Coronavirus-related research and services at EMBL

Contents

Introduction

1. The molecular life sciences have a central role in delivering new treatments or vaccines against Sars-CoV-2. EMBL has re-purposed existing facilities to provide a range of direct research and support services, including in partnership with institutes in Member States.

2. This document provides a summary of EMBL coronavirus-related research and service activity as of 8 September 2020, and will be updated as additional projects receive necessary safety and scientific approvals.

Update highlights

3. EMBL scientists have established a robust protocol for the detection of coronavirus using next-generation sequencing, which can process more than 5000 samples in one run. The approach will be made available to the wider scientific community soon (see item 19).

4. Scientists at EMBL Heidelberg have been involved in the development of a microscopy-based assay for the semi-quantitative detection of SARS-CoV-2 specific antibodies in human sera. The approach has been applied in a study on the 'Prevalence of COVID-19 in children in Baden-Württemberg' (see item 20).

5. An international team of researchers, including EMBL-EBI scientists, are exploring how existing drugs can be repurposed to prevent SARS-CoV-2 from rewiring human proteins. They identified over 70 drugs that may be repurposed to treat COVID-19 patients. Clinical trials for six compounds have been launched or are in planning (see item 22).

6. EMBL scientists and colleagues have studied the structure of SARS-CoV-2 spike protein and observed an unexpected level of flexibility, as well as a protective coat of sugar molecules on the spike protein. The findings have important implications for the development of vaccines and therapeutics (see item 28).

7. Several COVID-19-related research projects have been summarised in preprints or published as open-access publications (see items 20, 22, 24, 27, 28).

8. EMBL has transitioned many physical courses and conferences to virtual offerings. The European Learning Laboratory for the Life Sciences offers two new virtual programmes for science teachers and students (see items 37 – 41).

TOP

Coronavirus-related research and services at EMBL

Calls to action

9. EMBL is asking its Member States for contacts to COVID-19 serology studies. EMBL-EBI, as part of the European COVID-19 Data Portal, has the means to store and share this type of data through the BioStudies database, and is interested in working with the community of serology data producers and users on minimal reporting standards to sort out privacy issues and maximise interoperability.

10. EMBL-EBI scientists are following with interest wastewater testing as a means to track the spread of coronavirus and consider establishing a data sharing group for this purpose. We encourage feedback from Member States on the extent of ongoing testing activities, to explore whether the development of shared reporting standards, data storage and data sharing infrastructures in a European context will be beneficial.

TOP

Services for Member States

11. Rapid data access, analysis and visualisation

    EMBL's European Bioinformatics Institute (EMBL-EBI) launched the COVID-19 Data Platform in conjunction with the European Commission, the European Open Science Cloud, ELIXIR and a number of partner institutions across Europe. The aim is to enable rapid access to datasets and results pertaining to the SARS-CoV-2 pandemic, which will accelerate research and support the development of diagnostics, therapeutics and effective vaccines.

    The Platform consists of three connected components:
    - Data Hubs which organise the collection of sequence data from the outbreak and provide open data sharing for the European and global research communities
    - Federated European Genome-phenome Archive (EGA) which supports controlled access sharing of human COVID-19 biomolecular and phenotypic data
    - COVID-19 Data Portal, which brings together, and is continuously updated with relevant COVID-19 datasets and tools.

    In the first four months of its existence, the COVID-19 Data Portal has recorded close to three million web requests by around 73,000 users from more than 175 geographical locations, including most of the European countries. The COVID-19 Data Portal currently has 15,000 viral sequences, over 800 host sequences and 144,000 publication records, and its functionality is steadily improved by integrating additional data resources. We are looking to extend specifically into serology data and potential wastewater tracking.

