appropriate for the patient's case."

Ultrasound

Ultrasound machines use high-frequency soundwaves instead of radiation to create an image. A probe connected to an ultrasound machine sends and receives millions of soundwaves every second through the target area of the body, which, in the case of COVID-19 patients, is typically the lungs. When the waves hit a boundary, such as between soft tissue and fluid or soft tissue and bone, they echo back to the probe. The probe tracks the distance and intensities of the echoes and translates this into images.

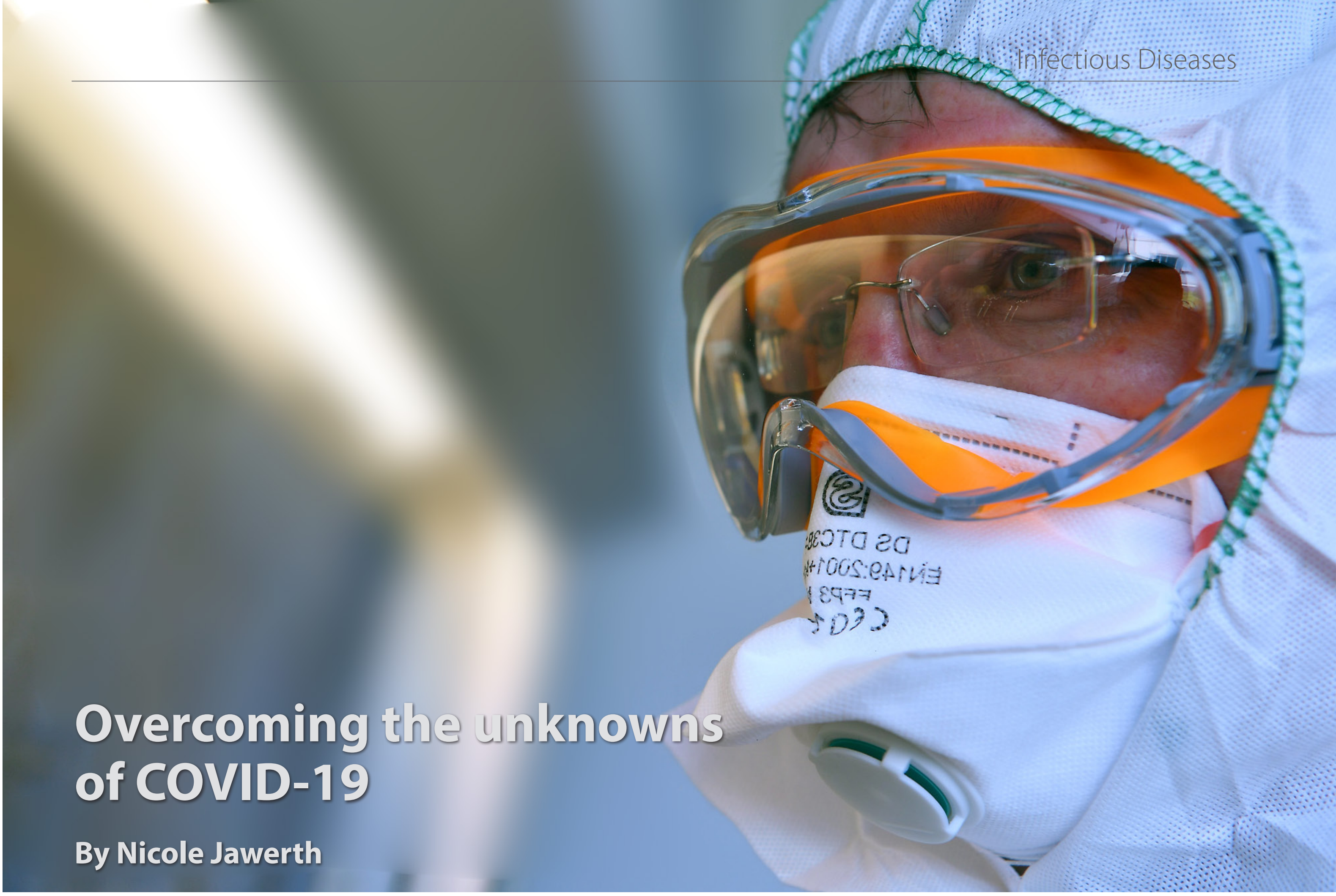
Ultrasound machines are low cost and more widely available than X-ray and CT machines. Being small, portable and easy to decontaminate, they can be easily used at patient bedsides, in an ambulance or in a triage situation. Since radiation is not involved, they can also be used more often without posing additional risks to patients and health care workers.

As ultrasound images are dynamically and instantly displayed on a screen, a trained health care professional can evaluate a patient on the spot. Ultrasound imaging of the lungs is a good starting point for evaluating patients displaying respiratory symptoms that could be signs of COVID-19, as it can display images that are strongly suggestive of the disease. However, as lung ultrasound only explores the periphery of the lungs and is user dependent so concrete and detailed images provided through chest X-rays and chest CT scans are needed for a conclusive diagnosis of COVID-19, as well as to follow and monitor the evolution of the disease in the patient.



Lung ultrasound of a patient with COVID-19 pneumonia.

(Photo: C. Serra/Nuclear Medicine Division, Bologna University Hospital Authority St. Orsola-Malpighi Polyclinic)



Overcoming the unknowns of COVID-19

By Nicole Jawerth

(Photo: D. Calma/IAEA)

"We don't know" has been uttered by countless doctors, scientists and policymakers during the global COVID-19 pandemic. Caused by a previously unknown coronavirus, COVID-19 has taken the world by storm and presented new questions and challenges that health professionals have been trying to answer and overcome, many of them with support from the IAEA.

"Every day our understanding evolves as new symptoms and complications continue to appear," said May Abdel-Wahab, Director of the IAEA's Division of Human Health. "The rapid evolution of the pandemic has resulted in radiology, nuclear medicine and radiotherapy centres around the world being quickly confronted with spreading infections, dramatically increasing patient admissions, overloading clinics, and staff and equipment shortages. Urgent guidance has been needed to address changes at every level."

When the global pandemic began in early 2020, the IAEA immediately recognized the need for guidance and information related to COVID-19 and how to continue essential radiation medicine services, such as nuclear medicine, radiology and radiotherapy, as well as radiation protection and the production of radioisotopes, during the pandemic and the unique conditions it presents.

"As COVID-19 is a new disease and knowledge was limited, there has been a lot of uncertainty around the pandemic," Abdel-Wahab said. "Routine medical practices needed to be urgently modified in order to triage patients before various procedures and to limit the spread of infections among patients and health care workers, but there was limited information on how to work in this kind of pandemic environment. Some of the practice changes we now see may continue to be implemented after the pandemic and will likely remain in the long term."

Quickly joining the global information exchange, the IAEA launched in March 2020 a series of multilingual webinars involving renowned experts and health professionals, which, as of June 2020, had received almost 10 000 live views. Held in collaboration with various organizations[1], the webinars have focused on the COVID-19 pandemic in relation to: operations of nuclear medicine departments; radiology in the fight against the disease; preparedness

(Photo: IAEA)

of radiotherapy departments; protocols and dose optimization for computed tomography (CT) scans of the chest for the COVID-19 disease; medical radioisotopes and radiopharmaceutical supply chains; sterilizing personal protective equipment with irradiation; reverse transcription–polymerase chain reaction for detecting the COVID-19 virus; radiation protection for health workers; and effective technical services for monitoring individuals.

"During these difficult times, we were in need of guidance on how to operate and how to continue providing essential services while also protecting our staff and patients all with only having limited information, much of which was only from a national perspective," said Stefano Fanti, a speaker at several of the IAEA webinars and Director of the Nuclear Medicine Division at the Bologna University Hospital Authority St. Orsola-Malpighi Polyclinic in Bologna, Italy, which is located in one of the European regions worst affected by COVID-19. "The information from worldwide experts through these webinars has been very useful because it provided a worldwide perspective. The webinars have also provided confidence-building guidance on how to move forward after easing lockdowns."

For many health professionals, the webinars have been an important avenue for connecting with and learning from experts, as well as for gaining an understanding of how to handle the new situation.

"During the IAEA webinar, we had a chance to learn directly from leading experts and other health professionals who we may otherwise not have had direct access to. This helped us to quickly adapt our radiology services, as well as consider how to best use CT and other imaging techniques for COVID-19 and lower risks for patients and medical staff," said Jasminka Chabukovska-Radulovska, a radiologist from North Macedonia, who participated in an IAEA webinar called COVID-19 and chest CT: protocol and dose optimization. Held in April 2020, the session covered CT and other imaging techniques now being used for evaluating and monitoring COVID-19, as well as how to ensure optimal and proper selection of parameters and protocols. Learn more about CT and other diagnostic imaging techniques on page 12.

[1] *Several of the IAEA's COVID-19 related webinars were organized and held in collaboration with: African Radiation Oncology Group, American Society of Nuclear Cardiology, American Society for Radiation Oncology, Arab Medical Association Against Cancer, Arab Society of Nuclear Medicine, Asia Oceania Federation of Nuclear Medicine and Biology, Asian Regional Cooperative Council for Nuclear Medicine, Asociación Ibero-Latinoamericana de Terapia Radiante Oncológica, Association de Radiotherapie et d'Oncologie de la Mediterranee, Australian and New Zealand Society of Nuclear Medicine, Austrian Society of Nuclear Medicine and Molecular Imaging,*

"More people getting diagnostic imaging scans such as CT due to COVID-19 means that patients and workers could be at greater risk of exposure to radiation and to the disease. This is being exacerbated by overburdened hospitals that have had to carry out these procedures in different ways or in environments not originally designed for this purpose, such as temporary health facilities in gyms," said Ola Holmberg, Head of the Radiation Protection of Patients Unit at the IAEA. "By addressing questions of doses, protocols and even how to maintain hygiene and work under stress in a pandemic environment, health workers are better able to ensure that these potentially life-saving imaging procedures are effective, while also being safe for their patients and themselves."

