Original article

Biotechnology in Cuba through the glass of the CIGB scientific output: a bibliometric approach

La Biotecnología en Cuba a través del prisma de la producción científica del CIGB: una aproximación bibliométrica

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ABSTRACT

Biotechnology has a strategic weight in the Cuban scientific output. In this context, the Center for Genetic Engineering and Biotechnology (CIGB) plays a fundamental

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role as the most productive scientific institute of the main Caribbean Island. In this work, the scientific production of this institution was assessed for the first time with an exhaustive bibliometric approach. A full bibliographic record was established, covering the period 1981-2022. Documentary analysis was applied, retrieving its editorial production, records in nine bibliographic databases and author profile pages at ResearchGate and ORCID. Foundational publishing milestones were addressed. Publishing dynamics alone and together with patent applications were studied, as well as its main properties and evolution. A total of 3667 institutional documents were studied, 66.6% of them indexed in mainstream databases, with an H index of 74. Institutional authors led the 69.45% of papers. The study confirmed CIGB as the top Cuban research institution attending to the number of works covered by Web of Science Core Collection and Scopus, only preceded by major universities. This center contributes 3.64-4.63% of national output in mainstream databases, 4.54-7.21% of cited documents and 6.09-8.10% of citations received by the Cuban output. After a continuous growing period, the output remained steady since the foundation of the Cuban Biotechnological and Pharmaceutical Industry (BioCubaFarma) in 2012, particularly in foreign indexed journals, and it was boosted since 2020 by the covid-19/sars-cov-2 pandemics. An updated ranking of Cuban institutions was also included, with CIGB in the top five ranking position.

Keywords: bibliometrics; national scientific output; genetic engineering and biotechnology; scholarly journals; scientific rankings; Cuba.

RESUMEN

La biotecnología tiene un peso estratégico en la producción científica cubana. En este contexto, el Centro de Ingeniería Genética y Biotecnología (CIGB) desempeña un papel fundamental como el instituto científico más productivo de la principal isla caribeña. En este trabajo se evaluó, por primera vez, la producción científica de esta institución con un enfoque bibliométrico exhaustivo. Para ello, se estableció un registro bibliográfico completo, durante el período 1981-2022. Se aplicó el análisis documental y se recuperó la producción editorial, los registros en nueve

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bases de datos bibliográficas y páginas de perfiles de autores en ResearchGate y ORCID. Se analizaron los hitos editoriales fundacionales, la dinámica de las publicaciones institucionales sola y junto con las solicitudes de patentes, así como sus principales características y su evolución. Se estudió un total de 3667 documentos institucionales, el 66,6 % de ellos indizados en las bases de datos convencionales, para un índice H de 74. Los autores institucionales lideraron el 69,45 % de los trabajos. El estudio confirmó al CIGB como la principal institución de investigación cubana en cuanto a número de trabajos incluidos en la *Web of Science Core Collection* y Scopus, solo precedida por las principales universidades. Se evidenció que este centro ha aportado entre el 3,64 y el 4,63 % de la producción nacional en las principales bases de datos; entre el 4,54 y el 7,21 % de los documentos citados; y entre el 6,09 y el 8,10 % de las citas recibidas por la producción cubana. Después de un período de crecimiento continuo, la producción se mantuvo estable desde la fundación de la Industria Biotecnológica y Farmacéutica Cubana (BioCubaFarma) en 2012, particularmente en revistas extranjeras indizadas, y se impulsó desde 2020 por la pandemia de la COVID-19/SARS-CoV-2. También se incluyó un *ranking* actualizado de las instituciones cubanas con el CIGB en la primera posición.

Palabras clave: bibliometría; producción científica nacional; ingeniería genética y biotecnología; revistas académicas; *rankings* científicos; Cuba.

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Introduction

Usually, universities are the main organizations that promote the research activities in all countries.[1] On very few occasions, a specialized institution is capable of leading the national scientific output.[2] This is the case of the Center for Genetic Engineering and Biotechnology (CIGB), which plays a fundamental role in the Cuban scientific output. The Cuban biotechnology and pharmaceutical industry (BioCubaFarma) has a strategic weight in the scientific production of the main Caribbean island,[3] and the CIGB is among its main institutions.

The scientific output of CIGB has been considered significant by several studies, either using esteem measures,[4] in nationwide bibliometric analyses,[5,6,7,8,9,10,11] or even considering its remarked patenting activity.[1,12,13] Previous studies have recognized CIGB as a leading institution in databases such as Scopus,[3] WoS and Medline.[14,15] Particularly, it has shown its highest quality indicators.[3] Articles published by CIGB have been among the top cited of the Cuban scientific output,[16,17] and some of their researchers have been included among the most productive and cited.[18,19] However, none of these studies had been focused specifically on the characteristics and evolution of the scientific output of the CIGB, which is one of the main objectives of the current paper.

Up to our knowledge, this is the first work directly addressing the scientific articles generated by CIGB since its foundation. It integrates the knowledge on its genesis, its institutional evolution and also documented information on the development of the academic publishing activity. More importantly, this work considers all the scientific institutional units involved, as well as the impact of organizational changes on its scientific output trends. For this purpose, a method proposed in a previous report for national level was applied at institutional level.[20] It combines the standard bibliographic approach with documentary analysis, and analyzing publications available not only at mainstream databases, but also publications from a scientific social network (i.e., ResearchGate) of unindexed sources. This is fundamental, considering that the output in mainstream databases only represent 60-70% of the entire Cuban output in foreign journals.[20]

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Theoretically, this work is framed within the quantitative studies of science and technology. In fact, the bibliometric analysis of institutional scientific performance is a strategic tool for research evaluation. This kind of studies contribute to the positioning and visibility of leading research institutions worldwide, as well as the development of Science and Technology policies.[21,22] For this purpose, a set of institutional bibliometric indicators have been previously implemented,[21] some of which were used in our research.

Methods

Information retrieval and processing

Scopus, Web of Science Core Collection (including Emerging Source Citation Index, ESCI; referred as WoS-CC from now on), Medline (PubMed), SciELO Citation Index (until 2020), CLASE and PERIODICA were the main bibliographic platforms used as data sources. Bibliographic records were retrieved until June 14th, 2022 otherwise stated, using and exhaustive search strategy described in the appendix. Documents were retrieved and bibliographic records were generated and added to an EndNote X9 library.

The Endnote library was then verified against, and increased from, documents and bibliographic data of other public information sources, mainly unindexed documents, including: *Curriculum vitae* of Dr. Pedro López Saura,[23] the CIGB digital yearbooks 2010-2014, and the lists of scientific publications declared at ResearchGate from 447 profiles of researchers with affiliation under 'Center for Genetic Engineering and Biotechnology'.[24] Profiles erroneously aggregated by the social network algorithm were discarded. Documents declared by authors at ResearchGate without CIGB's institutional affiliation data were considered only for works with transient rather than permanent author mobility, due to collaboration with foreign institutions. Metadata from publications on June-December 2022 were computed directly from documents until January 31th, 2023.

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Publications lists were structured as .ris records and overlapped in two rounds. First, publication titles' lists were overlapped for four main publications' categories regarded as relevant (Article, Conference Paper, Chapter and Book). Then, articles' html pages of non-coincident titles with the bibliographic database information were batch-downloaded and bibliographic records structured with custom Microsoft Word VBA macros, and contrasted again based on bibliographic data. Remaining non-coincident records were then revised, completed and standardized using original articles. Metadata of authors' declared documents with no verified bibliographic information at document, editorial page or database were excluded. Unpublished preprints were not considered. Authors' declared complete bibliographic information from predigital age literature (mainly prior to 2000) was included, despite online verification available or not. A final deduplication round was applied to the final EndNote library.

Literature for 1981-1986 was also retrieved using citation analyses of articles and documents published from 1984 to 1990. Also, CV information was analyzed. National monographies and books during the same period were searched, using the digitized periodic reports on Cuban bibliographic information of the José Martí National Library of Cuba.[25] Similarly, an open online search was also conducted to identify documented mention of the founding works of the institution, either published or presented at scientific conferences. Articles mentioning the CIGB scientific output were identified from a custom selection of articles on bibliometric analysis of the Cuban scientific output, and also from the retrieved information in this work, and they were further used for discussion and contextualization.

Information on books edited by the publisher Elfos Scientiae at CIGB was identified from the official ISBN book registry at the *Cuban Book Chamber*.[26] Then, books were consulted in print or downloaded from the Elfos Scientiae website (https://elfosscientiae.cigb.edu.cu). Records were generated both for books edited by CIGB authors as editors and their chapters. The serial *Avances en Biotecnología Moderna* (ISSN 1027-2860), publishing the abstracts of scientific conferences held at CIGB´ since 1992, was excluded, because of providing a conference abstracts which were historically published as original research elsewhere. For the same

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reason, the Proceedings of the III Cuban Workshop on Interferon and II Workshop on Biotechnology held in Havana, 1989 were not computed. The historic record of CIGB patent applications issued to the Cuban Industrial Property Office, was provided by the Patent Department at CIGB, and its trends were plotted with CIGB total scientific output for analysis.