TOP

Coronavirus-related research and services at EMBL

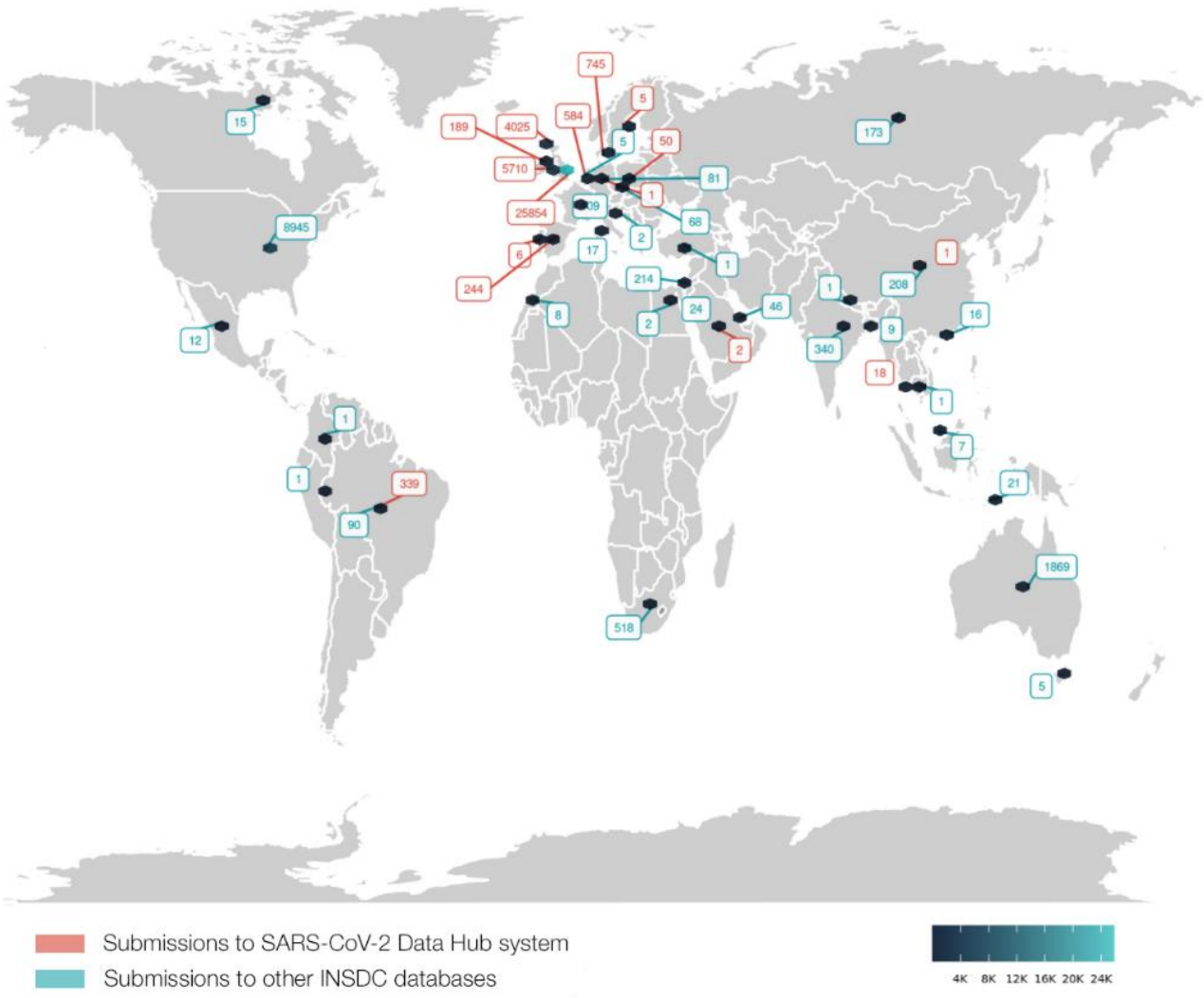

Figure 1*: World map of raw viral data submissions. Red boxes indicate data mobilised through the SARS-CoV-2 Data Hubs. Date: 25 August 2020.*

This activity enables the coordination of viral genome sequence data across Europe, and globally via International Nucleotide Sequence Database Collaboration. A specific feature offered to our Member States is the provision of support for setting up Data Hubs where viral genome sequence data can be coordinated (e.g., from a particular nation) with controlled public release. So far, we have engagement on Data Hubs from 18 Member States, Associate Member States, and Prospect Member States.

Many EMBL-EBI data resources, such as the Protein Data Bank in Europe (PDBe), UniProt, the Electron Microscopy Data Bank, RNAcentral, ChEMBL, PRIDE and Ensembl, have released dedicated datasets and tools for SARS-CoV-2 research.

Data from these specialised platforms are accessible directly through the COVID-19 Data Portal and allow for more in-depth analysis of specific data types.