Pool of information and guidelines

Complementing its webinars, the IAEA has also been reviewing and providing access to a wide range of relevant resources on COVID-19 for radiation medicine departments. Among these is a detailed compilation of peer-reviewed information on three diagnostic imaging techniques: X-rays, CT scans and ultrasound. Released in early March following requests from health workers worldwide, the compilation explains the role of each technique in COVID-19 diagnosis and provides examples of how COVID-19 often appears on medical scans at different stages of the disease. Learn more about these diagnostic imaging techniques on page 12.

"Knowing how to appropriately use medical imaging and what to look for is critical for understanding the impact of the disease on the body, as well as any possible complications," said Diana Paez, Head of the Nuclear Medicine and Diagnostic Imaging Section at the IAEA. "This compilation of information was developed so health workers could quickly learn what they need to do and what to look for to use medical imaging effectively for this new disease."

In April 2020, IAEA guidelines for nuclear medicine departments were also published in the *European Journal of Nuclear Medicine and Molecular Imaging*. These guidelines aim to help nuclear medicine departments adapt operating procedures to minimize the risk of COVID-19 infections among patients, staff and the public. They also draw attention to possible shortages of radiopharmaceuticals for imaging as a result of global air traffic restrictions.

The guidelines were produced in response to requests from nuclear medicine departments in several countries. They are based on World Health Organization (WHO) guidance for essential health services during an outbreak, as well as a review of available literature, contributions from international experts and results from the IAEA's webinars.

The document places emphasis on the importance of minimizing the risk of the virus spreading to staff, patients and family members, as well as controlling its spread when providing essential and critical nuclear medicine services.

It also details how to optimize a facility's settings and platform for delivering services, as well as how nuclear medicine practitioners should proceed if, during non-COVID-19 related procedures such as a positron emission tomography–computed tomography (PET–CT) scan for the evaluation of cancer, findings show patterns consistent with a possible additional COVID-19 infection.

"Sharing knowledge among peers during this pandemic has enriched our collective understanding while continuing to guide us towards the best approaches," said Paez. "This has not only benefited hospital staff, colleagues and patients, but is also helping us to ensure radiation medicine services can continue."

"During the IAEA webinar, we had a chance to learn directly from leading experts and other health professionals who we may otherwise not have had direct access to."

— Jasminka Chabukovska-Radulovska, radiologist, North Macedonia

British Nuclear Medicine Society, Brazilian Society of Nuclear Medicine, China Society for Radiation Oncology, European Association of Nuclear Medicine, European Society for Radiotherapy and Oncology, Federation of Asian Organizations for Radiation Oncology, Food and Agriculture Organization of the United Nations, German Society of Nuclear Medicine, Italian Association of Nuclear Medicine, Latin American Association of Societies of Biology and Nuclear Medicine, Philippine Society of Nuclear Medicine, Royal Australian and New Zealand College of Radiologists, Russian Association of Therapeutic Radiation Oncologists, Society of Nuclear Medicine and Molecular Imaging, South African Society of Nuclear Medicine, Uruguayan Society of Biology and Nuclear Medicine, World Association of radiopharmaceuticals and Molecular Therapy, World Federation of Nuclear Medicine and Biology, World Health Organization.

Trained and equipped to fight animal and zoonotic diseases

By Carley Willis and Nicole Jawerth

The AVL team carrying out training on analyzing unhatched eggs to determine exposure to the avian influenza virus.
(Photo: IAEA)

Hundreds of infectious animal diseases are out there, and, without the right preventative measures, they can strike at any time. While most of these diseases spread only between animals, some can jump from animals to people; these are called zoonotic diseases. To help tackle these threats to animals, people and economies, the right training and equipment in diagnostics is needed. One of the ways specialists get that is through support from the IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO).

"In some countries there is limited capacity to effectively control diseases that hinder livestock production. This was the case for the Accra Veterinary Laboratory (AVL)," said Joseph Awuni, Deputy Director and Head of the Veterinary Services Directorate at the AVL, in Ghana. "Through IAEA and FAO support, the AVL can now handle major animal disease outbreaks, and the laboratory is also considered a regional support laboratory in West Africa, as we are now able to provide diagnostic support and training to neighbouring countries."

For decades, specialists like those at the AVL have worked with the IAEA and FAO to improve their capacities to use nuclear, nuclear-derived and other methods to detect and diagnose animal and zoonotic diseases. These diagnostic methods are key to preventing, controlling and, when possible, eradicating these diseases, which can have disastrous consequences for animal and human health, as well as for communities and economies.

Outbreaks test skills

The AVL team's capabilities were put to the test in 2018, when an outbreak of avian influenza virus — a highly contagious infection causing a high rate of organ damage and death in domesticated birds such as chickens — was spotted in isolated areas around Boankra, in Ghana's Ashanti region. The team used their training and newly installed equipment to rapidly diagnose the disease using nuclear-derived and other techniques, as well as to assist with early containment, preventing a major economic blow to the region's poultry industry.

In that same year, African swine fever also began spreading across Ghana, threatening the country's pork industry. The AVL team immediately launched an active surveillance and culling campaign for affected pig farms and put in place tight restrictions on animal movement. In addition to collecting and testing tissue samples, they also began routinely using molecular diagnostics, which helped them to rapidly and accurately diagnose 27 suspected outbreaks of the disease.

While the source of the outbreaks was uncertain, the AVL team suspected the outbreaks came from contact with wild pigs. Most of Ghana's pig population is raised in areas of open forest, and African swine fever often spreads to domesticated pigs from wild boar or warthogs. To find the source of infection, the AVL team worked with experts from the IAEA and FAO to use a nuclear-related technique called real time reverse transcription–polymerase chain reaction (real time RT–PCR) (see page 8) to detect avian influenza, as well as real time polymerase chain reaction (real time PCR) to detect African swine fever in tissue samples.

"Identifying the source of an infection is always important for taking appropriate steps," said Hermann Unger, Technical Officer at the Animal Production and Health Section of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "A wildlife survey was initiated, and blood samples and ticks were collected from boar. All samples were tested with nuclear-derived molecular methods, and none were found to contain the virus. This meant the infection was among domesticated livestock. In response, biosafety measures were introduced into livestock markets and the outbreak was stopped."

Early disease detection

Early detection is key to preventing and controlling the spread of diseases. In Bosnia and Herzegovina, this is central to how they have been controlling brucellosis, bluetongue (BT) and lumpy skin disease (LSD).

For centuries, brucellosis — transmitted through direct and indirect contact between animals — has been an endemic disease in livestock in the Balkan Peninsula, while BT and LSD — transmitted by blood-sucking insects such as mosquitoes, ticks, midges and fleas — have emerged recently in the area. These diseases threaten animal health and production, as well as the livelihoods of farmers and their families. They also have an impact on the country's exports.

With support from the IAEA and FAO, in part through the IAEA's technical cooperation programme, specialists in Bosnia and Herzegovina can now read entire genome sequences and identify virus strains. In the past, this required support from international reference laboratories, which delayed detection, diagnosis and intervention. The specialists now also have access to high-tech laboratory equipment and consumables, enabling them to deepen their understanding of the epidemiology of BT and LSD using molecular tools such as whole genome sequencing and bioinformatics.

In 2020, "due to the presence of brucellosis in Bosnia and Herzegovina, the export of live animals is still not allowed by the European Union. However, thanks to the milestone we have reached in performing diagnostic tests quickly and reliably, we have made a big step towards fulfilling the standards of the European Union," said Toni Eterovic, a research scientist at the Faculty of Veterinary Medicine of the University of Sarajevo who took part in the project.

"Through IAEA and FAO support, the AVL can now handle major animal disease outbreaks."

— Joseph Awuni, Deputy Director and Head, Veterinary Services Directorate, Accra Veterinary Laboratory, Ghana

VETLAB Network

The Joint FAO/IAEA Veterinary Diagnostic Laboratory Network, or VETLAB Network, connects national laboratories worldwide in order to tackle animal and zoonotic diseases, which recognize no borders and can threaten livestock, farmers' livelihoods and public health. The VETLAB Network's association of laboratories, including the Joint FAO/IAEA Animal Production and Health Laboratory, work to build capacities for using nuclear, nuclear-derived and other methods for monitoring, early detection, diagnosis and control of animal and zoonotic diseases. These activities include expert advice and services, sharing data, knowledge and expertise, training courses and technology transfer.

The VETLAB Network's overall goal is to harmonize collaboration across borders for more effective prevention, detection and response to animal and zoonotic diseases.

Hunting for viruses in Sierra Leone with the help of nuclear technology

By Laura Gil

Catching bats in the jungles of Sierra Leone.
(Photo: L. Gil/IAEA)

It sleeps upside down, comes to life at night and can carry the Ebola virus. What is it? A bat. After suffering from a devastating Ebola outbreak in 2014, veterinary scientists in Sierra Leone have been training their peers from around Africa to catch, sample and diagnose potentially virus-transmitting bats by using nuclear-derived techniques.