Resulting records were analyzed in EndNote X9 and using VOSviewer version 1.6.18[27] for co-occurrence analysis with full counting criterion. Frequency tables and co-occurrence networks with Ling/Log normalization were generated, and cluster and overlay visualizations were obtained. General calculations and charts were implemented using Microsoft Excel 2016 software (Microsoft Corporation, USA).

Author name disambiguation

Top producers' lists were inferred both from Vosviewer frequency analysis of bibliographic data and ResearchGate declared publications, and previous knowledge on top producers at *Biotecnología Aplicada*.[28] Thereafter, detailed searches were done for first/second surname + first/second name initial variants in the EndNote library, records were inspected and aggregated for each top name variant. Author name disambiguation was implemented by a multilevel approach of author name and document data, complemented with participative intervention. Authorship was assigned first based on direct authors' list consultation in document, editorial page, database full name data or institutional email address of corresponding authors with unique name.surname@cigb.edu.cu pattern, and verified at Open Researcher Contributor Identification (Orcid),[29] ResearchGate[30] and available CVs.[31] No complex inferential algorithm implementation was required.[32] When such sources or data were unavailable, author collaborators were analyzed together by network analysis with article subject for author disambiguation, and one of the coauthors contacted for clarification. Then, unique identities were assigned to each disambiguated author surname + name initial variant. Co-authorship networks were generated in VOSviewer 1.6.18, with full

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counting and Association strength normalization with a minimal authorship of 20 documents.

Leadership, collaboration, rankings and subject distribution analyses

Leadership was computed using the corresponding author declared in records from Scopus and WoS, or directly in articles' web pages or documents when required and available. The first author was considered when corresponding author were not explicitly declared. Collaboration was established by classifying the records according to participating institutions in four categories: CIGB alone, CIGB-Cuba, CIGB-foreign and CIGB-Cuba-Foreign. Synchronous affiliation data was analyzed for authors' lists in works without author address' information sources. Besides, country and organizations' collaboration was further analyzed at WoS-CC.

Cuban institutions' ranking was established by analyzing ranking for top five positions at WoS-CC and the ranking of the same institutions at Scopus, respectively. For WoS-CC, records were first processed for institutional statistics with VOSviewer, and then, all the occurrences for each institution aggregated and searched back in the respective WoS-CC imported EndNote library. Results were limited to 1986 on for synchronous analyses. In Scopus, total database results were studied, and results for CIGB Affiliation ID 60043678.

Subject distribution was analyzed through source classification categories at WoS-CC and Scopus for the respective indexed records. Additionally, term co-occurrence was calculated with VOSviewer 1.6.18 with modular criterion from titles of the total scientific output computed *term minimal frequency of 10 and Ling/Log algorithm normalization). An *ad hoc* thesaurus was used for unifying molecules' names and their acronyms, and to eliminate high frequency words without technical relevance.

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Results and Discussion

Foundational developments and scientific output

The history of CIGB started as early as in 1981, instead of its official foundation on July 1st, 1986. It began at a small facility identified as 'House 149' in Havana, where human leukocyte interferon was formerly obtained for human use in 1981.[33] Thereafter, the first official and bibliographically declared institution was the Center of Biological Research (CIB), founded on January 20th, 1982[34,35] as the first working unit of the subsequent CIGB. Since 1983, a national strategy in Biotechnology conceived the institutionalization of these previous stages.[34] The CIB personnel and research lines were organizationally inherited and further expanded after CIGB foundation. Then, two other CIGB facilities were later created, the CIGB at Camagüey province, on July 25th, 1989, and the CIGB at Sancti Spíritus province, on April 10th, 1990.[36] In this work, the scientific output computed was aggregated considering the four institutions mentioned, and former publications since 1981 on.

The first documented published work of CIGB's foundational research was a meeting abstract of a work at the II Annual International Congress for Interferon Research, held in San Francisco, October 21-23, 1981.[37] The author, Dr. Manuel de Jesús Limonta Vidal (founder and first General Director of CIGB), presented the results of a children treatment with interferon during the 1981's hemorrhagic dengue outbreak in Cuba. This institutional pioneering work was amplified as a news article by the *Journal of the American Medical Association*,[38] and finally published in 1984 at the journal *Interferon y Biotecnología*.[39] A second work was presented at the III Annual International Congress for Interferon Research, held in Miami, 1982, on the treatment of hemorrhagic conjunctivitis with interferon.[40] In 1983, 27 conference papers on interferon medical applications developed by CIB researchers were published in the proceedings book of the I Cuban Workshop on Interferon, held in Havana, August 4-6, 1983.[41] Formally, the first article appearing officially under the CIB institutional affiliation was published at the *Revista Cubana de Investigaciones Biomédicas* (*i.e.*, *Cuban Journal of Biomedical Research*).[42] It was on former results of interferon treatment of eight Cuban patients suffering

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from laryngeal papillomatosis, together with information on the worldwide situation of this disease's therapeutics.

In those early days of Cuban biotechnology, there was reported some reluctance of foreign specialized journals to publish works on interferon developed by researchers from Third World countries.[43] This was probably one of the reasons backing the agreement taken at the I Cuban Workshop on Interferon in Havana, 1983, as part of the foundation of the Ibero-Latin American Society for Research on Interferon, to start an academic journal for publishing biotechnology works from Latin American countries. This led to the foundation of *Interferón y Biotecnología* (ISSN 0138-8878), run at the CIGB as a society journal, which first issue circulated in 1984. This journal was indexed at WoS from 1986 to 1989, when the journal title changed to *Biotecnología Aplicada* (ISSN 0864-4551 printed, currently ISSN 1027-2852, online).

The first scientific article under CIGB affiliation according to a strict bibliographic criterion was published in *Biotecnología Aplicada* on 1986, entitled "CIBSOFT: a package of programs for the analysis of nucleic acids and proteins".[44] Also in 1986, another volume of conference proceedings papers was published, corresponding to the II Cuban Workshop on Interferon and the I Cuban Workshop on Biotechnology, held in Havana, February 20-22, 1986.[45] The first article under CIGB published in a foreign journal appeared at the *Journal of Interferon Research*,[46] entitled "Alpha-Leukocyte Interferon in Treatment of Seropositives for HIV - Longitudinal-Study".

Bibliometric analysis of the CIGB scientific output

Output, output trend, document typology, language and publication sources

Up to 3667 bibliographic records of the scientific output of the CIGB from 1981 to June 14th, 2022 were studied (table 1). It included 10 erratum papers which were excluded for quantitative analyses since they are correction notes.

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Table 1 - Scientific output of the Center for Genetic Engineering and Biotechnology (CIGB) of Cuba, computed from available resources and bibliographic databases from 1981 to June 13th, 2022, classified by document type

Source type	Document type	Docs	%
Primary	Original research article	2535	69.13
	Review	245	6.68
	Systematic review	2	–
	Technical note	39	1.06
	Letter	29	0.79
	Conference paper	357	9.73
	Book chapter	141	3.84
	Book	9	–
Secondary	Meeting abstract	253	6.90
	Editorial	24	–
	Survey	13	–
	News	7	–
	Book review	3	–
	Erratum	10	–
	Total	3667	–

Up to 69.13% were original research articles and 6.68% review articles. More importantly, 1245 documents (33.95%) were identified not indexed in Scopus or WoS-CC, consistent with the relative representativeness of these two databases for the Cuban scientific output.[28] There were 3357 citable documents (91.54%), considering major article types. A sustained growth of CIGB publications occurred from 1983 to 1995, with a relative stabilization until 2017 over 100 (range 104-137; except 1997 (96), 2002 (89) and 2011 (96)), and a decline after 2018 (fig. 1A). Noteworthy, the notable declines in publishing in 2002, 2007 and 2010 were preceded by increased and sustained patenting activity starting the one-two years prior to the decline, the most significant in 2002 (fig. 1A).