EMBL-EBI's Europe PubMed Central (Europe PMC) open science platform has begun to index COVID-19 preprints and includes information on COVID-19-related funding grants to make the information more widely available and accessible.

Note: Correct at 8 September 2020. Updates will be provided as additional activity commences

Coronavirus-related research and services at EMBL

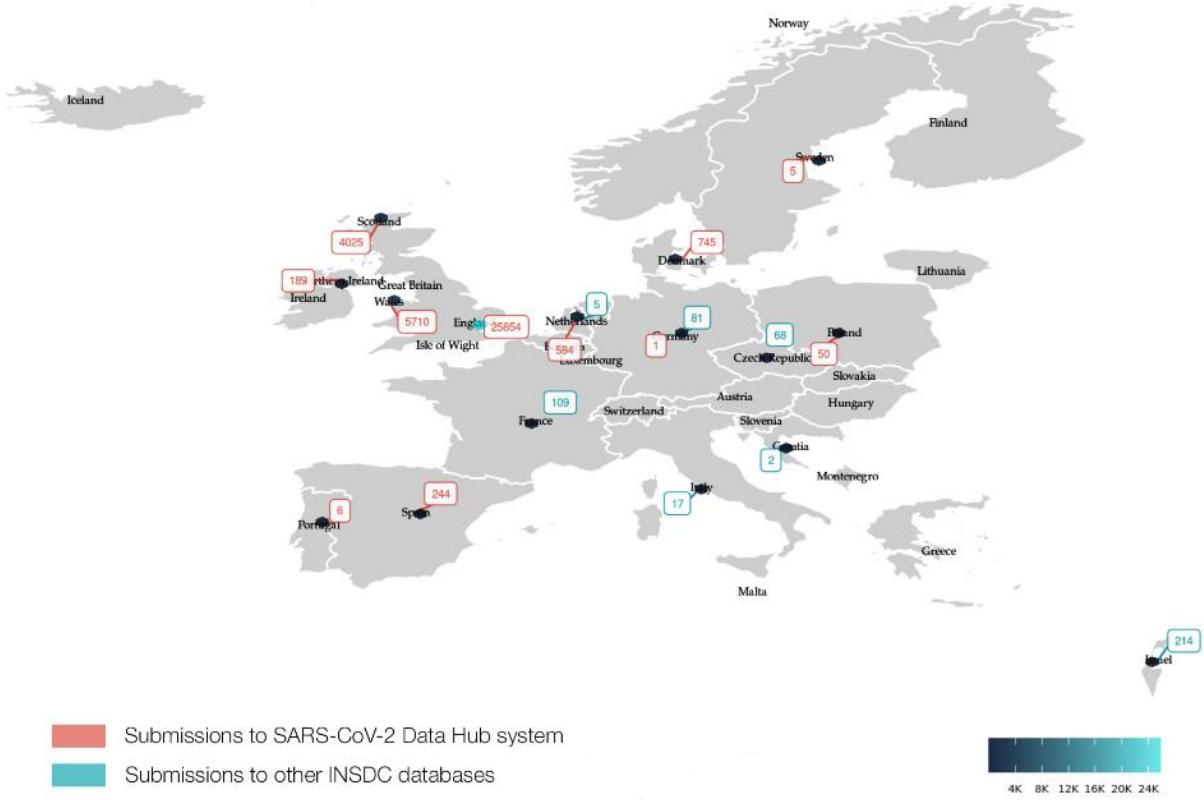

Figure 2: European contributions of raw viral sequence data, with red boxes showing data mobilised through the SARS-CoV-2 Data Hubs. Date: 25 August 2020.

12. Epidemiological situational awareness

    EMBL-EBI can also provide connections to leading infectious epidemiology groups for situational awareness of the outbreak to enable open and scalable infectious epidemiology analysis that can be fed by national and regional information. Additional national-level secure data feeds may also be available should EMBL Member States wish to pursue this option.

    EMBL has joined the Versatile Emerging Infectious Disease Observatory (VEO) consortium, an EC-funded international collaboration of 20 research institutions and universities to investigate outbreak scenarios and develop new methods to classify the risk and impact of future outbreaks.

