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Brazilian scientists: much to learn from the microbial biofilm lifestyle (a resistant, resilient, well-orchestrated, and dynamic organization)

Cientistas brasileiros: muito a aprender com o estilo de vida do biofilme microbiano (uma organização resistente, resiliente, bem orquestrada e dinâmica)

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Abstract *In the present perspective, some parallels are drawn between a career as a scientist in Brazil and the ability of microorganisms to form a biofilm. Do these connections really exist? Definitely the answer is YES. Over billions of years, microbial biofilms have evolved in order to form a cohesive, well-structured, organized and dynamic community, which is characterized by its resistant/resilient profile to several environmental stressors. Adapting to constant change is a necessary attribute for survival and perpetuation of all live organisms, which are key signatures present in the hereditary molecule. Brazilian scientists are faced with many stressful situations along their journey in academia, which requires constant adaptability, reorganization and, above all, resilience. Can we take some lessons from what we know about the biofilm lifestyle developed by microorganisms? The answer is yes!*

Key words *Brazilian scientists, Education, Microbial biofilm, Resistant, Resilience, Adaptability*

Resumo *Na perspectiva atual, alguns paralelos são traçados entre a carreira de cientista no Brasil e a capacidade dos microrganismos de formarem biofilme. Essas conexões realmente existem? Definitivamente a resposta é SIM. Ao longo de bilhões de anos, os biofilmes microbianos evoluíram para formar uma comunidade coesa, bem estruturada, organizada e dinâmica, que se caracteriza por seu perfil de resistência/resiliência a diversos estressores ambientais. Adaptar-se a mudanças constantes é um atributo necessário para a sobrevivência e perpetuação de todos os organismos vivos, que são assinaturas-chave presentes na molécula de hereditariedade. Nesse sentido, os cientistas brasileiros se deparam com diversas situações estressantes ao longo de suas trajetórias na academia, exigindo constante adaptabilidade, reorganização e, acima de tudo, resiliência. Podemos tirar algumas lições do que sabemos sobre o estilo de vida do biofilme desenvolvido por microrganismos? A resposta é sim!*

Palavras-chave *Cientistas brasileiros, Educação, Biofilme microbiano, Resistente, Resiliência*

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Introduction

In recent years, the news has not been good for Brazilian scientists and educators. Never before has so little of the national resources been invested in education, science, technology and innovation[1-4]. To make matters worse, Brazilian scientists are being subjected to a witch hunt, with false news being published almost daily in different social media platforms. Nowadays, unorthodox and unethical methods of performing science and interpreting data are being used by charlatans, who exploit the general ignorance of the great mass of the population to disseminate untruths and unproven results which can ultimately provoke serious medical implications. Contrarily, well-designed experimental works, with controls and, above all, using ethics that are a prerequisite of the scientific methodology, are employed by rigorous scientists. Regrettably, however, these scrupulous regimes have been conveniently ignored by ill-informed and irresponsible deniers. Science in Brazil is under threat, but it will not succumb to ideological hijacking, because our country has a solid base of competent and committed researchers who are acutely aware of both their social and moral obligations.

In truth, science in Brazil is made up of heroes. These unsung and typically nameless champions dedicate their entire lives towards improving the health and prosperity of their fellow countrymen. However, the vast majority of the Brazilian population does not even know who they are, what they do, what they think and the genuine importance of their discoveries. It is a sad, but true, reality in our contradictory country. Here in the 21st century it seems somewhat unbelievable that most Brazilians consider scientific research to be something utopian, mysterious, mystical, ethereal. In essence, the media either simply do nothing to enlighten the masses or, worse still, feed misinformation. Brazil is a country of continental proportions (8.516 million km² area; ~213 million population), and with its many social and economic inequalities there is a massive logistical problem regarding the equal dissemination of knowledge across all regions. Our educators/researchers strive to resist the terrible conditions and restrictions that are imposed on them daily, which greatly hinder the full development of their skills and efficient utilization of their education. Restricting personal growth and professional development can be paralleled with the radical pruning of a fruit tree, stunting growth and curtailing the bearing of new fruit. However, resistance and resilience are the main weapons of our educators/researchers who are striving to attain a more just and egalitarian Brazil, and who also endeavor to fulfill the hopes and aspirations of thousands of young dreamers who will be the future pillars of our country.

I am a Full Professor in a Brazilian public university and I have spent my entire scientific career in public educational institutions. In this context, I feel obliged to return all of the public investment that was offered to me through the creation and transmission of knowledge to those who will succeed me and become the next generation of researchers and academics of our country. This is the endless cycle of life! However, to be a scientist in Brazil requires patience, resilience and a belief that the future will be brighter and will bring better conditions for us to develop our work and ensure the best training and nurturing of our successors. When will this future come for Brazilian scientists? Over the last number of years, research in Brazil has been experiencing shocks, a veritable roller coaster of emotions and numerous contradictions. Drastic cutbacks in funding, coupled with draconian working conditions, have severely eroded the foundations of our education system and have had a hugely negative impact on the expansion of Brazilian science! We live on crumbs, but even so we have managed to carry out robust research, with quality and international recognition. In fact, my personal impression is that we are more valued and recognized for our work abroad than here in our own country. Other countries stand proud of their scientific heritage but, alas, this does not seem to be the case in Brazil. In this context, we Brazilians should stand proud amongst nations as our country has birthed a plethora of World-renowned scientists. Legends, such as Oswaldo Cruz, Carlos Chagas, Paulo de Góes, Adolfo Lutz, Vital Brazil, Césare Lattes, José Leite Lopes, Duilia de Mello and many others, struggled with adversaries and conducted their research under primitive conditions. Undoubtedly, their discoveries have saved countless lives as well as contributed decisively to the implementation of the postgraduate and research system in our country.