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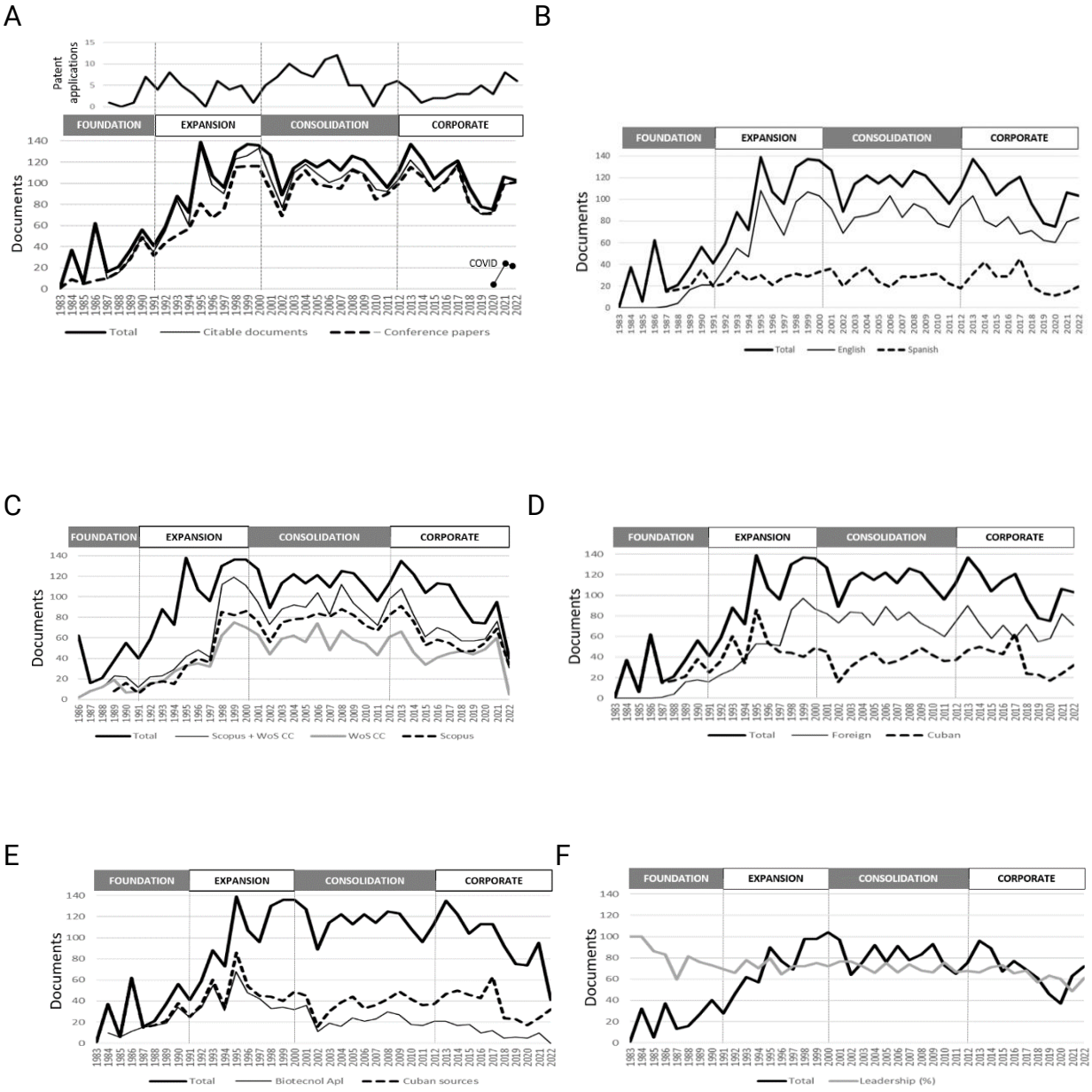

Fig. 1 – Analysis of the scientific output of the Center for Genetic Engineering and Biotechnology (CIGB) of Cuba. A) Trend including total output, citable documents and scientific output without Conference papers. B) Language. C) Main Stream of Science indexing. D) Foreign vs. Cuban sources. E) CIGB publications in Cuban sources and *Biotecnología Aplicada* (Biotecnol Apl). F) Leadership. The four discrete phases for institutional evolution regarding publishing activity are presented (Foundation, 1981-1990; Expansion, 1991-1999; Consolidation, 2000-2011; and Corporate, 2012-2022). Also, annual patent applications are shown starting on 1987, and output on SARS-CoV-2/COVID-19 (2020-2022). Citable documents were considered as Original research article, Review, Systematic review, Technical note, Letter, Conference paper, Book chapter and Book.

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Remarkably, this is the natural trend between patents and scientific publications, since knowledge and know how must be protected until the patent is issued internationally, therefore, delaying academic publications in about one year. In fact, this behavior was also identified by Thorsteinsdóttir *et al.*,[47] who showed the trend of Cuban publications and the United States Patent and Trademark Office (USPTO) in health biotechnology (1991-2002). A slow increase in patenting activity since 2013 coincided with a reverse kinetics in publishing, which reverted from 2020 on, due to the boosting effect, both in publishing and patenting, of the very fast emerging research field of the SARS-COV-2/COVID-19 pandemic.[48] In fact, at the time of writing, there were up to 44 articles with CIGB authors on this topic in just three years (fig. 1A).

Moreover, publications in foreign sources were above 80 with oscillations from 1998 to 2008, and remained quite stable in the range 60-80 until 2022. Spikes in total publications in 1993, 1995, 1998, 2000, 2004 and 2017 were due to the inclusion of conference papers. A pretty intense publishing activity associated to scientific conferences (i.e., conference papers and meeting abstracts) was preferentially found until 2000 (fig. 1A). This was consistent with the projection of CIGB on celebrating international scientific conferences to socialize the biotechnological knowledge mainly to Latin American and Third World Countries.[49]

In general, considering the years of maximal contribution of citable documents with maximal output, 1995, 1999 and 2013 can be regarded as the top output years. The slow decline in publications in the last period since 2013 to 2020 can be interpreted as related to a more selective publishing due to a careful patenting strategy. It was characterized by a lower publishing in national journals (fig. 1B), but with a steady publishing in foreign and high visibility journals of 60-80 papers yearly. This makes ineffective previous concerns regarding the possible negative effect on institutional R & D performance of turning research institutes into enterprises in Cuba, with publications as one of the most visible parameters[50] (fig. 1).

Overall, 2586 documents (70.52%) were published in English, 1075 (29.32%) in Spanish, and 6 in other languages (fig. 1C). Publishing in English was strengthened

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from 1991 on, due to *Biotecnología Aplicada* accepting manuscripts submitted in English and the sustained publication of manuscripts in foreign journals in English. Documents published also in Spanish at *Biotecnología Aplicada* from 2005 to 2014 were stably translated, due to editorial policies. A decline in publishing in Spanish was detected from 2017 on, caused by a lower publication in Cuban journals, and since 2015 at *Biotecnología Aplicada* exclusively in English (fig. 1D). As expected, the main coverage of Spanish output comes from Cuban, Latin American and Spanish journals indexed at Scopus, SciELO Citation Index and ESCI, mainly in biomedical sciences (see below).

Regarding publication sources according to editorial origin, 59.39% of the scientific output was found in foreign sources, mainly foreign journals. Special mention to *Vaccine* and the *Biochemical and Biophysical Research Communications* journals, which together with the ten top journals provided 15.27% of all the output in foreign sources. CIGB has also contributed with a substantial number of articles of the Cuban output published in highly reputed journals. These includes not only the most ancient and established academic journals, such as *Nature*, *Science*, *Journal of Biological Chemistry* or the *New England Journal of Medicine*, but also open access, high quality and consortium journals such as *Scientific Reports*, *PLoS* or *BMC* journals (table 2).

Table 2. Frequency tables of highly publishing sources for the output of the Center for Genetic Engineering and Biotechnology (CIGB) of Cuba, computed from available resources and bibliographic databases from 1981 to June 14th, 2022, classified by document type*

Foreign sources	Docs	Specific foreign sources	CIGB docs	Cuba docs	Cuban sources	Docs
Vaccine	73	Science	1	9	*Biotecnología Aplicada*	803
Biochemical and Biophysical Research Communications	56	Nature Biotechnology	6	8	*Interferón y Biotecnología*	78

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Journal of Interferon and Cytokine Research	48	Nature Protocols	1	2	*II Seminario Cubano sobre Interferón y I Seminario Cubano sobre Biotecnología*	51
Biotechnology and Applied Biochemistry	36	Nature	1	12	*Anales de la Academia de Ciencias de Cuba*	45
Journal of Biotechnology	29	Scientific Reports	5	54	*VacciMonitor*	29
BioProcessing Journal	21	Proceedings of the National Academy of Sciences USA	2	9	*I Seminario Cubano sobre Interferón*	27
Electrophoresis	19	The Lancet	1	32	Molecular Biology	23
Journal of Proteomics	19	The Journal of Immunology	6	24	*Revista de Producción Animal*	20
Analytical Biochemistry	18	Nucleic Acids Research	2	5	*Bionatura*	18
Biotechnology Letters	17	The New England Journal of Medicine	1	8	*Revista CENIC Ciencias Biológicas*	18
		Gene	4	4	*Revista de Salud Animal*	18
		Biotechniques	11	11		
		Yeast	11	13		
		Virology	3	9		
		The Journal of Virology	1	10		
		The Journal of General Virology	4	7		
		The Journal of Biological Chemistry	6	15		
		PLoS ONE / PLoS journals	10	142		
		BioMed Central	21	103		

Legend: * Top foreign, national and reputed journal publishing national output are shown. *Nature Biotechnology* changed title from Bio/Technology in 1996. Similarly, *Journal of Interferon and Cytokine Research* changed title from *Journal of Interferon Research* in 1995. The Cuban source entitled *Molecular Biology* is the textbook of Medicine career in Cuba, also used to teach molecular biology to foreign students at the Latin American School of Medicine, ELAM. Docs: documents. Cuba Docs: Documents under Cuba affiliation at Scopus and WoS. Cuba data was retrieved on June 14th, 2022.