13. Human genetic information

    EMBL-EBI is coordinating human (host) genetic information on the infection and response to COVID-19, via the Europe-wide federation of the European Genome Phenome Archive (EGA), which is a joint project from EMBL-EBI and the Centre for Genomic Regulation (CRG).

    To date the EGA has processed three submissions totalling 2.75 terabytes of data, which are now fully available for access requests and part of the COVID-19 Data Portal. The Helpdesk team continues to provide expedited support to a handful of ongoing submissions and we expect these submissions to continue to increase in the coming weeks.

Coronavirus-related research and services at EMBL

14. Deciphering the genomics behind COVID-19
    EMBL is providing expertise in establishing IT infrastructures to support the collection, distribution, and analysis of genomic data from COVID-19 patients, as part of the German COVID-19 OMICS Initiative (DeCOI) involving more than 20 universities and research institutes. DeCOI brings together experts in genomics, bioinformatics, and national data infrastructure initiatives.

    Combining the data that will be generated in large clinical studies across Germany and Europe will be necessary to determine the influence of our genes on coronavirus infections. Data generated through DeCOI will be rapidly shared with the worldwide scientific community, for example through the different components of the COVID-19 Data Platform.

15. Comorbidity risk assessment
    EMBL-EBI can provide Member States with the TensorCox software and necessary operational expertise to perform COVID-19 comorbidity risk assessments, potentially using all health records from across a country (if accessible). The software has been successfully run on datasets of six million individuals and is expected to be able to scale to 100 million people.

    The software would need to be run in a secure data environment nominated by the EMBL member state, for example in a national facility.

16. Re-opening Structural Biology services at EMBL Hamburg and EMBL Grenoble
    EMBL has re-opened the High-Throughput Crystallisation (HTX) Lab at Grenoble to provide access to a fully automated protein-to-structure pipeline. Researchers are able to send their samples to the facility and to access their results from their desktop, using the Crystallographic Information Management System (CRIMS).

    CRIMS is able to communicate with the European Synchrotron Radiation Facility (ESRF) synchrotron in Grenoble and the PETRA III synchrotron in Hamburg, to support automated and remote X-ray data collection.

    Together with ESRF, EMBL has restarted the activities of the Joint Structural Biology Group in Grenoble to support coronavirus-related projects. A new initiative will allow users to be granted access to the HTX lab at EMBL and to a macromolecular crystallography (MX) beamline at the ESRF with a single project proposal. The initiative will enable a streamlined process through crystal production, testing, and data collection. The high automation of HTX and the MASSIF beamline are unique and will be very valuable to support structural biology projects in conditions of confinement.

    At EMBL Hamburg, the Sample Preparation and Characterisation (SPC) Facility has reopened to support scientists working on COVID-19 research. The SPC Facility is one of the best equipped facilities in Europe and is therefore in high demand from external users for COVID-19 projects.

    In collaboration with DESY, Hamburg University, and the Heinrich-Pette-Institut (HPI), the SPC Facility has performed biophysical characterisation and optimisation experiments on two SARS-CoV-2 proteases (MPro and PLPro) and two non-structural proteins (nsp7+8) to support structural studies.

    Data on MPro protein crystals, obtained by collaborators at DESY, have been collected at the DESY and EMBL X-ray crystallography beamlines. Both EMBL Hamburg beamlines are also operating for remote user access.

Also at EMBL Hamburg, the small-angle X-ray scattering (SAXS) P12 beamline has resumed its activity as a Structural Biology service and implemented fast-track approval for COVID-19-related projects. So far, seven internal and external projects were conducted (see item 30).

17. Re-opening the cryo-EM service platform at EMBL Heidelberg
    To help the scientific community advance essential coronavirus research projects, EMBL reopened its cryo-EM service platform at EMBL Heidelberg during the shutdown of the Heidelberg site from mid-March to beginning of May 2020.

    EMBL experts carried out data collection in close consultation with users and performed cryo-electron tomography studies on viral particles that led to a manuscript recently published in Science (see item 28). Since partial reopening of EMBL Heidelberg in May 2020, service is no longer restricted to corona virus research and all users can send their samples to the cryo-EM service platform.

18. Producing proteins for coronavirus research
    Testing samples for coronavirus requires enzymes – proteins that perform a specialised task. The Protein Expression and Purification Core Facility (PEPCF) at EMBL Heidelberg has started to produce these enzymes using bacteria as host organisms. This allows colleagues at EMBL to develop new coronavirus testing methods (see item 19), and the newly developed workflows are currently being summarised in a joint manuscript.