"We've gone through the epidemic, unfortunately," said Dickson Kargbo, a local veterinary scientist, pushing branches aside as he walks into the depths of the jungle at dusk, net in hand, head lamp shining, blue scrubs on and a line of vets behind him. "But on the bright side, we now have the technology, the experience and much to share."

With the support of the IAEA and the Food and Agriculture Organization of the United Nations (FAO), veterinary scientists and wildlife specialists in Sierra Leone and other African countries have been trained in disease surveillance using nuclear-derived and other methods (see page 8 for PCR and 27 for ELISA), as well as in how to understand bats' behaviour in order to trap and sample them while following the right biosafety measures.

"The idea is for them to get hands-on experience and the right scientific knowledge to be able to capture free-roaming bats and probe them without killing them, so that they can return to the wild," said Hermann Unger, Technical Officer at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "Throughout the process, you have to protect both yourself and the animal."

In the jungle

To achieve a high level of surveillance, scientists study the bat species in their natural, wild habitat. This entails getting their hands dirty, both figuratively and literally.

"It's not easy. To diagnose and identify a virus, you need a high-quality sample, taken properly and shipped the right way," Unger said, explaining that, to capture a bat, a team of at least six people must enter the jungle during daylight, set up poles and nets to make traps, and wait until dark for the first bats to appear.

The idea is to cause as little disruption as possible to the ecosystem. As bats are nocturnal mammals, the virus hunters work at night, respecting the animals' rhythm.

"Bats come out at night, so that's when we can get them. We catch them and then later return them to the wild," said Temidayo Adeyanju, a wildlife researcher from Nigeria and a lecturer at training courses supported by the Joint FAO/IAEA Division, where participants learned about different bat-capturing methods according to habitat types and bat species.

After the vets, forest rangers and wildlife specialists trap the bats, they return to the lab, where the animals are identified, measured and probed for blood, faecal and oral samples in order to analyse any of the hundreds of viruses they can transmit to animals and humans, including the Ebola virus. To do this, they use nuclear-derived techniques and equipment donated through the IAEA technical cooperation programme.

"In Togo, we didn't even dare to touch bats for sampling because we didn't have the skills. But now we do, and we ought to. We cannot let our guard down," said Komlan Adjabli, an animal scientist from the Livestock Directorate of Togo, who in 2018 attended the second in a series of training courses supported by the Joint FAO/IAEA Division.

Despite the stigma surrounding bats, they are key to the ecosystem, said Adeyanju. "They're strange creatures. They come out at night, they eat insects or fruits, and people are scared of them. But if you take out the bats, you affect all the other species. They are a keystone."

While bats play a vital part in ecosystems, they also continue to carry threats to people; every year, around ten new viruses are discovered in bats. Among these are viruses like the Ebola virus, which can be transmitted through close contact with infected bats' blood, secretions, organs or other fluids.

"People are scared of Ebola," said Hawa Walker, a conservation specialist from Liberia, the country neighbouring Sierra Leone that also suffered from the epidemic in 2014. "They are obsessed with washing their hands and cleaning their houses. But in many households, bats are still food. They're a source of life for those who have no other choice."

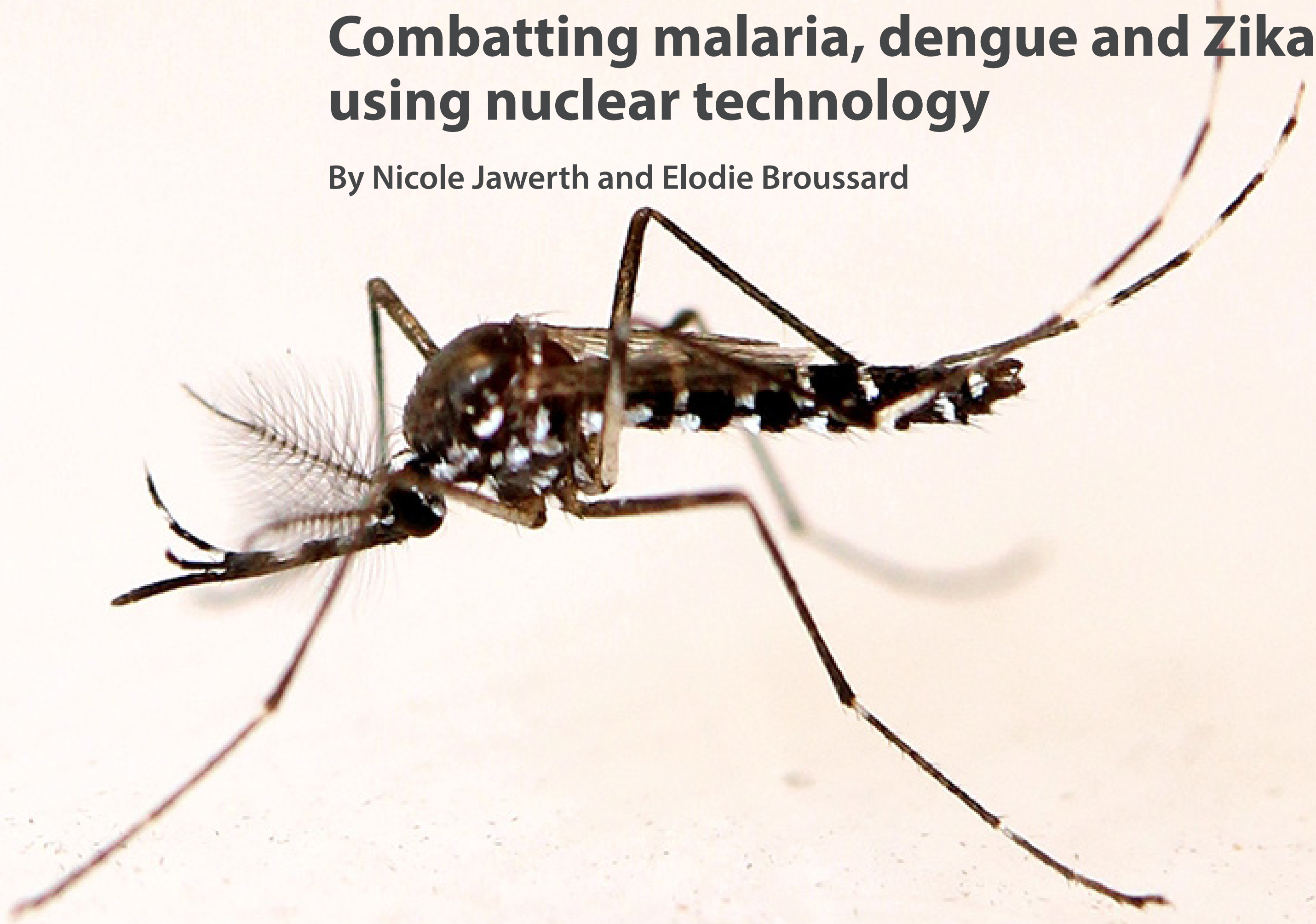
Training courses organized through support from the Joint FAO/IAEA Division are part of efforts to help African veterinary and wildlife scientists to join forces and, through active disease surveillance, anticipate or even prevent outbreaks in the region.

"We need a holistic approach to health," said Michel Warnau, an IAEA project manager who oversees these courses. "One of the issues during the Ebola outbreak in West Africa in 2014 and 2015 was the lack of preparedness. Through these courses, we want to build capacities to study and diagnose zoonotic diseases in livestock and wildlife before an outbreak occurs, in order to better anticipate risks to human populations."

Bats can carry a range of viruses, including Ebola.
(Photo: L. Gil/IAEA)

Combatting malaria, dengue and Zika using nuclear technology

By Nicole Jawerth and Elodie Broussard



A male *Aedes* species mosquito.
(Photo: IAEA)

Diseases such as malaria, dengue and Zika, spread by various mosquito species, are wreaking havoc on millions of lives worldwide. To combat these harmful and often life-threatening diseases, experts in many countries are turning to nuclear and nuclear-derived techniques for both disease detection and insect control.

Dengue and Zika

The dengue virus and Zika virus are mainly spread by *Aedes* species mosquitoes, which are most common in tropical regions. In most cases, the dengue virus causes debilitating flu-like symptoms, but all four strains of the virus also have the potential to cause severe, life-threatening diseases. In the case of the Zika virus, many infected people are asymptomatic or only have mild symptoms; however, the virus can cause serious birth defects in newborns, and it can lead to a debilitating neurological disorder in some adults.

One of the most accurate and widely used laboratory methods for detecting the dengue and Zika viruses is reverse transcription–polymerase chain reaction (RT–PCR) (see page 8). Experts across the world have been trained and equipped by the IAEA to use this technique for detecting, tracking and studying pathogens such as viruses. The diagnostic results help health care professionals to provide treatment and enable experts to track the viruses and take action to control their spread.

When a new outbreak of disease struck in 2015 and 2016, physicians weren't sure of its cause, but RT–PCR helped to determine that the outbreak was the Zika virus and not another virus such as dengue. RT–PCR was used to detect the virus in infected people throughout the epidemic, which was declared a public health emergency of international concern by the World Health Organization (WHO) in January 2016. During that time, many countries received support from the IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), in using this method.