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From the CIGB output in national journals, 61.51% was published in *Biotecnología Aplicada* (fig. 1D). Other important national sources were *Anales de la Academia de Ciencias de Cuba* (43), *VacciMonitor* (28), *Revista de Producción Animal* (20), *Revista CENIC Ciencias Biológicas* (18) and *Revista de Salud Animal* (18) (table 2). Publications in *Anales de la Academia de Ciencias de Cuba* can be traced back as esteem indicator, due to publishing mostly papers summarizing the Awards of the National Academy of Sciences of Cuba. In this regard, CIGB was identified as the second most awarded Cuban institution in the period 1996-2010, contributing 22 out of the 147 awards granted in the section of Agricultural and Fishery Sciences.[4]

Main stream database coverage, citation analysis and institutional H index

CIGB comprised 1551 records in WoS CC and 1944 records in Scopus (table 3, fig. 1E). Particularly at WoS-CC, there were found 74 different institutional name variants. In this last source, up to 86.13% were indexed at SCI-Expanded database.

Tabla 3 - Main quantitative bibliometric parameters for CIGB and Cuba scientific output, and their relative weight (%) in the period 1986-2022 at the Web of Science Core Collection (including ESCI) and Scopus

Database	Docs	Cuba (%)	Cited	Cited (%)	Cited % Cuba	Citations	Citations % Cuba	H index	Cuba Docs	Cuba Cited	Cuba Citations	Cuba H index
Scopus	1944	3.64	1566	80.60	4.54	31 667	6.09	74	53 262	34 449	519 308	210
WoS-CC	1551	4.63	1298	83.68	7.21	30 553	8.10	74	33 481	21 505	377 100	175

Legend: *Citations in the entire Web of Science platform, all databases (computed from the Z9 field tag). Data retrieved on June 14th, 2022. Docs: documents; Cited % Cuba and Citations % Cuba: representative percentage of the number of CIGB articles cited and their citations, respectively, in respect to the cited documents and total citations of Cuba at the database.

A previous report informed on 680 journal articles by CIGB authors at SCI-E from 1986-2006, with over 3000 citations.[51] The higher record number at Scopus derives from the higher coverage of Latin American journals, which includes Cuban

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biomedical journals mainly indexed at SciELO. These Cuban journals are not covered by WoS-CC, except for those included at ESCI,[52] or in SciELO Citation Index. Indexing became more relevant since 1998 (fig. 1E), due to increased coverage of *Biotecnología Aplicada* in Scopus.

Considering WoS-CC and Scopus, more than 80% of papers published by authors from CIGB were cited. In proportion, cited papers from CIGB were 5-7% of all Cuban cited documents, which received 6-8% of all citations to Cuban papers in both databases (table 3). Remarkably, it shows an H index of 74 in WoS, which is the second top H index among Cuban institutions after Havana University (101). Moreover, the CIGB has 10 articles in the H-core of the Cuban most cited articles in both databases, three of them with the corresponding author from CIGB (table 4).

Tabla 4 - Top cited articles of the Center for Genetic Engineering and Biotechnology of Cuba (CIGB) in academic journals indexed at the Web of Science Core Collection databases and Scopus*

Article citation	WoS-CC			Scopus		
	CIGB rank	Cuba H index rank	Citations	CIGB rank	Cuba H index rank	Citations
The Proteomics Identifications (PRIDE) database and associated tools: status in 2013. Nucleic Acids Res. 2013;41(D1):D1063-D9	1	2	1558	1	6	1554
Vaccine adjuvants: Current state and future trends. Immunol Cell Biol. 2004;82(5):488-96	2	16	662	2	31	692
Vaccine adjuvants revisited. Vaccine. 2007;25(19):3752-62‡	3	41	395	4	76	391
A synthetic conjugate polysaccharide vaccine against *Haemophilus influenzae* type b. Science. 2004;305(5683):522-5	4	49	362	3	73	401
Homology modeling, model and software evaluation: three related resources. Bioinformatics. 1998;14(6):523-8	5	67	292	5	112	308

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Epidermal growth factor enemas with oral mesalamine for mild-to-moderate left-sided ulcerative colitis or proctitis. N Engl J Med. 2003;349(4):350-7	6	105	235	6	133	276
BisoGenet: a new tool for gene network building, visualization and analysis. BMC Bioinformatics. 2010;11‡	7	124	221	7	189	224
Rapid and sensitive anthrone-sulfuric acid assay in microplate format to quantify carbohydrate in biopharmaceutical products: Method development and validation. Biologicals. 2008;36(2):134-41‡	8	130	217	8	215	208
The novel *Cladosporium fulvum* lysin motif effector Ecp6 is a virulence factor with orthologues in other fungal species. Mol Microbiol. 2008;69(1):119-36	9	143	201	9	234	196
Review of Levan polysaccharide: From a century of past experiences to future prospects. Biotechnol Adv. 2016;34(5):827-44	10	175	175	11	270	177
Oncogenes and tumor angiogenesis: The HPV-16 E6 oncoprotein activates the vascular endothelial growth factor (VEGF) gene promoter in a p53 independent manner. Oncogene. 2000;19(40):4611-20	–	182	172	10	256	184*

Legend: * Citation rank, out of the Cuba's H index which was 175 at the Web of Science Core Collection (including ESCI) and Scopus. Data retrieved on June 14th, 2022. ‡ Publication with CIGB leadership by corresponding author.

Leadership and institutional collaboration

Leadership is a high-quality indicator of the leading role an institution or a researcher plays on conducting research, while influenced by collaboration.[21] At article level, leadership is commonly measured by corresponding author information, or by the first authorship instead. Authors from CIGB were the leaders in 2542 out of its 3667 publications (69.32%) (fig. 1F), in line with its innovative and product-oriented profile of institutional research. The decreasing behavior of this indicator (from 100 to 60%) indicates the gradual opening towards national and international collaboration. Up to 1,446 articles led by CIGB authors (56.89%) were published in foreign journals, these high rates confirming the findings of previous reports.[3]

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The bibliometric institutional collaboration was analyzed at three different levels: with Cuban or foreign institutions, by country and organizations. Most CIGB organizational collaboration has been established with Cuban institutions (41.53%). A progressive and intense international collaboration was implemented (26.56%; fig. 2), 8.45% simultaneously with Cuban institutions. Publications exclusively by the CIGB reached 40.38%. This was also the annual trend, with Cuba-Foreign collaboration quite steady since 2004 and Foreign collaboration intensifying since 2012.

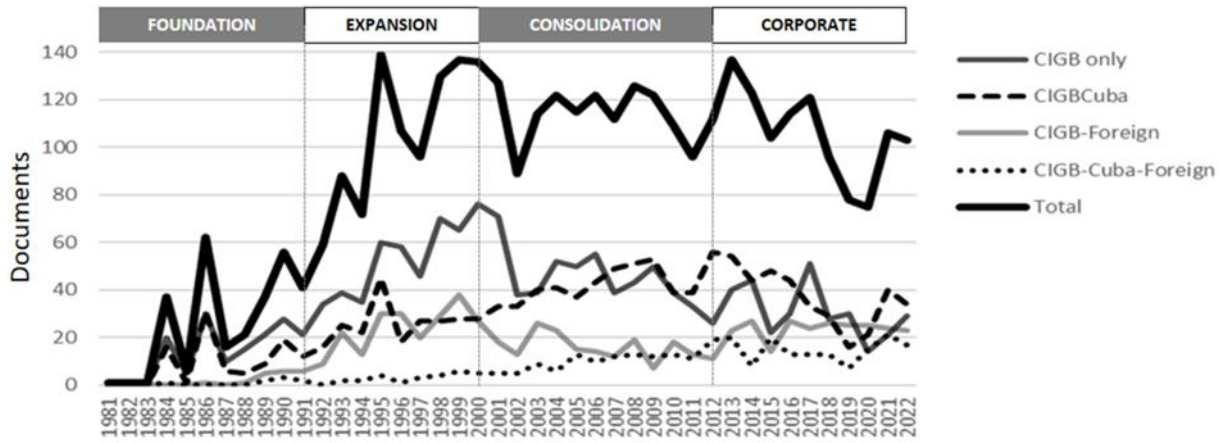

Fig. 2 – Collaboration of the Center for Genetic Engineering and Biotechnology (CIGB) of Cuba in 3667 academic publications in the period 1981-2022. The output was segmented in authored only by CIGB (CIGB only), and collaboration with Cuban (CIGB-Cuba), Foreign (CIGB-Foreign) or both (CIGB-Cuba-Foreign) institutions.

According to WoS-CC, the CIGB has collaborated with 60 countries (fig. 3). Spain (97), England (96), Brazil (66), Mexico (62), USA (58) and Germany (56) had over 50 documents in co-authorship. Older collaborations were established mostly with European countries and have diversified in recent times to Latin America (mainly with Argentina and Brazil) and with the People's Republic of China. A significant effort in former years for technical training and technological framework import from European countries have been largely documented, with Sweden as the most remarkable example, mostly on monoclonal antibodies. The large representation of studies published exclusively by authors from CIGB or in collaboration with

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colleagues from Cuban institutions (2694 out of the 3667; 73.46%) indicates the leading role of the institution as generator of novel knowledge and new scientific products.