    PEPCF is also providing enzymes to colleagues at the Zentrum für Molekulare Biologie der Universität Heidelberg (ZMBH), and the protocols and expression constructs are being shared with other academic groups as well.

    PEPCF has successfully produced the SARS-CoV-2 spike protein and its receptor-binding domain, the human ACE2 receptor, the viral Nsp5 protease and Nsp12 catalytic subunit of the viral polymerase, providing these proteins to several other coronavirus-related research projects at EMBL, to assist the development of new strategies to fight the virus.

TOP

Research

19. New methods to scale up coronavirus testing
    EMBL Heidelberg is contributing to a community effort involving partners at Heidelberg University. A pilot project is under way to develop large-scale testing methods, using liquid handling robots and DNA sequencing machines.

    The team has established a robust protocol for the detection of coronavirus using next-generation sequencing, which can process more than 5000 samples in one run. Most of the assay has been successfully automated and optimised to use almost exclusively non-proprietary reagents and in-house produced enzymes. The scientists are currently preparing a protocol to make the approach available to the wider scientific community. In future, this could help scientists and clinicians to regularly test large parts of the population to avoid the further spread of the virus when lockdowns are relaxed.

Coronavirus-related research and services at EMBL

20. Developing an imaging-based antibody screening method to perform clinical immunity studies
    Scientists at EMBL Heidelberg have been involved in the development of a microscopy-based assay for the semi-quantitative detection of SARS-CoV-2 specific antibodies in human sera. By providing high-throughput image processing technology, the scientists enabled the semi-automated detection of antibodies against the entire viral proteome.

    The approach is summarised in a preprint and has been applied in a study on the 'Prevalence of COVID-19 in children in Baden-Württemberg', which analysed the co-occurrence of SARS-CoV-2 infections in children and their parents and was jointly conducted by the University Hospitals in Heidelberg, Tübingen, Ulm, and Freiburg. All raw images and processed data have been made freely available via EMBL-EBI's BioImage Archive.

21. Identifying how potential COVID-19 drugs work
    EMBL researchers are using a technology called thermal proteome profiling, which can systematically identify targets for potential drugs in living cells. This will help scientists to quickly propose efficient drugs or drug combinations to treat COVID-19, which are urgently needed until a vaccine is developed and made available globally. The project relies on services provided by EMBL's Proteomics Core Facility.

22. Repurposing existing drugs to prevent SARS-CoV-2 from rewiring human proteins
    An international team of researchers has analysed how SARS-CoV-2 hijacks the proteins in its target cells. One study, in which EMBL-EBI scientists took a leading role, was published in *Cell*. It shows how the virus shifts the cell's activity to promote its own replication and to infect nearby cells. The scientists also identified seven clinically approved drugs that could disrupt these mechanisms.

    Clinical trials for six compounds have been launched or are in planning to assess their potency and safety in treating COVID-19 patients. The study has received wide attention in the media, including articles from the San Francisco Chronicle, BBC Mundo, and The Financial Times.

    In another study, published in *Nature*, the scientists investigated the interactions between viral and human proteins. They identified 66 SARS-CoV-2-interacting human proteins for which 69 drugs already exist or are under development. These drugs may be repurposed to treat COVID patients as well.

    EMBL-EBI scientists continue to be heavily involved in follow-up work and are about to submit a third manuscript, in which they compare how SARS-CoV-1, SARS-CoV-2, and MERS differ in using human proteins for their replication.

23. Detecting SARS-CoV-2 antibodies
    EMBL researchers are developing a test that can diagnose whether someone has been infected by SARS-CoV-2 in the past. The test is not intended as a clinical diagnostic but instead to support scientific and epidemiological studies.

24. Exploring synthetic antibodies to stop coronavirus
    Scientists working at EMBL Hamburg and their collaborators at Karolinska Institutet Stockholm have identified and structurally analysed synthetic antibodies – known as nanobodies – that bind to a surface protein of the novel SARS-CoV-2 coronavirus and prevent viruses from infecting cells *in vitro* (neutralisation). The scientists further improved the binding strength of the selected nanobodies by generating derivatives, increasing their neutralisation efficiency more than 300-fold.