While the ongoing Zika threat has been manageable since the epidemic ended in

November 2016, dengue has continued to be a growing problem. Some countries in Latin America and the Caribbean, for example, reported increases of up to three times the number of dengue cases in January 2020 compared to the same period in 2019. Meanwhile, in Asia, over 80 000 cases were reported in Bangladesh in 2019, making it the country's largest dengue outbreak on record.

The situation has been further compounded by the global COVID-19 pandemic that began in early 2020. "The combination of dengue and COVID-19 has overburdened many health care systems," said Diana Paez, Head of the Nuclear Medicine and Diagnostic Imaging Section at the IAEA. "This is further exacerbated by dengue and COVID-19 sharing similar symptoms and some laboratory features, making differential diagnosis difficult. When one disease is misdiagnosed as the other, it complicates disease management and control, which is why accurate tests like RT–PCR are critical."

Besides diagnosing and tracking these diseases in people, experts have been looking for ways to reduce the virus-spreading *Aedes* mosquito population. One option has been area-wide insect management using, among other techniques, a nuclear-based insect birth control method called the sterile insect technique (SIT) (see The Science box).

"SIT has been successfully implemented against numerous insect pests of agricultural importance and is now being adapted for use against mosquitoes," said Rafael Argilés Herrero, entomologist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "The method is very specific to the target species and has no impact on other living organisms or the environment."

Research on the use of SIT against *Aedes* mosquitoes has intensified worldwide, in part through IAEA and FAO support. Examples include a four-year project launched in 2016 to help countries in the Latin America and the Caribbean region. In 2019, upon Bangladesh's request, a four-year work plan was agreed for testing SIT for suppressing dengue-spreading mosquitoes. Projects have also been launched in Asia and Europe, and pilot tests have been initiated in 13 countries worldwide, with some achieving as high as 95% suppression.

In early 2020, the IAEA, FAO, Special Programme for Research and Training in Tropical Diseases (TDR) and WHO released the *Guidance Framework for Testing the Sterile Insect Technique as a Vector Control*

(Photo: IAEA)

Tool against Aedes-Borne Diseases. The publication outlines how an SIT programme can be initiated and how to decide whether to implement it in a country's affected areas.

"Diagnostic imaging is able to detect malaria infections that have not been detected through routine screenings."

— Hadj Slimane Cherif, Head, Office of Peaceful Nuclear Technology, Ministry of Foreign Affairs, Oman

Malaria

Malaria is an infectious parasitic disease spread by female *Anopheles* mosquitoes. This disease threatens approximately half of the world's population by causing a range of adverse health symptoms and, in some cases, death.

Health professionals can diagnose malaria by testing a patient's blood for microscopic signs of the parasite, as well as by measuring antigens from the immune system's response to the parasite. Polymerase chain reaction (PCR) testing is also able to detect malaria, particularly in cases with low levels of parasites or when other infections are present. Through medical imaging techniques such as X-ray and computed tomography (CT), physicians can evaluate the clinical complications of the disease.

"Diagnostic imaging is able to detect malaria infections that have not been detected through routine screenings," said Hadj Slimane Cherif, Head of the Office of Peaceful Nuclear Technology of Oman's Ministry of Foreign Affairs. He explained how the number of reported malaria cases has dropped in Oman in the last two decades and the significant role molecular diagnostic imaging methods, acquired through the IAEA's technical cooperation programme, play in the country's new policy to screen travellers from malaria-endemic places. "This policy will eventually lead to Oman becoming a malaria-free country."

By reducing the population of *Anopheles* mosquitoes using SIT, experts are also hoping to reduce the spread of malaria. Some technical challenges they face have been ensuring only male sterilized mosquitoes are released, as well as developing efficient trapping systems. This has created obstacles to the large-scale use of SIT against this type of mosquito.

One of the ongoing challenges with SIT for mosquito control is how to effectively release these fragile insects. In June 2020, researchers found that using drones to release sterilized males was more cost-effective, faster and less damaging to the mosquitoes than other common release methods, such as on-the-ground or by airplane. These findings marked a major breakthrough in expanding the use of SIT against mosquitoes.

THE SCIENCE

Sterile Insect Technique

The sterile insect technique (SIT) uses radiation to sterilize male insects that are mass produced in special facilities. Large quantities of the sterile male insects are systematically released from the ground or by air. They mate with wild females in nature, which results in no new offspring. Over time, this brings the insect population down, or, when insect populations are isolated, it can eradicate an entire population. SIT has been successfully used for over 50 years against agricultural insect pests.

(Graphic: R. Kenn/IAEA)

Vietnamese authorities control the spread of African swine fever with the use of nuclear-derived techniques

By Gerrit Viljoen

In 2019, the pork industry in Viet Nam escaped a wave of African swine fever (ASF) and other animal diseases hitting South-East Asia, thanks to quick action by researchers at the country's National Centre for Veterinary Diagnosis (NCVD). The research team used training and equipment obtained through IAEA support, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), to rapidly diagnose diseases like ASF with nuclear-derived and other techniques, controlling the spread of these diseases, protecting the country's livestock industry and ensuring food security.

China, which shares a border with Viet Nam, reported its first case of ASF in August 2018. The disease quickly spread to the southern part of the country and eventually to Viet Nam. Since a vaccine for ASF was still unavailable, early and accurate detection of the disease was essential in order to implement strict sanitary and biosecurity measures to contain and eventually eliminate the disease.

Immediately after the news of the outbreak in China, the IAEA, in cooperation with the FAO, provided a training course to veterinary diagnosticians from South-East Asia, including Viet Nam, on the diagnosis of ASF and other infectious diseases. Armed with this knowledge, Vietnamese experts were able to diagnose ASF early and put in place measures to protect the country's pig farms.

"Being able to proficiently perform testing is a major milestone, not only for our institute but for the entire country," said Thanh Long To, Director of the NCVD. "With increased trade and travel across the region, we fear that Viet Nam will face transboundary animal and zoonotic diseases at an increased frequency."

In Viet Nam, home to 30 million pigs, most of which are raised on family farms, pork makes up roughly three quarters of total domestic meat production and consumption. Demand for pork has been increasing by 6 to 8% per year.

(Photo: L. Gil/IAEA)

Before the training course, the NCVD had to send suspected ASF samples to reference laboratories abroad for confirmation. This could take between three and four weeks, which is too long for the timely implementation of control measures. Now, equipped with the knowledge in-house, testing samples can be carried out within a day, To said.

The NCVD now has the capacity to screen around half a million samples per year and to help contain not only ASF, but also foot-and-mouth disease, leptospirosis, rabies and goat pox, among other diseases (see The Science Box on page 29).

The support was provided through an IAEA technical cooperation project to strengthen the NCVD's capacities to use serological, molecular and nuclear techniques for the early and rapid diagnosis and control of transboundary and zoonotic diseases. The NCVD also receives support as one of 19 members in Asia involved in the Veterinary Diagnostic Laboratory (VETLAB) Network of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

Bulgaria stops the spread of animal disease with the help of the IAEA and FAO

By Laura Gil

Bulgarian authorities at a local farm carrying out their disease control work.
(Photo: S. Slavchev/IAEA)

In 2018, Bulgaria halted the spread of *peste des petits ruminants* (PPR) — a disease that can devastate livestock — thanks in part to the support of the IAEA and the Food and Agriculture Organization of the United Nations (FAO). This was the first time PPR had been recorded in the European Union, which made halting its spread early an important goal for the region.

Summer outbreak

In the summer of 2018, cattle breeders on the farms of Voden in south-eastern Bulgaria noticed that their animals were suffering from a disease. Soon after, authorities reported that the country was facing an outbreak of PPR. Within days, two Bulgarian scientists came to the IAEA to receive training and materials to rapidly detect and characterize the PPR virus using nuclear-derived techniques. The area underwent active surveillance, and no more cases have been reported since July 2018.

Although not transmittable to humans, PPR can have a severe impact on livestock, killing between 50 and 80% of infected animals, mostly sheep and goats. Its high economic impact makes PPR one of the most significant livestock diseases. Also known as ovine rinderpest or sheep and goat plague, PPR originated in Africa but has also been reported in Asia and the Middle East.

“Most European laboratories are generally neither familiar with nor prepared to deal with this disease,” said Giovanni Cattoli, Head of the Animal Production and Health Laboratory at the Joint FAO/IAEA Division of Nuclear Techniques for Food and Agriculture. “It is exotic, off their radar. But, luckily, Bulgaria reacted quickly, and we stepped up to support them.”

The European Union Reference Laboratory for *peste de petits ruminants*, based in

Montpellier, France, later confirmed their findings.

Immediately after the outbreak was confirmed, Bulgarian authorities imposed a quarantine zone around the village of Voden in order to contain the disease. Additionally, they ordered blood tests on small livestock and banned the trade and transport of all livestock in the regions along the Turkish border, the area of the country affected by the disease.

As a consequence of the emergence of the disease, animal movement restrictions and trade barriers were put in place to limit the spread of the infection and facilitate the eradication of the disease. This is standard procedure in the European Union. Bulgarian authorities also implemented active surveillance in the area to remove any potentially infected animals from herds. “We have a lot of confidence in Bulgaria’s capacity to control the disease, but work should continue,” Cattoli said. “The same way it reached Bulgaria, it could reach other European countries.”

Six months after the last case occurred, active surveillance indicated that the virus was no longer circulating in the country — a pre-requisite to lifting the ban.

Eradication?

