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UNCOVERING THE SECRETS OF THE AMAZON

DR GUILHERME OLIVEIRA, BASED AT THE **VALE INSTITUTE OF TECHNOLOGY** IN BRAZIL, LEADS A TEAM WORKING WITH AMAZONIAN BIODIVERSITY. TOGETHER, THEY CONDUCT GENOMIC ANALYSIS ON PLANTS, ANIMALS AND MICROORGANISMS IN A HABITAT THAT IS EXTREMELY DIVERSE AND STILL RELATIVELY UNKNOWN

TALK LIKE AN ENVIRONMENTAL GENOMICS AND BIOINFORMATICS TECHNOLOGIST

BIOINFORMATICS – a subdiscipline of biology and computer science concerned with the acquisition, storage, analysis and dissemination of biological data

DNA SEQUENCING – the process of determining the order of the four chemical bases that make up a DNA molecule

ENVIRONMENTAL DNA (eDNA) – DNA from environmental samples, such as soil and water

GENOME – the set of genes contained in a cell

GENOMICS – the branch of biology focusing on genomes

DNA BARCODING – a method of species identification using a short section of DNA

TAXONOMIST – a scientist who specialises in the classification of organisms

GENE EXPRESSION – the process by which information stored in DNA is activated to produce proteins and other molecules

GENE FLOW – the transfer of genetic material from one population to another

ENVIRONMENTAL STRESS – environmental conditions (natural or caused by humans) that can have a negative impact on species

NEXT-GENERATION SEQUENCING (NGS) – technology that allows detailed and fast identification of differences in DNA

NUCLEOTIDE POLYMORPHISMS – variations in DNA sequences among individuals

TRANSCRIPTOMICS – the study of the complete set of RNA transcripts produced by the genome – under specific circumstances or in a specific cell – using high-throughput methods such as RNA sequencing (RNAseq)

TROGLOBITIC – a cave-dwelling species

The Amazon is an area that spans eight countries: Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana and Suriname, as well as French Guiana, which is an overseas territory of France. Its rainforest covers about 40 percent of Brazil's total area and is home to an estimated one in every 10 species found on Earth, which gives you an idea of its enormous size and the significant diversity contained within it.

The Amazon is one of the most remarkable areas on our planet and its vastness and the richness of life it contains are just two of the reasons why it is of keen interest to scientists across a range of disciplines. The rainforests situated in the Amazon contain between 90 and 140 billion tonnes of carbon, which helps to stabilise the global climate. Protecting this rainforest and understanding more about the life located within the Amazon region is of particular importance to researchers like Dr Guilherme Oliveira.

Guilherme is the Scientific Director of the Vale Institute of Technology – Sustainable Development. His field of research is environmental genomics and bioinformatics, which has seen him trawl through and across the Amazon to conduct genomic analysis of plants, animals and microorganisms. The chief aim of his research is to understand more about this beautiful region and uncover some of its biological mysteries.

WHAT IS GUILHERME WORKING ON SPECIFICALLY?

Guilherme's team participates in CABANA (Capacity Building for Bioinformatics in Latin America), a programme strengthening the field of bioinformatics in Latin America. CABANA involves an international consortium of organisations – one in the UK and nine in Latin America – and is focusing on the three areas of communicable disease, sustainable food production and protection of biodiversity, with Guilherme focusing on the latter. His research uses DNA sequence data with the aim of describing and protecting biodiversity. However, alongside this, Guilherme is working on projects relating to species of importance to agriculture and health.

HOW DOES GUILHERME CONDUCT HIS RESEARCH?

Guilherme's team employs DNA barcoding, which uses a short part of the genome of a given species to establish a sequence that is unique to it. "We first determine the sequence for a specimen, identified by a taxonomist, in a particular group. We can capture the taxonomic knowledge in the DNA sequence and, for future specimens, we can identify species by sequencing," explains Guilherme. "This is an enormous advantage as we can produce DNA sequences and analyse them on a large scale, while the taxonomist can optimise their time to generate other references or resolve difficult issues."

As with the barcodes that you find in supermarkets that identify a specific product, DNA barcodes identify a specific species, but while you scan a specific barcode in supermarkets, Guilherme and his team are able to use a sample – which can be water, soil, faeces or even air (known as environmental DNA or eDNA) – to identify a species.