The results have been made available in a preprint and submitted for publication (under review). In the future, nanobodies have the potential to be used as compounds to stop SARS-CoV-2 from infecting humans, or as tools in coronavirus diagnostic tests.

25. Identifying neutralising antibodies against SARS-CoV-2
EMBL scientists will use droplet microfluidics techniques to screen blood serum from recovered COVID-19 patients for neutralising antibodies that could potentially stop the infection before it enters the cell.

Collaborators at the University of Bergen will carry out validation experiments on the nature of the antibodies detected. The work could eventually contribute to targeted treatments for COVID-19 and also enable the identification of related neutralising antigens that could support vaccine development.

26. Taking a closer look at infected cells to better understand COVID-19
Little is known about the mechanisms used by coronavirus to infect and destroy its target cells in humans. To better understand the changes in cell structures occurring in cells infected by SARS-CoV-2, the Department of Infectious Diseases at Heidelberg University Hospital shared samples of infected human lung cells with a team of EMBL electron microscopy (EM) experts.

EMBL scientists performed a full study of infected cells, including transmission electron microscopy, electron tomography, and focused ion beam scanning electron microscopy (FIB-SEM) of cells at different time points post-infection. The analysis revealed the role of cellular organelles in virus replication and virion formation and identified structures in cells that undergo changes after infection with the virus. The results of this collaborative work will be a stepping stone to support the development of new treatments against COVID-19.

27. Understanding how SARS-CoV-2 behaves in the gut
Scientists at EMBL, the German Cancer Research Center (DKFZ), and Heidelberg University Hospital are studying how the novel coronavirus behaves in the gut. By combining advanced imaging and sequencing technologies to study coronavirus in human intestinal cells and organoids – lab-grown clusters of cells that develop features of our small intestines – the scientists found that intestinal epithelial cells fully support the SARS-CoV-2 replicative lifecycle.

They also observed a strong, type III interferon-mediated immune response upon viral infection in these cells, which efficiently reduced virus replication and production. The work, which has been summarised in a preprint and published in *Cell Reports*, fills gaps in our understanding of SARS-CoV-2 epidemiology and identifies the gastro-intestinal tract as an active site of SARS-CoV-2 replication.

In a follow up study, the scientists have performed single-cell RNA sequencing experiments on infected cells (manuscript under preparation).

28. Studying the structure of SARS-CoV-2 spike protein
Scientists at EMBL Heidelberg, the Max Planck Institute of Biophysics, the Paul Ehrlich Institute, and Goethe University Frankfurt/Main have employed cryo-electron tomography and molecular dynamics simulations to study the structure of SARS-CoV-2 spike protein on viral particles. They observed an unexpected level of flexibility within the spike, which may allow the protein to scan host cell surfaces.

They also found a protective coat of sugar molecules on the spike protein, which hides it from antibodies, which has important implications for the development of vaccines and therapeutics. The results were made available in a preprint and as a publicly available dataset, and have recently been published in *Science*.

29. Understanding the SARS-CoV-2 infection cycle
    Using thermal proteome profiling (see item 21) and phosphoproteomics, EMBL scientists aim at better understanding the infection cycle of the novel coronavirus. The scientists have already profiled the time-course of SARS-CoV-2 infection using thermal proteome profiling and are now performing follow-up experiments to see whether identified proteins are relevant targets for preventing coronavirus infections.

30. Using small-angle X-ray scattering to study the structure and interaction of SARS-CoV-2 molecules
    Researchers at EMBL Hamburg are studying COVID-19-related molecules by exposing them to high-brilliance X-ray beams, using biological small-angle X-ray scattering (SAXS). SAXS makes it possible to reconstruct the 3D shapes of crucial molecular units in a cell or virus.

    The technique was used to determine the structure of the viral receptor binding domain when bound by synthetic antibodies (see item 24). The research is part of a global effort by scientists to elucidate the structural organisation of SARS-CoV-2 proteins, identify key antibodies, and pinpoint molecular drug targets to hopefully halt the virus in its tracks.

31. Mechanistic insights into SARS-CoV-2 biology
    Scientists at EMBL Grenoble are combining X-ray crystallography, cryo-electron microscopy, nuclear magnetic resonance, and small-angle X-ray scattering to try to solve some of the puzzles of the novel coronavirus' molecular mechanics. They are studying several viral key targets, such as the virus's replication machinery and the protein the virus uses as a pair of molecular scissors to set other viral proteins free.