The University of Havana and organizations belonging to the former Scientific Pole of Western Havana, such as the Center of Molecular Immunology (CIM) and the National Center for Scientific Research (CNIC), have shown the most intense interaction (fig. 3). It goes far from just at publication level, due to the integration in both ways between the Cuban university system and the technological sectors,[53,54] particularly in biotechnology.[55]

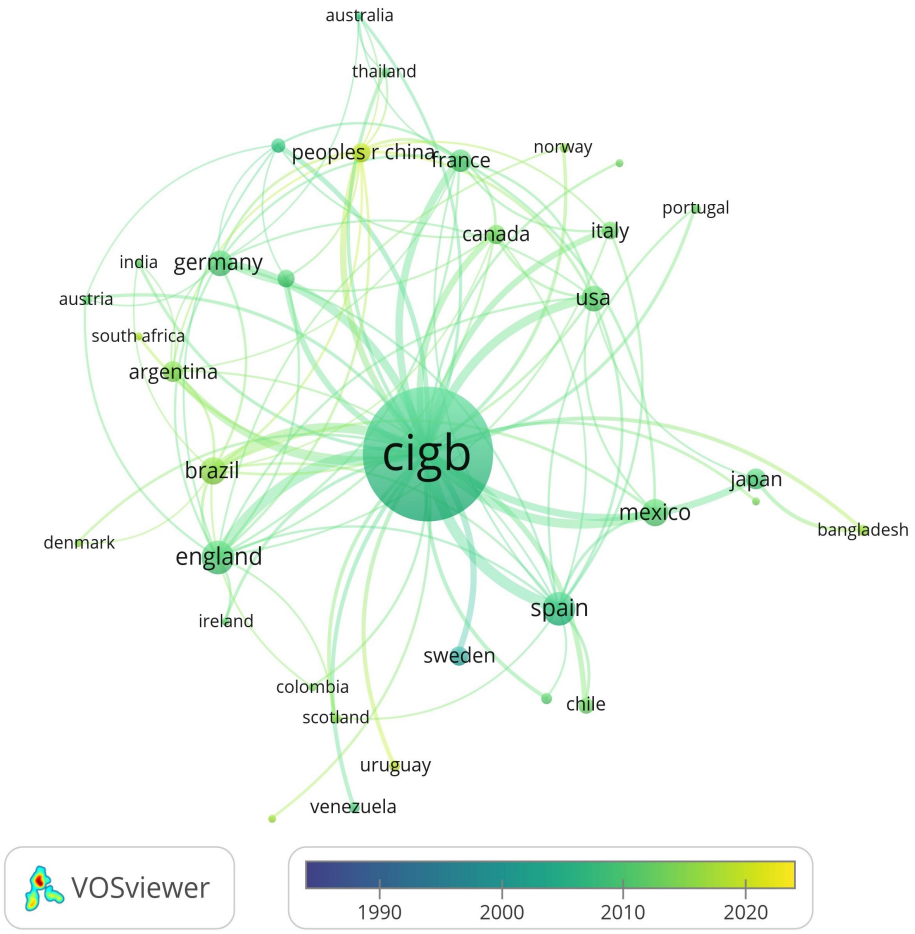

Fig. 3 – International collaboration of the Center for Genetic Engineering and Biotechnology during the period 1986-2022. Data analyzed from 1551 Web of Science Core Collection indexed records with the software VOSviewer 1.6.18. All countries, visualized by timeline overlay.

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As expected, due to the historical framework during the genesis and the evolution of the CIGB, the former CNIC collaboration on basic biological and biotechnological research was followed with a more recent and persistent collaboration with CIM, in vaccine-related and immunological studies (fig. 4). A progressive relationship with the National Institute of Gastroenterology, mostly on hepatitis B and C vaccine and treatment research, was observed. Interactions with the National Institute of Oncology and Radiobiology on cancer research, and later on with the National Institute of Angiology and Vascular Research due to research on Heberprot-P®, have been also in growth. Clinical trials have been mainly developed with the Center of Medical and Surgical Research in Havana. The collaborations with the Institute of Tropical Medicine Pedro Kourí (IPK), the Finlay Institute of Vaccines, and the National Center for the Coordination of Clinical Trials, have been constant through time.

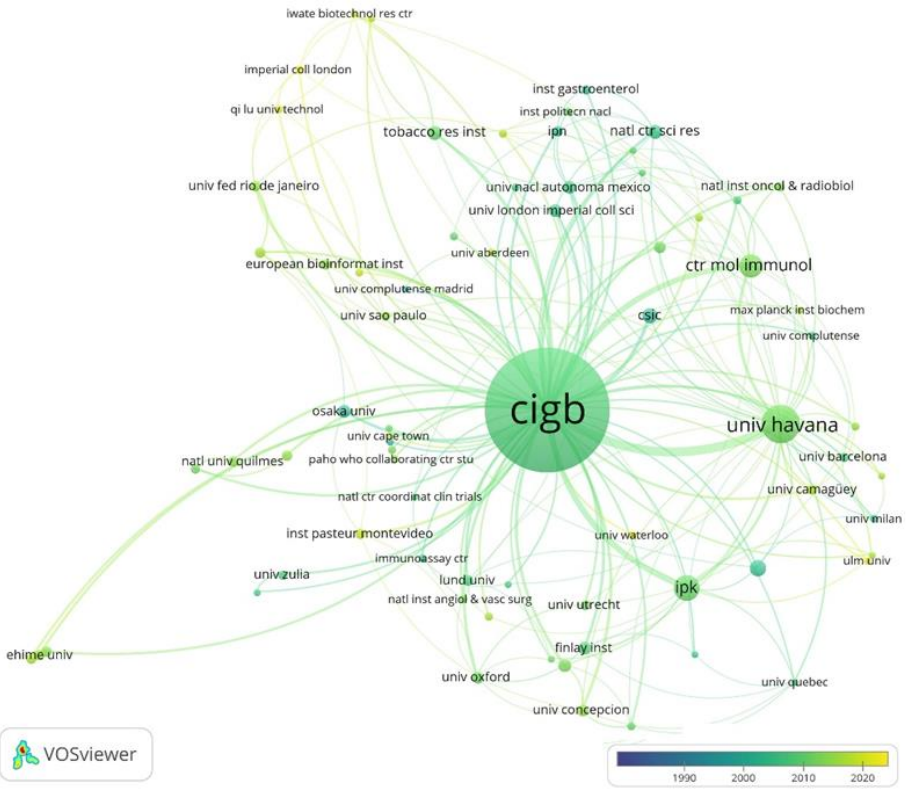

Fig. 4 – Collaboration network of the Center for Genetic Engineering and Biotechnology (CIGB) during the period 1986-2022, at organizational level. Data processed from the Web of Science Core Collection database with the software VOSviewer 1.6.18. Institutions with 5 or more documents are visualized by timeline overlay.

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Regarding foreign collaboration, most remarkable exchanges were established formerly with: CSIC and *Universidad Complutense de Madrid* in Spain, in basic research; Lund University in Sweden on monoclonal antibody and phage display technology; Osaka University in Japan on mass spectrometry; the Universidad Nacional Autónoma de México (UNAM) and Instituto Politécnico Nacional (IPN) in México on agricultural research; and the University of London Imperial College of Science, Technology & Medicine in the United Kingdom, on epidermal growth factor (EGF) physiology and therapy (fig. 4). The most recent collaboration has been more selective, mostly due to either research project coordination for applied research and products' studies, or due to scholarships and research training. Particular cases in the most recent collaborations are those established due to author mobility, either national as in the case of the University of Camagüey, or abroad to Chinese, European and Latin American institutions.

Most productive authors

Studies addressing top Cuban scientific producers are scarce, due to the lack of authority-controlled lists, except for micro-level analysis of academic journals and aside of high frequency signatures in major databases. This somewhat limits the accurate ranking of the CIGB's top authors reported at country level in mainstream databases. There were some advantages which helped us to reduce data divergence and facilitated the correct authority assignation (e.g. Cuban researchers' population comprise almost exclusively national researchers, limiting the high frequency of foreign surnames and names; available ORCID and ResearchGate profiles, organizational email address pattern). In fact, the availability of author-declared lists of works and CVs, also used by similar international reports,[29,30,31,32] facilitated the normalization process for top producers.

In our study, a list of 50 top authors from CIGB was established, based on the works frequencies declared at ResearchGate author pages, and the analysis of author name frequency variants from bibliographic records using VOSviewer. Twenty-two of them contributed 48.5% of the entire CIGB scientific output. Most of these

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scientists have been also identified among the top Cuban authors by previous reports, including founders of Cuban Biotechnology such as Dr. Pedro Antonio López Saura (1947-2016), Dr. Jorge Víctor Gavilondo Cowley (1949-2021), Dr. Luis Saturnino Herrera Martínez, and the current Research Director of the institution, Dr. Gerardo Enrique Guillén Nieto.[7,18,19] Taking advantage of Scopus and WoS data, main quantitative and impact bibliometric indicators were calculated for each author (table 5).