Guilherme is often in the field gathering data. As the leader of the institute, he is interested in identifying new species (his group has identified thousands of genetic references of fauna and flora to date). DNA barcoding is important as specialists like Guilherme can ascertain whether what they are reviewing has ever been identified before. "For some of the studies, we will process the samples to identify variations, sequence the entire genome, determine which genes are expressed, or find out which proteins are being produced," says Guilherme. "Once the data is produced, the bioinformatics team takes over. The analysis is conducted by the bioinformaticians in collaboration with the biologists and all sequences are deposited in public databases and published in open access journals."

WHAT CAN MOLECULAR MARKERS TELL US ABOUT PLANT HEALTH?

By using DNA barcodes and eDNA, Guilherme and his team can monitor any given species in an environment. "We can observe where DNA that was previously observed is no longer detected, which can show that the environment has been disturbed in some way," explains Guilherme. "If we have deeper knowledge of a plant at the genomic scale, we are able to verify if the genetic diversity of the species is being eroded by nature. Such findings can point to the diminished capacity of a species to adapt to its environment. Furthermore, if we have studies of gene expression of the species, we can correlate that with environmental stress and use the gene as a marker for monitoring the health of a species."

WHAT HAVE GUILHERME'S STUDIES SHOWN, SO FAR?

One of Guilherme's key findings is related to gene flow in the Amazon. Gene flow is fundamental to evolution. In Brazil, legislation indicates that the conservation of a species requires the maintenance of the genetic diversity observed in nature; determining the gene flow is essential to understanding the health and status of species in the Amazon. One of Guilherme's studies has, for the first time, discovered that cave environments within the Amazon are connected underground. "We observed that populations of certain cave dwellers are the same across long distances," explains Guilherme. "This observation has contributed to how we perceive the iron cave systems in the Amazon. They were initially taken to be individualised caves, such as islands, but now we know that there is gene flow between troglobitic species."

By using landscape genomics to study a particular species, Guilherme and his team are able to understand more about how a species is structured and how gene flow occurs between populations. Such understanding is essential to determining whether genetic diversity is being maintained in the Amazon. If it is not, then there is cause for concern, as without diversity, a species could easily die out over time.

Guilherme, his team and others involved in the wider CABANA project are working to establish a new standard for biodiversity work that enables conservation while industrial activities occur. "While we do not participate in decision making, we are able to provide the best science to support any decisions, at the same time as creating educational resources for society," says Guilherme. "We all need to respect the environment and the Amazon is a vast genetic resource that is essential to local communities and their livelihoods."

DR GUILHERME OLIVEIRA

Scientific Director of Vale Institute of Technology – Sustainable Development, Brazil

FIELDS OF RESEARCH

Environmental Genomics, Bioinformatics

RESEARCH PROJECT

Conducting genomic analysis on plants, animals and microorganisms in the Amazon to understand more about this still relatively unknown area of the world

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ABOUT ENVIRONMENTAL GENOMICS AND BIOINFORMATICS

If environmental genomics can be thought of as a means of collating knowledge of organisms and ecosystems through analysis, then bioinformatics is the method by which scientists are able to make sense of the data. Although the two fields are distinct, they complement each other, as is shown through Guilherme's research.

While we live in an age where it appears that everything we can know is at our fingertips (one only needs to perform a search engine query to find the answer to a given question), environmental genomics and bioinformatics help to demonstrate how much there is that we do not know. The biodiversity that is found within the Amazon region is truly staggering – and it is remarkable to think that there are still places on Earth that remain unexplored – but Guilherme's group is working through the detection and identification of plants, animals and microorganisms to help us better understand the world in which we live.

WHAT DOES A TYPICAL DAY LOOK LIKE FOR GUILHERME?

As you can imagine, field work in the Amazon is tough – there are no smooth roads or easy access to the areas the team is working in, and the area they are looking at is vast (most of the work the team conducts is in an area of over 1.2 million hectares). The temperature and humidity of the area can also be problematic! "The Amazon has distinct seasons, and it can be extremely hot in the dry season and very wet in the rainy season," explains Guilherme. "Generally, we start work at sunrise as we need to be back by sunset, except for some of the bat work that has to be conducted at night. Despite the environmental challenges, the region is gorgeous, and I never miss an opportunity to be out in the field."

WHAT ADVICE CAN GUILHERME OFFER?