    Their synergistic research efforts aim to dissect key mechanistic aspects of coronavirus molecular machines and potentially accelerate the development of new antivirals to contain the pandemic.

32. Editing the mouse genome to study SARS-CoV-2 infection
    To study how SARS-CoV-2 infects cells, researchers can use mice that have had their genome modified so that they express a human version of a protein called ACE2 – the receptor that binds the SARS-CoV-2 spike protein and allows the virus to enter the cell. However, the transgenic mice currently available do not show the full disease spectrum observed in human patients.

    The Gene Editing and Embryology Facility (GEEF) at EMBL Rome is generating a sophisticated transgenic mouse line that could help to solve this problem. Instead of adding artificial copies of human ACE2, the scientists subtly edit the mouse version of the gene so that the protein it produces is like the human version only at critical points where it interacts with the SARS-CoV-2 spike protein. Initial data indicate the successful editing of the ACE2 gene at the first critical site; once confirmed, the other critical points will be targeted.

33. Silencing the SARS-CoV-2 receptor with epigenetic modifications
    Scientists at EMBL Rome have recently developed a new version of a CRISPR molecular tool used for epigenome editing, making it smaller and easier to deliver into cells. This tool is able to cause targeted epigenetic modifications of specific genes in specific cell populations.

The scientists currently optimise this tool in mice to target airway cells that express the ACE2 protein. Once directed to these specific cells, the editing system is able to cause epigenetic modifications that temporarily silence the expression of ACE2.

The expected outcome is to block the entry route for the virus and make cells resistant to SARS-CoV-2 infection. The project will investigate the wider potential of epigenetic editing as a general strategy for future prevention or treatment options. It has been featured on Technologynetworks.com in an interview with EMBL group leader Jamie Hackett.

34. Using data science to help our fight against SARS-CoV-2
EMBL has launched a diverse set of data science projects on COVID-19, including exploration of host genetics, drug repositioning for COVID-19 treatment, protein-protein interactions to better understand the operation of the virus, viral RNA biology, and single cell genomic analysis.

    Many of the research projects mentioned above apply data science approaches. EMBL-EBI researchers have also been involved in recently published studies that explore computational strategies to combat COVID-19 and analyse the perils of ignoring metadata standards when reporting COVID-19-related data.

35. Helping researchers identify host proteins used by coronavirus
EMBL scientists have created the RBPbase database, which stores information on more than 4,000 proteins that have been identified as RNA-binding proteins (RBPs) across multiple studies. RNA viruses, such as SARS-CoV-2, require cellular RBPs as host factors to create more copies of themselves and influence cellular functions.

    RBPbase will help researchers worldwide to identify candidate proteins in infected cells as coronavirus-interacting RBPs. This may lead to a better understanding of how SARS-CoV-2 multiplies in cells, and may enable the design of novel therapeutic strategies.

36. Distinguishing coronavirus genome mutations from inadvertent errors
Scientists at EMBL-EBI have performed a large-scale analysis of over 4,700 SARS-CoV-2 genomic sequences. They found that many of the apparent most interesting changes in the SARS-CoV-2 genome that have been reported so far are likely to be technical artefacts, rather than biological mutations.

    Based on their analysis, the EMBL scientists and their colleagues developed a set of recommendations for the analysis of SARS-CoV-2 genomic data. This will help other researchers to interpret SARS-CoV-2 genomic sequences and ensure the mutations they identify are real. The recommendations are updated regularly, and are freely available via an online epidemiology forum.

TOP

Coronavirus-related research and services at EMBL

Training and courses

Past activities

37. EMBL has transitioned many physical courses and conferences to virtual offerings, following the success of the initial virtual conference, the EMBO | EMBL Symposium: The Four-Dimensional Genome at the end of March. So far five conferences / symposia and five courses have been offered online by the EMBL International Centre for Advanced Training (EICAT) with the Course and Conference Office (CCO) and EMBL-EBI Training, which attracted a total of 2209 participants of over 100 nationalities residing in over 80 countries, including 98 virtual speakers. Twelve additional virtual conferences and eight more courses have been confirmed for 2020 as listed under item 41.