Due to the competence of our researchers, we work miracles and transform the little and derisory budget into excellent final products that gain international recognition not only for their excellence but also for their global importance. However, we have never been so harassed, mistreated, devalued and disliked as we are now. Inevitably, we ask ourselves: why does science generate such

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much antagonism? Why is providing knowledge to society something that our leaders consider to be a threat? In developed countries, investing in education, scientific knowledge and innovation are focal points, the core of the issue and the transformation towards a society better prepared to face forthcoming storms. Scientific knowledge and the products generated with research/innovation allow a nation to have autonomy, leadership and sovereignty.

In the midst of this chaos and neglect can we find any positives? Whilst some others cannot see any enlightenment, I, the eternal optimist, always believe good experiences can evolve even (and maybe particularly) during times of crisis. In this context, this is why I have drawn some parallels about the situation of research in Brazil with biofilm formation by microorganisms, a structure considered resistant to several environmental stressors. This comparison was made because I have been learning from these microorganisms that adaptation to adverse conditions is essential for survival. Indeed, in this context it is no wonder that microorganisms have inhabited our planet for billions of years throughout which time they have been challenged by a multitude of powerful and destructive environmental forces. Their survival hinged on their ability to withstand and adapt. Will Brazilian scientists be able to withstand the adverse conditions that once again have been imposed on them – can they weather the storm? In response, maybe we should "think and act" as a powerful microbial biofilm organization.

Microbial biofilm

A biofilm is really a typical social cooperative in which communities of regimentally organized microorganisms attach to an inert or living substrate and shield themselves using a self-produced extracellular polymeric matrix, which works like an adhesive favoring cell-cell and cell-substrate interactions. Microorganisms growing in a biofilm present a variety of physiological advantages over their free-living (planktonic) counterparts[5]. Biofilms have been compared to multicellular organisms, in which cells differentiate with specialized functions and work together towards a common goal: survival!

Education and biofilm

In reality, the Brazilian scientists' community is a veritable biofilm organization. In this parallel, the most experienced scientists are at the base of this cellular organization, as they were the first to colonize an ecological niche. The pioneers spawned fruits, which are in the intermediate phase of this plural organism and are actually formed by a diversity of individuals who are at different stages of their careers, maturity and a capacity to generate more or less offspring. The uppermost layer is made up of younger individuals, who have a lot of energy, but who are still dependent upon the inner layers for full consolidation. This entire organism lives in perfect symbiosis, being protected by a layer of knowledge (herein, the extracellular matrix of the Brazilian scientific biofilm), in which the exchanges of ideas and experiences are one of the main purposes. This complex organism is nourished by nutrients present in the environment, which provide minimal and decent conditions for its support, survival and growth. However, in Brazil, the environment is very unstable, which generates insecurity and threatens sterility. Nutrients (e.g., salaries, scholarships and research funding incentives), necessary for the maintenance of the organism as a whole, are always scarce, conditions that prompt great instability in the Brazilian scientific biofilm. Despite being a structure of resistance, the Brazilian scientific biofilm suffers from several severe inconsistencies, which leads to its disarticulation. The disarticulation can lead to the death of immature individuals (or to the abandonment of their activities), or motivate them to colonize other environments, including abroad, for survival. The lack of minimal and encouraging conditions has led our brilliant but disenchanted young minds to leave Brazil, which can only be considered as a veritable brain drain. Undoubtedly, this hemorrhage will cost our scientific system and our society in the near future. Will the consolidated and more experienced individuals, located at the bottom of the biofilm, have the energy, motivation and strength to continue on? Many of these mature scientists have already been forced into retirement out of fear of the instabilities within the financial system. This has created another major problem for the organization as a whole: the loss of knowledge transfer from the old to the young.

Although the above-mentioned two scenarios are concurrently in motion in Brazil, a possible salvation pathway remains feasible: persistent cells, which are characteristic of all microbial biofilms. Persistent cells have an altered metabolism and, therefore, they are resistant to different physicochemical stressors. Persistent cells represent a small fraction of the microbial biofilm (~5%);

however, they are able to restart the cycle and form a new biofilm[5]. This process takes time and energy, but the system will eventually re-establish itself, generating fresh fruits and new environments that can be colonized.

Health system and biofilm

Similar to the educational system, health professionals in our country also fit this same comparison with the microbial biofilm, as they play a fundamental role under adverse working conditions. This situation was exposed during the pandemic caused by SARS-CoV-2, which revealed all the deficiencies in the Unified Health System (SUS) in Brazil. Public health professionals, like SUS members, needed to be resilient, as they carry out their activities in inhospitable environments, without the minimum conditions to carry out well-organized and dignified work, literally working miracles to sustain a structure in ruins due to the decades of neglect by Brazilian leaders. The health infrastructure is below the minimum needs of our population, which creates strong stress on SUS members, often generating health problems in these professionals that make their relevant activities unfeasible.

Conclusions

The research groups of Brazilian scientists are indeed real biofilms and are constantly fighting against adversity. Brazilian scientists need to learn to live (survive) as a biofilm, because only then, together and through energy and knowledge transfer, will retain the strength to carry our banner of education and scientific knowledge through the ages. As with gold and oil, knowledge itself is a currency. So, let's think and act like biofilms! Together, we are stronger and better able to withstand the onerous conditions plaguing the scientific scene in Brazil. There is hope for better days, for a prosperous and dignified future for our students. Long live the Brazilian scientific biofilm lifestyle!

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