In general, these top researchers were leaders in their respective topics at cluster level, and those central to the entire network have been more collaborative (fig. 5). Their positioning coincides mostly with their long-term output in the publication period analyzed and its managerial role at research level (table 5). Nine main clusters were structured relating them to specific subject areas (different colors in the figure), with up to 167 authors with at least 20 articles. The largest cluster was led by Luis Saturnino Herrera Martínez (grouping 40 researchers; studying multiple subjects, including biomedical and agricultural subject areas). Gerardo Enrique Guillén Nieto (24 researchers), Pedro López Saura (24 researchers) and Luis Javier González López (21 researchers) led the clusters specialized on dengue vaccine research, clinical research and mass spectrometry, respectively. Other author collaboration clusters were identified, on monoclonal antibody production (Rodolfo Valdés Véliz); electron microscopy studies (Viviana Falcón Cama); animal biotechnology (Mario Pablo Estrada García); peptide synthesis and vaccine studies (Osvaldo Reyes Acosta); and molecular biology (led by Eduardo Pentón Arias, who also contributed to research on interferon).

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Tabla 5 - Performance of top authors at the Center for Genetic Engineering and Biotechnology of Cuba (CIGB) with permanence in the publication record at least half the period 1984-June 2022*

Rank	Author	Publication period	Docs	WoS-CC			Scopus		
				Docs	Cit	H	Docs	Cit	H
1	Pedro Antonio López Saura†	1984-2019	285	73	1535	22	68	1373	21
2	Gerardo Enrique Guillén Nieto	1993-2022	276	142	2742	29	164	2728	28
3	Luis Saturnino Herrera Martínez	1984-2022	175	51	1477	19	68	1783	20
4	Luis Javier González López	1992-2022	159	89	1508	22	99	1527	22
5	Jorge Víctor Gavilondo Cowley†	1984-2022	147	75	1486	23	84	1354	22
6	Jorge Amador Berlanga Acosta	1993-2022	143	66	1783	23	85	1972	24
7	Viviana Falcón Cama	1992-2022	140	58	1494	22	81	1523	21
8	Vladimir Armando Besada Pérez	1989-2022	138	71	1432	23	75	1365	21
8	Mario Pablo Estrada García	1988-2022	138	67	1200	21	74	1193	21
10	Osvaldo Reyes Acosta	1995-2022	134	73	1226	20	82	1236	20
11	Rodolfo Valdés Véliz	1993-2022	126	57	518	13	58	497	11
12	Hilda Elisa Garay Pérez	1995-2022	118	62	882	19	69	899	18
13	Gabriel Ramón Padrón Palomares	1984-2022	114	62	1258	20	69	1414	21
14	Eduardo Pentón Arias	1984-2022	113	54	506	13	35	541	13
15	Julio César Aguilar Rubido	1999-2022	109	48	1681	16	50	1738	19
16	Alexis Musacchio Lasa	1994-2022	98	54	1061	17	72	1238	18
17	Marta Ayala Ávila	1990-2022	94	53	1059	20	58	948	19
18	Silvio Ernesto Perea Rodríguez	1986-2022	94	40	714	16	40	722	16

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19	Carmen María Valenzuela Silva	1998-2018	88	48	945	19	45	926	18
20	Merardo Mariano Pujol Ferrer	1989-2022	87	38	839	18	59	918	18
21	Lila Rosa Castellanos Serra	1984-2019	84	45	1219	21	51	1368	22

Legend: *Data computed and calculated as on June 2022, on a set of 3667 documents (Docs) published under CIGB affiliation. Citations (Cit) and H index (H) were calculated from indexed data at the Web of Science Core Collection (WoS-CC, including ESCI; 1551 records) and Scopus (1944 records), as on June 14th, 2022. † Passed away. The output of listed authors covers 50 % of the total output.

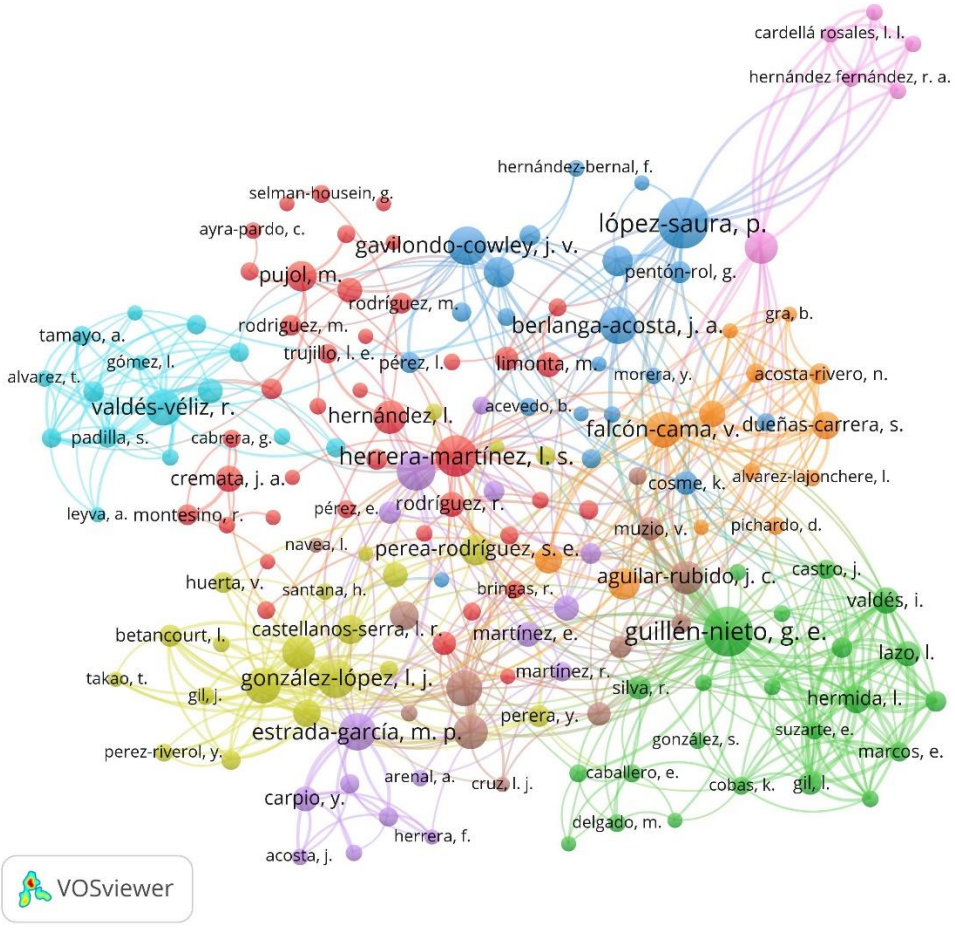

Fig. 5 – Co-authorship network of the most productive authors from the Cenfer for Genetic Engineering and Biotechnology. Records of 3667 documents published from 1981 to January 16th, 2023, were analyzed with the VOSviewer 1.6.18 software. Authors with 20 or more documents are visualized by coauthorship frequency overlay.

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National institutional ranking and contribution to the national scientific output trend

The CIGB's output has indisputably contributed both to the indexing and repositioning of Cuba in major international bibliographic databases,[6,10,11] and influenced in the trend seen for the national output. Moreover, it has been traditionally recognized as one of the Cuban top producers, as the leading research institution of BioCubaFarma[3,15] and aiding to its ranking as the top Cuban institution at the Scimago Institutional Rank 2022.[56] For long, it was regarded as the second producer nationwide after Havana University, despite the very recent repositioning of the Universidad Central Marta Abreu de Las Villas, particularly at Scopus (table 6). Noteworthy, rankings are determined mostly by the type and number of aggregated information resources.

Table 6. Scientific output ranking of Cuban leading institutions according to journals indexed at the Web of Science Core Collection databases (including ESCI; WoS-CC) and Scopus*

Rank	WoS CC									Scopus		
	Institution	Docs	1986-2022	SCI-E	ESCI	CPCI-S	Article	Proc. Paper	Cit	Institution	Docs	Journal
1	Havana University	6874	6717	4385	810	499	5459	652	85 634	Havana University	7615	–
2	Central University Marta Abreu at Las Villas	2182	2171	1199	468	318	1733	326	26 265	Central University Marta Abreu at Las Villas	2485	–
3	Center for Genetic Engineering and Biotechnology	1551	1551	1336	25	63	1272	81	30 553	Pedro Kourí Tropical Medicine Institute	2292	822
4	Oriente University	1246	1236	729	233	174	959	185	8956	Center for Genetic Engineering and Biotechnology	1944	394
5	Pedro Kourí Tropical Medicine Institute	1243	1227	1020	23	41	943	17	26 775	National Center for Scientific Research	1908	–
6										Havana University of Medical Sciences	1813	–
7										Oriente University	1490	–

Legend: SCI-E: Science Citation Index-Expanded; ESCI: Emerging Source Citation Index; CPCI-S: Conference Proceeding Citation Index-Science; Proc. Paper: Proceeding Paper; Cit: citations; Docs: Documents. Journal: indicates the institutional scientific output published in *Biotecnología Aplicada* for Center for Genetic Engineering and Biotechnology and *Revista Cubana de Medicina Tropical* for the Pedro Kourí Tropical Medicine Institute; *Scopus ranking was extended to positions covering the top five institutions considered for ranking at WoS-CC.