After the eradication of rinderpest, the ‘older sister’ disease of PPR that affects bigger livestock such as cows, was declared in 2011, the FAO and the World Organisation for Animal Health (OIE) set a goal for the global eradication of PPR by 2030. Achieving this could have a major positive impact on affected economies and communities. For example, the eradication of rinderpest in 2011 in Africa alone led to an annual estimated economic benefit of US $920 million for the region, according to FAO estimates.

“If you look at the virus and the epidemiology of the disease, technically this is achievable,” Cattoli said, referring to the eradication of PPR. “The difference is that there are far more goats and sheep whose location and movements are sometimes difficult to trace, so having exact figures and calculating the right doses for a vaccine programme can be a challenge.”

In partnership with the FAO, the IAEA assists national experts in developing and adopting nuclear-based technologies to optimize animal health management practices. These techniques, such as enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR), are extremely precise (see The Science box).

THE SCIENCE

Enzyme-linked immunosorbent assay & polymerase chain reaction

Enzyme-linked immunosorbent assay (ELISA) and **polymerase chain reaction (PCR)** are two nuclear-derived techniques commonly used for disease diagnosis.

ELISA is easy to set up and use, which makes it suitable for any veterinary laboratory. Scientists place a diluted serum sample from an animal onto a prepared dish and, if the sample contains the suspected disease, it causes an enzyme in the fluid to change the liquid’s colours, confirming the presence of the disease. ELISA is often used for initial tests and for screening large populations, but it cannot be used to precisely identify virus strains.

See page 8 for more information on PCR.

Morocco controls foot-and-mouth disease with the help of nuclear-derived methods

By Elodie Broussard

Taking a sample from a cow to test for foot-and-mouth disease.
(Photo: F. El Mellouli/LRARC)

In early 2020, Morocco celebrated a year without foot-and-mouth disease (FMD), a highly contagious animal disease, after launching a series of vaccination campaigns to control a new strain of the FMD virus, which was identified in 2019 using nuclear-derived methods. This achievement was made possible in part through the support of the IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO).

FMD is an often fatal disease that affects cattle and ruminants, both domesticated and wild, and can severely impact food security and livelihoods. Morocco has 29 million cattle, sheep, goats and camels, and its livestock sector contributes nearly 13% of agricultural gross domestic product.

When outbreaks hit several Moroccan provinces in 2019, herds were rapidly infected in five locations. For each confirmed case, all livestock within a three-kilometre radius were slaughtered, and a surveillance zone with a radius of ten kilometres was established, blocking the sale of animals and animal food products.

To rapidly control the spread of the disease, the Regional Laboratory for Analysis and Research of Casablanca (LRARC) used nuclear-derived techniques, which can provide quick and accurate analysis (see the Science Box). Other techniques take longer to identify the disease, resulting in an increased number of infected animals and higher outbreak-related costs.

“The real challenge for national veterinary authorities was to know whether the outbreaks were caused by the same strain of the FMD virus as the one detected in 2015 during the previous outbreak,” said Ivancho Naletoski, Animal Health Officer at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

In 2017, experts from the Joint FAO/IAEA Division, with support from the IAEA technical cooperation programme, trained ten veterinary laboratory staff from Morocco and provided them with equipment and supplies to facilitate disease identification and guide control and response measures. The trainees included staff from LRARC, who subsequently identified the new FMD strain in early 2019 by using their acquired skills, as well as the genetic sequencing service established through the Joint Division.

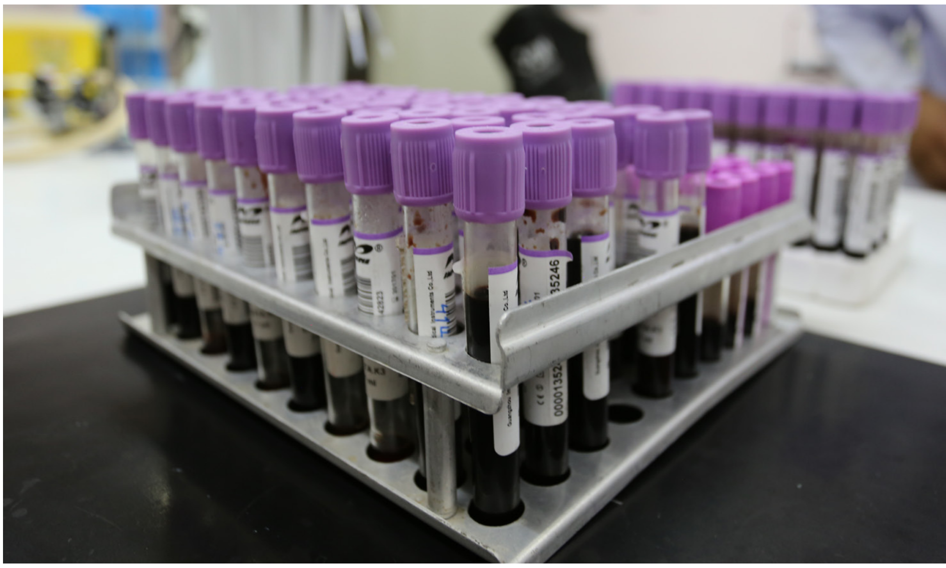
Shortly after the FMD outbreak, the specific virus genome was sequenced by LRARC and compared with the locally circulating strains. LRARC simultaneously sent samples for genetic sequence analysis to the Laboratory for Animal Health in Maisons-Alfort, France, a reference institution for FMD identification, where LRARC's diagnosis was confirmed.

"Identifying the strain of a virus is the first step for national veterinary authorities in the case of an outbreak. The second step is to select or develop a proper vaccine, as each strain needs a specific one," said Naletoski.

Once the new strain and vaccine were identified, the Moroccan veterinary authorities implemented vaccination campaigns within a few weeks, which rapidly halted the spread of the disease. Compulsory mass vaccination campaigns for susceptible ruminants (cattle, goats and sheep) were carried out across the whole country at no cost to farmers. These campaigns have helped to strengthen the animals' immunity and have prevented the spread of the virus.

"The genome sequencing transferred by the IAEA to our lab enabled us to rapidly discriminate the circulating strains in the country and to adjust disease control plans accordingly," said Fatiha El Mellouli, Head of the Animal and Plant Health Service at LRARC.

The benefits of these efforts are tangible for farmers, producers and exporters of animals and animal products in Morocco. The country has also ultimately maintained its national FMD control programme, endorsed by the World Organisation for Animal Health (OIE) since 2012, and is continuing its efforts to improve animal health and related trade.



Samples from livestock waiting to be tested for viruses.

(Photo: N. Jawerth/IAEA)

THE SCIENCE

Genetic sequencing & polymerase chain reaction

Genetic sequencing is a nuclear-derived technique that analyzes the way in which nucleic acid — ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) — information is arranged inside pathogens. This technique describes the composition of the genetic material, helping scientists to predict the function of the analysed gene, its impact and the behaviour of the pathogen. This not only helps to diagnose a disease but can also disclose its origin and evolution, as well as its potential threat.

Such nuclear-derived tools and techniques are frequently used for the phylogenetic analysis of FMD and other diseases such as rabies, brucellosis and Ebola.

See page 8 for more information about **polymerase chain reaction (PCR)**.

Irradiated animal vaccines keep Ethiopia's animals healthy, helping exports and food security

By Miklos Gaspar

Cattle are an important part of Ethiopia's economy.
(Photo: M. Gaspar/IAEA)

Ethiopia exports over one million cattle per year, a number which would not be possible without nuclear techniques. To prevent epidemics, all livestock destined for export, as well as domestic consumption, need to be vaccinated against animal diseases. In Ethiopia, vaccines are developed and produced at the National Veterinary Institute (NVI). These vaccines are developed to fight evolving pathogens and then produced for use both domestically and in neighbouring countries. The IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), supports both stages of the process.

"Livestock exports are vital to our economy, and the contribution of the NVI to the livestock sector is immeasurable," said Wondemagegn Tufa, a Director at Ethiopia's Ministry of Agriculture in charge of ensuring export procedures for cattle. The Ministry buys vaccines from the NVI and then distributes them among farmers, including pastoralists in the eastern part of the country whose animals are most at risk of exposure to disease, given that they roam across a large area and mingle with wild animals.

With 60 million cattle, Ethiopia has the largest livestock population in Africa and the fifth largest in the world, according to the World Bank. The livestock sector accounts for around one-fifth of the country's economy and close to 10% of its exports.

To keep up with both increasing demand from farmers and the changing regulations of importing countries, the NVI has increased its vaccine production from 93 million doses to 260 million doses per year over the last decade. This has also enabled the export of vaccines to neighbouring countries, including those vaccines that prevent *peste des petits ruminants*, a viral disease of goats and sheep, the eradication of which is a major goal of the African Union.

Vaccines and how they work

The availability of and access to effective vaccines is vital for controlling and preventing the spread of many animal diseases, some of which can also spread to humans. Vaccines work the same way in animals as they do in humans, by activating an immunological response that helps the body prepare to fight off a future disease. However, some vaccinations use live microorganisms, like viruses, which could lead to an eruption of the disease. Radiation can help to address this by inactivating a microorganism so that it cannot infect the vaccinated animal. At the same time, radiation does not affect the microorganism's structure, so the immune system can still recognize it, allowing the animal to develop a protection mechanism. The irradiation of vaccines also ensures that the vaccines do not contain any contamination.