Guilherme emphasises the importance of having a multidisciplinary approach to your work – not just for those interested in following a similar path to him, but for research in general. "Having a multidisciplinary approach will enrich your life, irrespective of the career path you take, so get your boots dirty, do some field work, experiment in the lab, talk to ecologists and do some programming!" he says. "Then, dive into one of the areas you are most interested in. The world is not divided into scientific specialisations that don't cross over, so talk to as many different specialists as needed to get a broader view of the subject of your study. This will give you a better understanding of how your work is connected and develop your analysis."

EXPLORE A CAREER IN ENVIRONMENTAL GENOMICS AND BIOINFORMATICS

- The European Bioinformatics Institute website (**www.ebi.ac.uk**) has a lot of training materials and opportunities.
- The International Society for Computational Biology (**www.iscb.org**) is a great resource for computational biology.
- Guilherme says that the International Barcode of Life events are fantastic for DNA barcoding: **ibol.org**
- The Genetics Society is also very useful: **genetics.org.uk**
- **Salaryexplorer.com** has the average salary for a bioinformatics technician in Brazil as 93,000 BRL annually.
- According to **glassdoor.co.uk**, the average yearly salary for someone in the field of Bioinformatics in the UK is £40,000, while in the US, it is $90,000.

PATHWAY FROM SCHOOL TO ENVIRONMENTAL GENOMICS AND BIOINFORMATICS

Guilherme is a strong advocate for developing basic knowledge in the life sciences. He is also passionate about the benefits of learning basic computer programming skills, particularly as he believes these skills will become increasingly important in the future.

To begin a career as a bioinformatician, you will need a master's degree. However, you will not necessarily need a degree in bioinformatics for a master's; life sciences, computer science, maths, physics and engineering degrees are possible pathways. A PhD in bioinformatics, computational biology, genetics or genomics is generally required to engage in advanced research.

More information can be found at:
www.degreesandcareers.info/stem/bioinformatics

www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/genetics

Photo courtesy of Catherine Brooksbank, EMBL-EBI

ASK GUILHERME

WHO OR WHAT INSPIRED YOU TO BECOME A SCIENTIST?

As a child, I was enchanted by nature documentaries, in particular, those from Africa. As a biology student, many professors were a source of inspiration – my university had a very strong human diseases department, specialising in parasitic diseases, which is where I focused my studies. Once genomics became my focus, I established a research group at my previous home, the Oswaldo Cruz Foundation. However, nature was always on my mind. My role at the Vale Institute of Technology was the perfect opportunity as it was a chance to combine genomics and nature studies!

WHAT ASPECTS OF CONSERVATION AND BIODIVERSITY WILL THE NEXT GENERATION OF RESEARCHERS BE FOCUSING ON?

Lives and communities depend upon biodiversity; young researchers have a huge challenge to contribute to its conservation. They do not have much time, so I think that prioritisation is necessary. This should be based on the level of threat an environment or a species faces, or on how society will benefit. As a consequence, one may need to work on a species that is not necessarily the biggest, the most beautiful, or the most scientifically curious, but the one that is most threatened or that will enhance the lives of people who are most vulnerable.

HOW IMPORTANT ARE ENVIRONMENTAL GENOMICS AND BIOINFORMATICS IN THE CONTEXT OF CURRENT GLOBAL CHALLENGES?

The COVID-19 pandemic has highlighted how important genomics is. We need it to understand our world today, and bioinformatics is a tool to make good use of genomics data. Being able to utilise basic computer programming skills is key to improving our understanding of the data we gather, but I expect artificial intelligence will play an increasingly important role; it permeates much of what we do already, but it will soon become an essential tool in overcoming environmental challenges around the world.

WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS, SO FAR?

I am very proud to have established genomics and bioinformatics research groups at two different institutions. In one case, for the study of human infectious diseases and in the other, for the study of biodiversity. In both instances, I am certain we have produced works that have been important for the advancement of the field.

WHAT ARE YOUR AMBITIONS FOR THE FUTURE?

Looking ahead, I would like to be involved in revealing the hidden resources within Amazonian biodiversity. I firmly believe that the use of genomics will unlock tools for biodiversity conservation, new nature-based solutions, and products for the benefit of humanity, with the focus on the enhancement of the lives of traditional peoples.

GUILHERME'S TOP TIP

Every path is unique, but my advice is to trust people, ask for support and establish a strong network. Nobody constructs a career on their own.