    External Training has also launched a new online learning platform, 'EMBL eCampus', implemented a virtual social programme, and offer fee waivers and childcare grants for virtual events.

38. EMBL hosted the Virtual EMBL Conference: SARS-CoV-2: Towards a New Era in Infection Research on 3 July, which brought together leading experts in virology, infectious disease pathogenesis, structural biology, molecular and cellular biology, immunology, drug discovery and resistance, vaccinology, data science, and epidemiology.

    The speakers presented latest findings from their research on SARS-CoV-2 and other viruses, showed first epidemiologic data on the ongoing pandemic, and addressed current limitations in our scientific understanding of emerging pathogens. They highlighted the importance of basic research, collaboration, and data sharing in containing the SARS-CoV-2 pandemic, and discussed opportunities to improve the response to pandemics in future. Many of the presentations have been made freely available online.

Upcoming activities

39. EMBL is hosting the Virtual Conference: The impact of the COVID-19 crisis on women in science: Challenges and Solutions on 9 September, and the EMBL Science & Society Programme has initiated a new seminar series 'Infectious Disease & Society'.

40. The European Learning Laboratory for the Life Sciences (ELLS) offers two new virtual programmes for science teachers and students, starting in October 2020. The virtual formats will increase our capacities to allow more students and teachers to take part in EMBL's educational activities.

    The aim of the EMBL Virtual School Visit programme is to make life sciences come alive in classrooms. Groups of secondary school and high school students will be able to connect in real time with EMBL scientists, hear about their research, discover career options in the life sciences, and experience an interactive visit to EMBL's facilities and laboratories. Offering virtual visits free of charge, in a flexible format, and in different languages will improve accessibility and help to reach a broad range of participants across member states.

    The first virtual learning lab 'Introducing your microbiome', a free training course for secondary school science teachers, will run from 2 November to 7 December 2020. Its modular structure enables teachers to attend outside working hours. The course will provide an overview of current human microbiome research and introduce bioinformatics as a tool in research.

Coronavirus-related research and services at EMBL

41. Further confirmed virtual conferences and courses over the next months include:

3–5 September:	EMBO Workshop: Chemical Biology 2020
9 September:	The impact of the COVID-19 crisis on women in science: Challenges and Solutions
11–18 September:	EMBL Course: Liquid Biopsies
14–16 September:	EMBO | EMBL Symposium: The Molecular Basis and Evolution of Sexual Dimorphism
28 Sept – 2 Oct:	EMBL Course: Mathematics of Life: Modelling Molecular Mechanisms
28 Sept – 5 Oct:	EMBL Course: Genome Engineering: CRISPR/Cas from Cells to Mice
30 Sept – 2 Oct:	EMBL Conference: Molecular Mechanisms in Evolution and Ecology
7–9 October:	EMBO | EMBL Symposium: The Complex Life of RNA
8–9 October:	EMBL – Case Summit: Advancement Summit for Life Sciences
12–16 October:	EMBL Course: Summer School in Bioinformatics
13–15 October:	EMBO | EMBL | HHMI Conference: Gender Roles and their Impact in Academia
19–23 October:	EMBL Course: Computing Skills for Reproducible Research
21–24 October:	EMBO | EMBL Symposium: Organoids: Modelling Organ Development and Disease in 3D Culture
28–30 October:	EMBO Workshop: Neuroepigenetics: From Cells to Behaviour and Disease
2–6 November:	EMBL Course: Metagenomics Bioinformatics
2 Nov – 7 Dec:	ELLS Learning Lab: Introducing your microbiome
4–5 November:	21st EMBL Science and Society Conference: Our House is Burning: Scientific and Societal Responses to Mass Extinction
16–19 November:	EMBL Conference: From Functional Genomics to Systems Biology
23–27 November:	EMBL Course: Structural Bioinformatics
24 November:	EMBL Technology Day: Extracellular Vesicles: From Biology to Biomedical Applications
27–28 November:	22nd EMBL PhD Symposium: The Roaring 20s: A New Decade for Life Sciences
4–10 December:	EMBL Course: Design Thinking: Approaches for Chronic Disease Management
6–8 December:	EMBO Workshop: In situ Structural Biology: From Cryo-EM to Integrative Modelling

TOP