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In this regard, higher education has been long recognized as the most productive sector in Cuba, with an intensive production since 2006.[1] Their number of researchers became even bigger after the aggregation of educational institutes nationwide from 2012 on.[57] Major universities aggregate larger and more varied research communities, with a wider subject categories spectrum than research institutes.[2] Furthermore, their evolution in the last years have been influenced by the demand of higher quality publications and database indexing indicators, accelerating their positioning in specialized institutional rankings (i.e., QS World University Rankings ranking, etc.).

Subject analysis

The subject distribution of the CIGB's scientific output was calculated based on source classification either by WoS-CC or Scopus subject classification of indexed works, and by direct analysis of titles of the computed scientific output. As shown in figure 6 and mostly expected, major and almost equal contributions in WoS-CC were on Life Sciences topics: *Biotechnology & Applied Microbiology* (343 articles) and *Biochemistry & Molecular Biology* (337). Other subject areas with over 100 works versed on *Immunology* (248); *Biochemical Research Methods* (192); *Pharmacology & Pharmacy* (116); *Medicine, Research & Experimental* (113); and *Chemistry, Analytical* (103).

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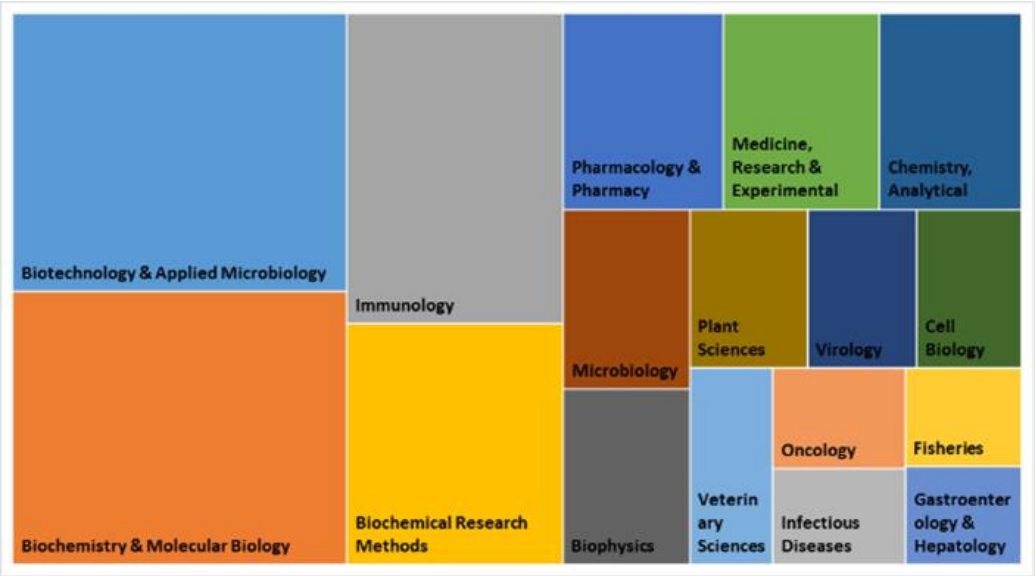

Fig. 6 – Hierarchy chart for subject categories of the scientific output of 1551 documents computed for CIGB in the period 1981-2022 at the Web of Science Core Collection (including ESCI database).

Similarly, the scientific output at Scopus were mainly on *General Medicine* (377), *Biochemistry* (317), *Biotechnology* (256), *Molecular Biology* (231), *Applied Microbiology and Biotechnology* (213), *Immunology* (174), *Bioengineering* (169), *Molecular Medicine* (166), *Drug Discovery* (125), *Cell Biology* (122), *Biophysics* (113), *Genetics* (109) and *Pharmacology* (108) (fig. 7). This last distribution did not include the works on *Biotecnología Aplicada*, for a pairwise comparison between both databases mostly on foreign journals' output. When included, it repositions *Biotechnology* (649), and *Applied Microbiology and Biotechnology* (606) as top subject areas. At the same time, the subject classification by the Scopus ASJC is more diversified than WoS-CC subject categories, as explained for the Cuban scientific output classification.[58]

Just for comparison, the CIGB scientific output indexed at WoS-CC stands for 50% of works on *Biotechnology & Applied Microbiology* subject of Cuba and one third (31.82%) on *Biochemistry & Molecular Biology* and on *Immunology* (33.6%). These three subject areas, together with *Physics, Applied* in the third position, are the top four Web of Science subject categories for the Cuban scientific output. In this regard, the CIGB was highlighted as the top producer institution when studying the

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Cuban output indexed at Scopus and Pubmed from 2001 to 2010.[9] Furthermore, Arencibia Jorge in 2010 described that CIGB was among the Cuban institutions in 2003-2007 with the highest international visibility above the world average in *Pharmaceutical Science*, *Chemical Engineering*, *Cancer Research*, *Structural Biology*, *Industrial and Manufacturing Engineering*, and *Process Chemistry and Technology*.[59] A similar analysis for 2011 found 560 documents and ranked CIGB in the second position nationwide in those topics.[24]

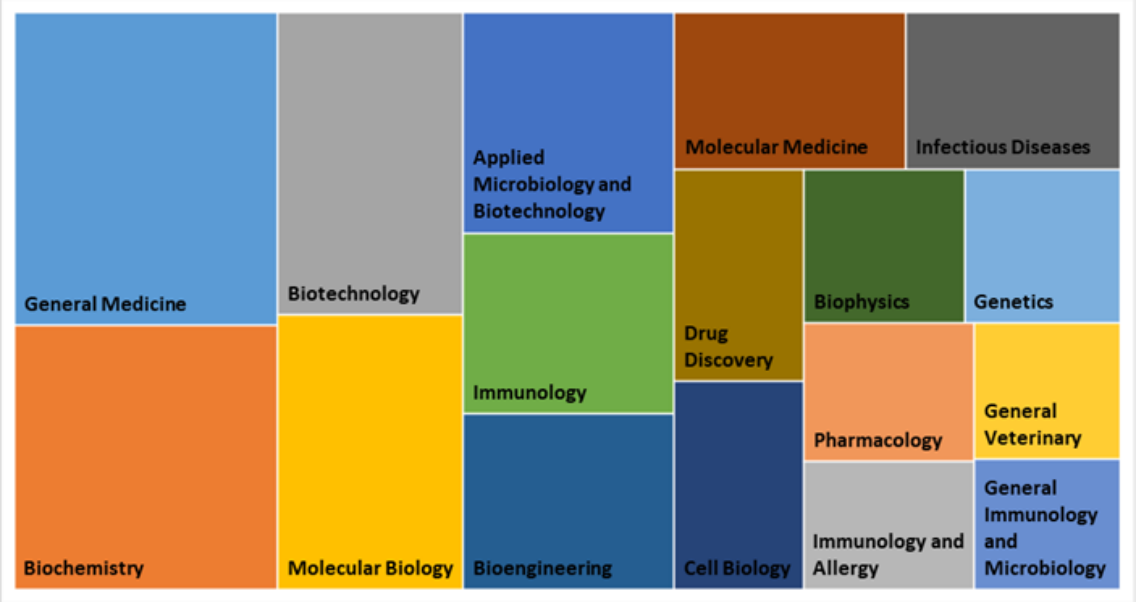

Fig. 7 – Hierarchy chart for subject categories of the scientific output of 1994 documents computed for CIGB in the period 1981-2022 at the Scopus database by the All Journal Source Classification (AJSC) system.

A finer grain subject analysis by term co-occurrence was done in VOSviewer 1.6.18, from titles of the records computed for the total scientific output since 1981. As shown in figure 8, the main subject terms have been those central for the field of research: molecules, protein and peptides as main components of vaccine and therapeutic products. This is coincident with expression systems and biotechnological hosts for protein production: *Escherichia coli*, *Saccharomyces cerevisiae* and *Pichia pastoris* yeasts, transgenic mouse and plants (particularly *Nicotiana tabacum*). Regarding types of molecules and its arrays, there were

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antigens (113), *viruses* (113), *antibodies* (105), *monoclonal antibodies* (98), and *cellular factors* (73).