Using irradiation technology to develop vaccines is safer for the animals because it does not require additional chemicals or other compounds that are traditionally used for deactivating viruses. "These irradiated vaccines are of a higher quality because they better preserve the structure of the microorganism, which results in a broader immune protective response," said Charles Lamien, an Animal Health Officer at the Joint FAO/IAEA Division of Nuclear Techniques for Food and Agriculture.

Through its technical cooperation programme and in partnership with the FAO, the IAEA supports the NVI in staff training and in the supply of consumables and equipment. All technical staff in the NVI's Research and Development Department have benefitted from training by the FAO and IAEA. "Whether through short courses or longer fellowships, they have all been exposed to cutting edge science," said Martha Yami, Director General of the NVI.

Vaccine development

The IAEA played a pivotal role in establishing the NVI's molecular laboratory, where new strains of viruses are characterized so that vaccines can be adjusted to provide protection against them, Yami said.

This characterization of the viruses' deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) is carried out using nuclear-derived molecular techniques, which can reveal the differences between strains. This technology is used to compare the wild virus from an outbreak with the vaccine itself, and, if they are closely related, the vaccine will provide the required protection. If they are not, the vaccine needs to be modified.

The IAEA now relies on the NVI's experts to train scientists from across Africa in the use of various nuclear techniques in animal health, Lamien said. "Animals, and with them the diseases they carry, cross borders," he said. "Therefore, a continent-wide approach is required to fight these diseases."

Beyond dollars and cents

The impact of this work is visible across Ethiopia, where cattle roam on hillsides, pastures and roads. Many of the country's 12 million farming households depend on cattle and therefore benefit from nuclear technology, whether they know it or not.

"The importance of cattle and their health is more than just economic," said Tufa. "Cattle are a way of life for pastoralists. They are central to the culture and function as a storage of wealth and as insurance to use in times of hardship." Improving the health and well-being of these animals and increasing their productivity is a key development objective of the Government, he added.

A scientist at the National Veterinary Institute researching the genetic make-up of a virus.
(Photo: M. Gaspar/IAEA)

We need a global response to the pandemic threat

By Maria Helena Semedo

Maria Helena Semedo, Deputy Director-General, Food and Agriculture Organization of the United Nations. She is a leading expert in global development issues and has worked in public service for over 30 years.

The COVID-19 pandemic has upended the world as we know it, marking the first disease in over a century to grind our day-to-day lives and our economies to a halt.

Some of the most damaging disease outbreaks in recent decades have involved zoonotic diseases, such as the Ebola virus disease, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). Each year, zoonoses — diseases and infections that go from animals, mostly wildlife, to humans, and then spread between humans — cause illnesses in around 2.5 billion people and almost 3 million deaths.

The impact of these diseases in countries, regions and, in some cases, around the globe, not only affect people's health directly, but also damages livelihoods and causes economic downturn. When the Ebola virus disease ravaged and stole thousands of lives in West Africa in 2014, restrictions and controls to contain the disease also intensified food insecurity. Agricultural supply chains were disrupted, limiting farmers' ability to grow or sell food. People went hungry. Some starved. Many lost their livelihoods.

Previous disease crises have led to similar experiences. Now we see the direct and indirect ramifications of the COVID-19 global pandemic jeopardizing food security and livelihoods for hundreds of millions of people. We cannot underestimate the widespread impact of zoonotic diseases on our communities, economies and society as a whole.

Zoonotic diseases are on the rise.

Deforestation, climate change impacts and the intensification and industrialization of agricultural activities, combined with increasing urbanization and population growth, are all contributing to the greater encroachment of humans and livestock into natural wildlife habitats. In many parts of the world, people still rely heavily on animals for transport, draught power, clothing and food, with hunting and eating wild animals also a common practice. This close relationship between animals and humans means that if an animal or zoonotic disease strikes, it can spread quickly, jeopardizing a country's development efforts and potential.

Animal health workers on the front lines

One of our first lines of defence is animal health professionals and specialists. Their ability to monitor animals and keep them healthy through prevention, surveillance, detection and response to infectious animal diseases is a chance to pre-empt the emergence of zoonotic diseases.

For decades, the Food and Agriculture Organization of the United Nations (FAO) has provided training and technical assistance to animal health professionals worldwide, particularly in at-risk countries. Bolstering countries' abilities is part of the FAO's wider efforts to strengthen their disease control, as well as their preparedness and response, through laboratory diagnostics, disease surveillance, outbreak investigation and reporting, and to support national and policy infrastructure, including evidence-based planning and decision making.

Connecting laboratories through the Veterinary Diagnostic Laboratory (VETLAB) Network helps to channel expertise and coordinate actions towards our collective efforts in disease control. Established by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, the VETLAB Network comprises veterinary laboratories in different countries, including the Joint FAO/IAEA laboratories, as an avenue for working together towards improving national laboratory capacities, as well as emergency response for detecting and controlling animal and zoonotic diseases both inside and across borders.

Over the years, recognizing the critical importance of quick and early disease diagnosis, the Joint FAO/IAEA Division has been boosting national capacities, as well as training and equipping hundreds of professionals, in the use of one of the fastest and most accurate diagnostic laboratory tests for animal and zoonotic pathogens: polymerase chain reaction (PCR) and its variant, reverse transcription–polymerase chain reaction (RT–PCR). When used in 'real time', these techniques can provide results in just a few hours. These diagnostic testing methods are not just for use by animal health professionals. They have also been used for decades to diagnose a range of diseases in humans. Learn more about this on page 8.

Real time RT–PCR is now the most widely used laboratory test for COVID-19. The FAO and the IAEA have been strengthening capacities by providing technical advice and support to countries in using this technique. Emergency diagnostic kits, including critical laboratory testing reagents, personal protective equipment, sampling materials, disinfectants, consumables and other equipment, have also been provided under this partnership.

Global health, global responsibility

Borders are meaningless to diseases. If one country lacks the capacity to adequately deal with a disease, we are all at risk. The FAO and its member countries and partners, including the IAEA, the World Organisation for Animal Health (OIE) and the World Health Organization (WHO), are taking steps to work together in order to protect people, animals and the environment.

Information and communication within and across borders can help the world stay one step ahead. The FAO collaborates with national, regional and international officials and experts to monitor and assess disease situations. Governments and disease control professionals receive up-to-date information on disease threats through FAO communication channels, such as the Early Warning Bulletin and action reports. These channels draw on sources from national, regional and international governments, as well as organizations and other expert sources, to provide as much information as possible to encourage fast and appropriate response measures.

Specially designed software and systems for data collection, analysis and modelling are helping to spot trends and forecast potential disease threats, which supports countries' preparedness and enables their rapid response. For example, data submitted in real time, often by local farmers, experts and governments, through the FAO's Event Mobile Application (EMA-i) for smartphones, is one of several data sources that feeds into the FAO's EMPRES Global Animal Disease Information System (EMPRES-i). With daily data updates from over 190 countries, EMPRES-i generates maps of potential threats and is linked to the Global Early Warning System for Major Animal Diseases, including Zoonoses (GLEWS+), which shares information with the WHO and the OIE.

A One Health approach

Responding to the next global pandemic will require all of us to work across all sectors and disciplines. The FAO, along with its partners, such as the United States Agency for International Development (USAID), is advancing a One Health approach. This means coordinating actions by linking human, animal and environmental health at the local, national, regional and global levels. This is especially relevant in tackling zoonotic diseases and antimicrobial resistance, as well as for improving biosafety and biosecurity, national laboratory systems and workforce development.

By engaging animal health specialists alongside experts such as physicians, biostatisticians, biologists, ecologists, scientists and field epidemiologists, it forms a comprehensive line of defence that can strengthen our global position against the emergence of zoonotic diseases.

Our global health counts on all of us sharing information, collaborating and taking concrete action to safeguard human, animal and environmental health. Only then can we protect ourselves from the impact of zoonotic diseases and further our work towards achieving food and global health security as set out in the United Nations' Sustainable Development Goal 3. This is essential to our daily lives and to continuing our global efforts towards achieving the goals set out in the United Nations 2030 Agenda for Sustainable Development.

A global victory against COVID-19 requires creative partnerships

By Takako Ohyabu

Takako Ohyabu is the Chief Global Corporate Affairs Officer of Takeda Pharmaceutical Company Limited. She has extensive experience in global corporate communications in a variety of industries and has a background in political science and public administration and affairs.

The global response to COVID-19 has reinforced humanity's resilience and spotlighted the unparalleled power of creative partnerships. It also highlights the stark human and financial cost of weak health systems, the consequences of which are unfortunately keenly familiar to those communities dealing with infectious and non-communicable diseases in the developing world. As the fight against COVID-19 began, battles against numerous other health threats had already long been raging.

The challenge for any health crisis — whether immediate or decades in the making — is bigger than developing safe and effective medicines or vaccines. The world needs enough qualified health workers to serve all patients; supply chains that ensure reliable access to essential equipment, clean water, food and medicines; uninterrupted preventive care for all, particularly for children, mothers and other vulnerable populations; communities empowered with knowledge and access to care; and so much more. All of this requires a multitude of committed partners to engage and stay the course.

Strengthening health systems and building capacities requires significant, long-term financial commitments and relies on cross-sector and cross-agency partnerships that can sometimes be difficult to understand and maintain. While these priorities rarely deliver the fanfare of immediate results, in times of crisis their benefits shine, as even the most sophisticated arsenal of interventions and technologies cannot succeed on a major scale without functioning systems to support them.

For over a decade, Takeda's Global Corporate Social Responsibility (CSR) Program and partnerships have been making long-term commitments to strengthening health systems and building capacities in the developing world. The fight against COVID-19 only amplifies the importance of our Global CSR Program, as well as the partnerships we support and the capacities these partnerships have built, which now serve as part of the global armoury against the pandemic.

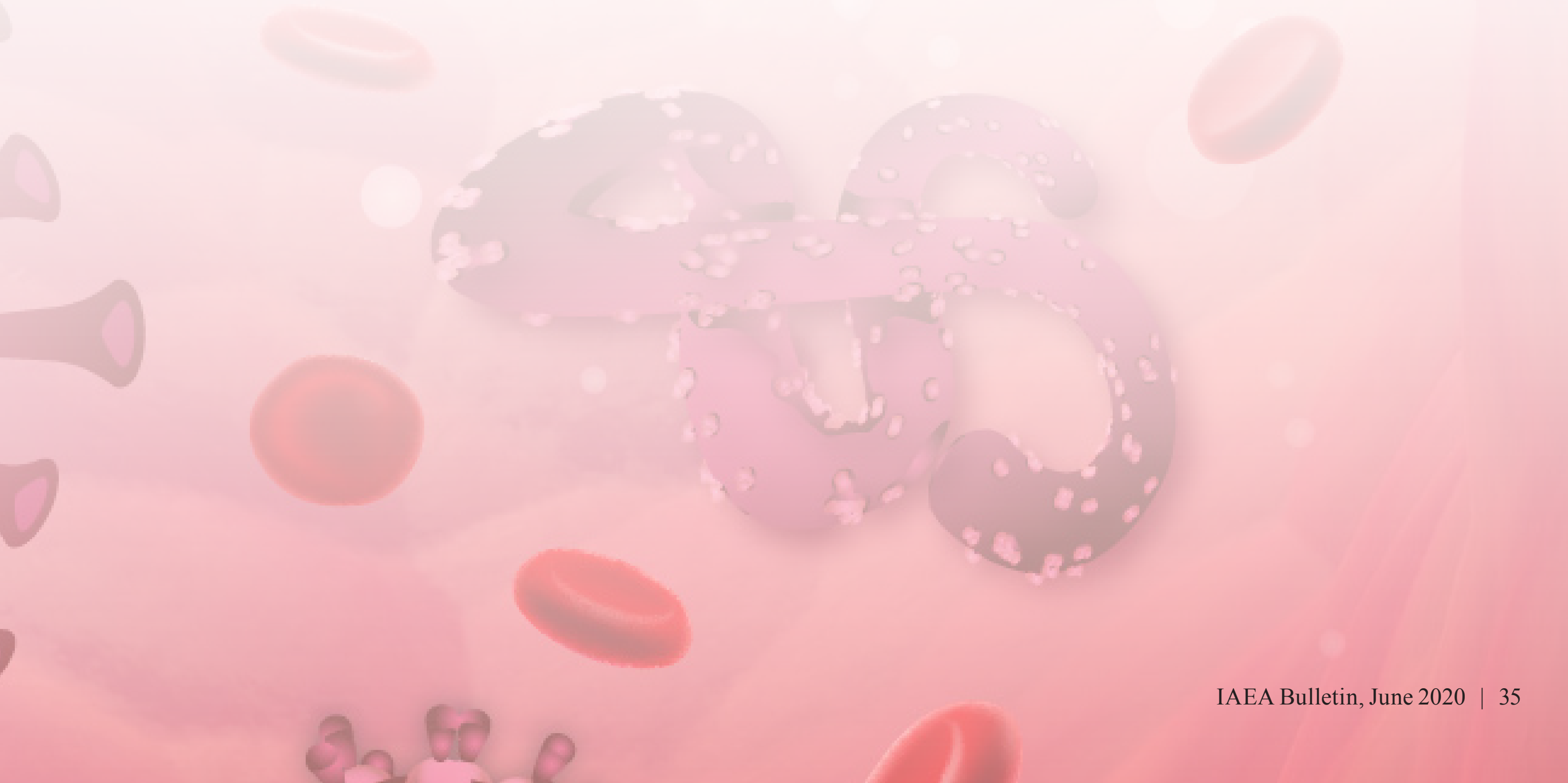
At Takeda, we have been thinking long and hard about how to continue the support we know is crucial to helping health systems cope with entrenched challenges and existing emergencies while also responding to the unprecedented new challenge of COVID-19. We will continue the Global CSR Program's support for ongoing work with health systems such as maternal, newborn and child health, as well as for supply chain strengthening and health worker training. We have also formed the CoVIg-19 Plasma Alliance with industry peers to accelerate the development of a potential plasma therapy for COVID-19, and we have identified thoughtful ways to leverage philanthropic resources throughout the pandemic life cycle and for continuing to bolster health systems now and in the long term.

It is important to us that the efforts we support work collaboratively and comprehensively — not in isolation. The result: a US $23 million donation across three United Nations-led organizations: the IAEA, the World Food Programme (WFP), and the United Nations Population Fund (UNFPA). The unique efforts of these organizations in enhancing national diagnostic capacity, strengthening public health pandemic supply chains and ensuring continued access to quality maternal and newborn health care, respectively, directly align with the United Nations' Global Humanitarian Response Plan for COVID-19 and strengthen global systems for preventing future emergencies.

Through our established relationship with the IAEA, we learned that the IAEA was already working on the detection and diagnosis of zoonotic diseases. The IAEA had existing, highly relevant technology to leverage in the face of the new pandemic, which, as a member of the World Health Organization-led COVID-19 United Nations Crisis Management Team , it was ready to deploy to meet the immediate needs of United Nations Member States.

When evaluating possible COVID-19 donations, we appreciated that the IAEA's emergency assistance not only included diagnostic kits and critical biosafety equipment such as personal protective equipment and lab cabinets, but also featured technical capacity building to help rapidly and accurately detect and identify the novel coronavirus that causes COVID-19. This comprehensive approach addresses the immediate challenge at hand in countries across the globe and enhances the technical and operational diagnostic capabilities of national laboratories over the long term.

The synergy between the IAEA, WFP, and UNFPA's COVID-19 activities enables a 'combined arms' approach to this crisis, with each organization deploying a unique set of complementary forces to amplify one another's impact. Takeda supports cross-agency collaboration as much as it does individual efforts to strengthen the response to today's crisis. We believe in the power of strong health systems and creative partnerships to address the challenges of today and to prevent and prepare for what may come tomorrow.



Belarus receives IAEA equipment to assess radiological threats associated with forest fires

Crew of the new mobile laboratory during a practical training exercise for soil and air sampling in the Chornobyl Exclusion Zone in May 2020. (Photo: R. Nenashev/Polessye State Radioecological Reserve, Belarus)

When forest fires occur on sites with significantly elevated radiation levels, such as the fires that broke out in the Chornobyl Exclusion Zone, which straddles the border between Belarus and Ukraine, in April 2020, officials and the public want to know whether there is an elevated risk of radiation exposure. While there was no such risk posed by the series of wildfires in northern Ukraine in the exclusion zone, just 16 kilometres from the Belarusian border, new equipment sent to Belarus by the IAEA will better prepare scientists for radiation monitoring in the future.

Forest fires are recurring events in the abandoned areas of the exclusion zone, a 4760 square-kilometre area surrounding the nuclear power plant that has mainly been uninhabited since the Chornobyl nuclear accident in 1986. In such circumstances, sound scientific data is needed to ensure the appropriate response and to protect the health of both the public and directly affected personnel, such as firefighters, forest workers, border guards, scientists and technicians working in the zone.

Responding to Belarus' request, the IAEA helped to design and procure a mobile laboratory in the country, complete with instruments and tools for radiation monitoring of the air and environment.

"The dedicated work of IAEA specialists and Belarusian counterparts allowed for the design and delivery of a well-equipped and fit-for-purpose mobile laboratory to support Belarus in its prompt response to current radiological threats posed by forest fires in the exclusion zone," said Peter Swarzenski, Acting Director of the IAEA Environment Laboratories.

The mobile laboratory can be taken on off-road operations and serves as a work station for a crew of four in the field. It is equipped with a portable air-sampling device, a handheld gamma spectrometer, a radiation monitor for measuring environmental samples, a soil-sampling kit, personal protective equipment, navigation and communication tools, an electric generator and a workplace with a computer and other appliances.

The air samples collected at the sites of forest fires need to be analysed to accurately determine the activity of radioactive isotopes of caesium, strontium and transuranium elements.

The assistance provided to Belarus by the IAEA is taking place as part of a technical cooperation project launched in 2018, which has been primarily focused on helping the scientific and technical staff of the Polessye State Radioecological Reserve in Belarus to advance their professional knowledge and skills, particularly in relation to the dosimetry of inhalation intake of radionuclides, as well as the identification and procurement of appropriate instruments, tools and consumables for radiation monitoring, air and soil sampling, and sample processing and measurements.

"Along with the mobile radiological laboratory, the IAEA has made a significant contribution to strengthening our activities in the fields of research and radioactive pollution monitoring through training activities, scientific visits and the procurement of necessary equipment and supplies. This is just what we need in this period," said Mikhail Patsiomkin, Chief Specialist at the Belarusian Ministry of Emergency Situations.

Scientific data supports better communication with local populations

Along with the collection and analysis of data, communicating information to the local population is a crucial component of emergency response when forest fires are burning a few kilometres away from their communities.