As expected, in the case of specific molecules, works on interferons (152), interferon alpha (58) and EGF (91) were outstanding, with a sustained permanence throughout the years. In fact, the works on interferons and EGF are the founding research lines of CIGB since 1981, and the primary product-oriented and clinical research projects.[33,43] More significantly, interferon research has been boosted worldwide during COVID-19 pandemics and CIGB's interferon products were not the exception.[60] This has also been accompanied by the recent, progressive introduction of HeberFERON®, a therapeutic combination of interferons alpha2b and gamma to treat non-melanoma skin cancer.[61] For EGF works, a more progressive trend is seen, notably boosted due to its formulation for intralesional administration in diabetic foot ulcers since its patenting in 2001 and product development under the trademark Heberprot-P®,[62,63] and other applications.[64]

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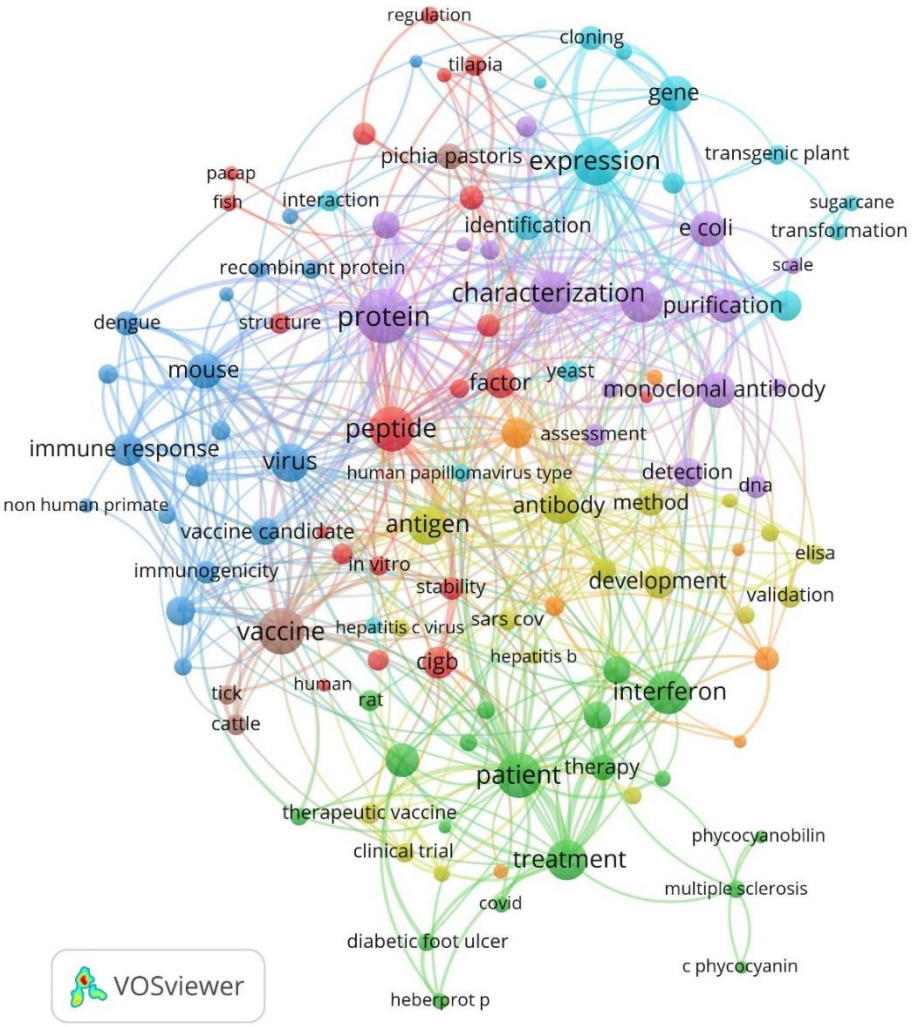

Fig. 8 – Term co-occurrence network from titles of 3667 documents published by the Center for Genetic Engineering and Biotechnology (CIGB) from 1981 to June 14th 2022. Bibliographic records were analyzed with the VOSviewer 1.6.18 software, and the top 123 terms co-occurring at least 10 times were visualized by coauthorship frequency overlay.

Other constant and remarkable CIGB's research lines have been vaccines and immunization (171; together with vaccine candidates, 55), monoclonal antibodies (98; particularly their production), protein and peptide purification studies (82), industrial biotechnology development studies (74), all of them with their associated technologies and molecules. In the case of vaccines and vaccine candidates, the largest output was focused on preventive human hepatitis B and C viruses, dengue, human immunodeficiency virus type 1 (HIV-1) and meningococcal vaccines, therapeutic vaccination against chronic hepatitis B and HIV-1, and remarkably,

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vaccination against cattle tick. This last is one of the steady former research lines in veterinary and agricultural sciences, from 1994[65] to 2022.[66] And as expected, the last addition to the arsenal of vaccines and immunogens developed by the CIGB are the Abdala vaccine[67,68] and other anti-Sars-cov-2 antigens.[69] Regarding monoclonal antibodies, special mention deserve works on the production and characterization of the CB.Hep-1 monoclonal antibody for the production of hepatitis B antigens for vaccine production.[70]

In summary, the publishing features of the CIGB scientific output have been delineated, historically, its properties and main indicators and indexes. Remarkably, the scientific output computed was not limited to indexing sources, but also covered documents in print, the institutional editorial production and online information available as provided by authors in scientific social media and online authors' profiles. The methodology used for information retrieval and annotation provides a consistent record of the CIGB scientific production, which could be contrasted against existing administrative or personal records of scientific production. It is important since scientific social media is consistently gathering more attention to evaluate academic profiles for scientific performance and reputation, and the methods used for its processing and verification become progressively more relevant. At the same time, the framework of indicators used in this work for the analysis of the scientific output of the CIGB could be used to study in parallel the performance of other scientific institutions, included or not. This is essential due to the absence of a national ranking and analysis system of the scientific output of Cuban scientific institutions.

On the other hand, and as shown here, the scientific output of the CIGB has become more selective and remained steady after the constitution of BioCubaFarma and the implementation of the corporate dynamics of the Cuban Biopharmaceutical Industry. This was encompassed by a steady emission of scientific document to high quality indexed journals (particularly to SCI-E indexed journals), and regardless the scientific boom accompanying the COVID-19/SARS-CoV-2 pandemics. Overall, the CIGB has contributed on its entire history a substantial piece of scientific results, information and knowledge to the patrimony of the Cuban nation.

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Appendix Search strategy

Metadata were searched for 'cuba' in the affiliation field.[20] Searches were further refined concurrently for 'center for genetic engineering and biotechnology', 'center of biological research', 'centro de ingeniería genética y biotecnología', 'centro de investigaciones biológicas', 'cigb', 'cib', 'ctr genet engn & biotechnol' and 'ctr ingn genet & biotecnol' (institutional bibliographic standard database abbreviations in WoS). A search was also launched in Scopus under Affiliation ID 60043678 for Center for Genetic Engineering and Biotechnology Havana (10 affiliation name variants). Works with declared official institution name contractions were also retrieved in the remaining bibliography by searching in the author address field for: 'biol' + 'res', 'inv' + "biol', 'genet' + 'eng', 'gen' + 'ing' and 'genet' + 'biotec', followed by visual confirmation. Particularly for the Center of Biological Reserch results, exclusions were established except for works in collaboration (e.g., Ctr Invest Biol Celular & Mol, San Jose, Costa Rica; Ctr Invest Biol Noroeste, CIBNOR, Mexico; and CSIC, Ctr Invest Biol, Madrid, Spain). Redundant searches were implemented with physical address particles as second level non-automatic verification criteria: POBox for '6162' (CIGB in Havana), '6996' or '6332' (CIB), '387' (CIGB Camagüey), '83' or '2345' (CIGB, Sancti Spíritus). ZIP Code information was also inspected, despite grouping several nearby institutions: '10600', '10 600', '11 600' or '11600' (CIGB Havana); '71000', '71 000' or '74650' (CIGB Camagüey); 60 200' or '60200' (CIGB Sancti Spíritus). A final redundant search was done in the remaining unselected records for 'biotec'.

CLASE and PERIÓDICA were searched through its BiBlat affiliation category 'centro de ingeniería genética y biotecnología'; the webpage results were downloaded and batch converted to *.ris* format files with Scopus RIS metadata scheme tags, with the aid of custom Word VBA macros.[20] A custom library containing the full aggregated record of CIGB output in the journal *Biotecnología Aplicada* (©Elfos Scientiae, former *Interferón y Biotecnología*) was used instead of Scopus and WoS database records, to avoid incomplete yearly database coverage. Retrieved records were imported into an EndNote X9 library, and duplicate records were discarded. Information was visually inspected and analyzed based on previous results of the

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bibliometric analysis of *Biotecnología Aplicada* 1984-2012.[28] A final search for 'biotec' among unidentified records retrieved by searching for 'cuba' in the affiliation address was done. The records were inspected and those identified with mistyped data were added.

Furthermore, the documentary collections of Cuban journals *Revista CENIC Ciencias Biológicas* and *Revista CENIC Ciencias Químicas* were searched for CIGB metadata in the article affiliation at document level, and CIGB authored documents were selected. The same was done with the proceedings of the I Cuban Workshop on Interferon (Instituto de Cooperación Iberoamericana 1984), the II Cuban Workshop on Interferon and the I Cuban Workshop on Biotechnology (Instituto de Cooperación Iberoamericana 1986). Also, the official pages of the journals *Anales de la Academia de Ciencias de* Cuba, *VacciMonitor*, *Electronic Journal of Biotechnology, LabCiencia* and *Bionatura* journal were searched for CIGB affiliation.

Conflict of interest

The authors declare the absence of conflicts of interest. E. G. R., Y. R. G. and M. V. C. work at the CIGB, but all the ideas and statements are technically supported and can be confronted with scientific literature and publicly available information sources. Information was managed according to ethical procedures, and scientific authors' data are freely accessible through online resources. The ideas and statements are the sole responsibility of the authors and by no means cannot be regarded as official nor institutional statements.

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