"When assessing radiological challenges and threats during the recent fires in the Ukrainian part of the exclusion zone, the media took into account the opinion of the Polessye State Radioecological Reserve, which was strengthened by IAEA technical and scientific support. As a result, information published in the Belarusian mass media was mostly reliable and based on an authoritative opinion," said Patsiomkin.

As of May 2020, the IAEA technical cooperation project is approaching completion, and Belarus is now well equipped to assess radiological threats that may arise from forest fires in the future.

— By Elodie Broussard

Drought-tolerant crops: IAEA and FAO help Zambia improve production and farmers' income

Two new varieties of cowpea, a crop that provides a major source of protein for people in Zambia, are being released to offer significantly improved yields and quality to farmers and local communities. The new varieties of cowpea, a grain legume that is predominantly cultivated in Africa, mature earlier and therefore require less water, allowing them to better withstand drought. They produce higher yields than local varieties under drought conditions and have also demonstrated better performance than local varieties in the face of certain diseases and pests. Developed using nuclear technologies, seeds of these cowpea varieties will be available to farmers in late 2020.

The IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO), works to improve food security worldwide by using nuclear science. Through this partnership, plant breeding programmes are carried out with the use of nuclear technologies, resulting in the production of more crops with improved characteristics.

"Crop production in much of Africa, including Zambia, is hindered by heat, drought, pests and diseases, to the point where some farmers cannot grow enough food," said Fatma Sarsu, a plant breeder and geneticist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "Increased drought in recent years, as well as the effects of climate change, are amplifying the challenges farmers

Kalaluka Munyinda, Lecturer at the Department of Plant Science, stands in the experimental field for growing new plant varieties at the University of Zambia. (Photo: University of Zambia)

already face. Developing improved crop varieties through plant breeding is one way to address this issue."

The two new cowpea varieties, called Lunkhwakwa and Lukusuzi, were developed using irradiation, a technique which speeds up the natural process of producing genetic variation in plants. The crops are currently being multiplied, and the seeds will be distributed to 800 farmers in November 2020 for planting.

"We are primarily targeting farmers in the dry areas of the country, who have had trouble growing enough food in recent years due to the extremely dry conditions," said Kalaluka Munyinda, Lecturer in the Department of Plant Science of the University of Zambia. "The challenges these farmers faced were crucial problems that we needed to address with mutation breeding. Additionally, as these new varieties are also more tolerant to diseases, we are planning to eventually grow them in high-rainfall areas as well, where yield losses resulting from disease are a bigger threat to famers."

To meet farmers' demand for desired crop characteristics, scientists at the FAO/IAEA Agriculture and Biotechnology Laboratory in Seibersdorf, Austria, subjected the seeds of local varieties to gamma irradiation, inducing changes in their genetic make-up. Following this, the irradiated seeds were sent back to Zambia, where they were planted in test fields to observe their characteristics under local conditions. During the testing process, farmers worked alongside scientists to select improved plants.

"We have been badly impacted by droughts over the past two years between 2018 and 2020, and crops have not been performing well here, but now we have varieties that do well with little rainfall," said a farmer from the Chirundu District in southern Zambia. "Initially, we only had one variety of cowpea that was late maturing, but now we have access to new varieties that are early maturing. We want to build a community that is climate-resilient by increasing the number of varieties grown in our community."

The project is expected to lead to increased food security as well as higher incomes for farmers. "In some locations, the new varieties are up to ten per cent higher yielding than the parent varieties, which means that farmers will not only be able to grow more food, but also increase their income," said Munyinda. "These varieties are also more tolerant to diseases such as Ascochyta blight, which severely inhibit yields in some areas. As a result, we are expecting to improve national food security in terms of both increased availability of food and improved nutrition."

— By Carley Willis

New varieties of cowpea plants are helping many farmers around Africa grow more food despite drought.

(Photo: Prince M. Matova/Crop Breeding Institute, Zimbabwe)

IAEA provides standards to help laboratories measure changes in the environment

Carefully handling a sample for analysis.
(Photo: IAEA)

In 2020, the theme of World Environment Day, held on 5 June, was 'Time for Nature'. Indeed, now is the time to understand the messages that nature is sending through the millions of tiny changes that are beginning to cause major shifts in global ecosystems. The IAEA and its partners have access to nuclear tools that have allowed them to measure these changes with great precision for over 50 years. The resulting datasets and reference materials, which have been accumulated by thousands of scientists in hundreds of laboratories, are now fully available online to the public and policymakers with the aim of developing effective conservation policies.

Laboratories around the world can be assured of their performance and their degree of accuracy by directly comparing their results with known standard reference materials that have been carefully measured and quantified. This is why easy access to reference standards is essential for a quantitative and fair assessment of a laboratory's proficiency.

Since the early 1960s, the IAEA has developed and made available a large collection of reference materials for laboratories worldwide to assist them in quality assurance for results they obtained using nuclear analytical techniques. These reference products pertain to reliable and accurate results in studies of environmental radionuclides, stable isotopes, trace elements and organic contaminants. They are available on the IAEA website through the newly upgraded IAEA Reference Products for Environment and Trade web portal, which offers enhanced repository data, improved search capacity and an online system for purchasing certified reference materials.

"The modernized website makes it easy to navigate through a comprehensive range of reference products available to our external customers, which helps them to improve and maintain their analytical excellence," said Manfred Groening, Head of the IAEA's Terrestrial Environment Laboratory.

Organic substances obtained from a wide range of materials, such as fish and oyster powders, rice, grass, spruce needles, moss, cellulose, ancient and modern woods, soil and marine sediment, seawater, distilled water, powdered rock materials (such as obsidian), carbonates, and pure chemicals and gases, are processed at the IAEA Environment Laboratories under strictly controlled conditions. They serve as reference materials for scientific purposes to help laboratories investigate and protect the environment.

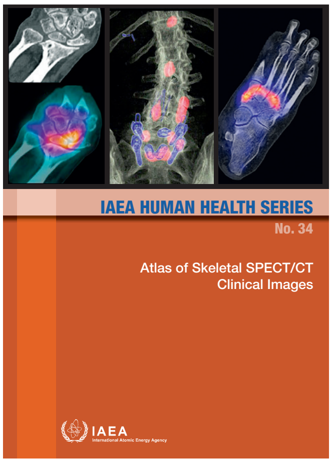
"Regular participation in IAEA proficiency tests and access to reference materials for measurements of radionuclides in the environment are very important to us," said Hamid Marah, Scientific Director of Morocco's National Centre for Nuclear Energy, Sciences and Technology (CNESTEN). "This access helps our research centre to demonstrate its analytical excellence and supports our activities to ensure the well-being of the public."

Over 90 different reference materials for radionuclides, stable isotopes, trace elements and organic contaminants have been made available to the scientific community. Altogether, more than 2000 individual units of these reference materials are distributed to over 600 laboratories every year. In addition, 700 laboratories benefit annually from quality assurance services by receiving several thousand similar dedicated samples through IAEA proficiency tests free of charge, largely handled through the Reference Products for Environment and Trade web portal.

"The IAEA is the world's largest supplier of matrix reference materials for radionuclides. Some of these reference products, for example those characterized for stable isotope ratios, are at the highest metrological level as international measurements standards," said Groening.

The upgraded web portal will provide enhanced access to this library of reference materials so that laboratories worldwide can purchase specialized reference materials from the IAEA through a more user-friendly system, as well as register for accompanying proficiency tests. Annually, more than 1000 laboratories in over 70 countries make use of the registered services available through this dedicated system.

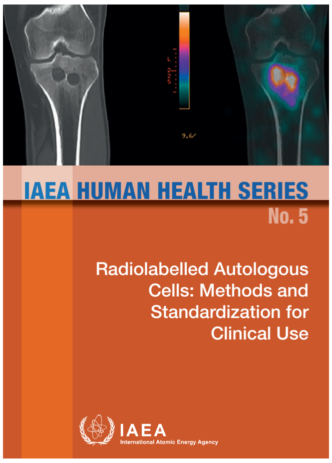
— By Jennet Orayeva and John Brittain



Atlas of Skeletal SPECT/CT Clinical Images

focuses specifically on single photon emission computed tomography/computed tomography (SPECT/CT) in musculoskeletal imaging, and thus illustrates the inherent advantages of the combination of the metabolic and anatomical components in a single procedure. In addition, the atlas provides information on the usefulness of several sets of specific indications. The publication, which serves more as a training tool than a textbook, will help to further integrate the SPECT and CT experience in clinical practice by presenting a series of typical cases with many different patterns of SPECT/CT seen in bone scintigraphy.

IAEA Human Health Series No. 34; ISBN: 978-92-0-103416-8; English Edition; 75.00 euro; 2016



Radiolabelled Autologous Cells: Methods and Standardization for Clinical Use

serves as a useful resource for nuclear medicine physicians, radiologists, radiopharmacists, pharmacologists and other researchers engaged with radiolabelling of autologous products for clinical application. It provides practical guidelines towards clinical work with radiolabelled autologous products and aims to streamline the variety of strategies that have evolved, for example, in the handling of radiolabelled red and white blood cells. The publication highlights the importance of the quality of radiolabelling services, provides advice on safety issues, and also addresses the use of other radiolabelled autologous products and their translation into the clinical environment.

IAEA Human Health Series No. 5; ISBN: 978-92-0-101310-1; English Edition; 55.00 euro; 2014

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