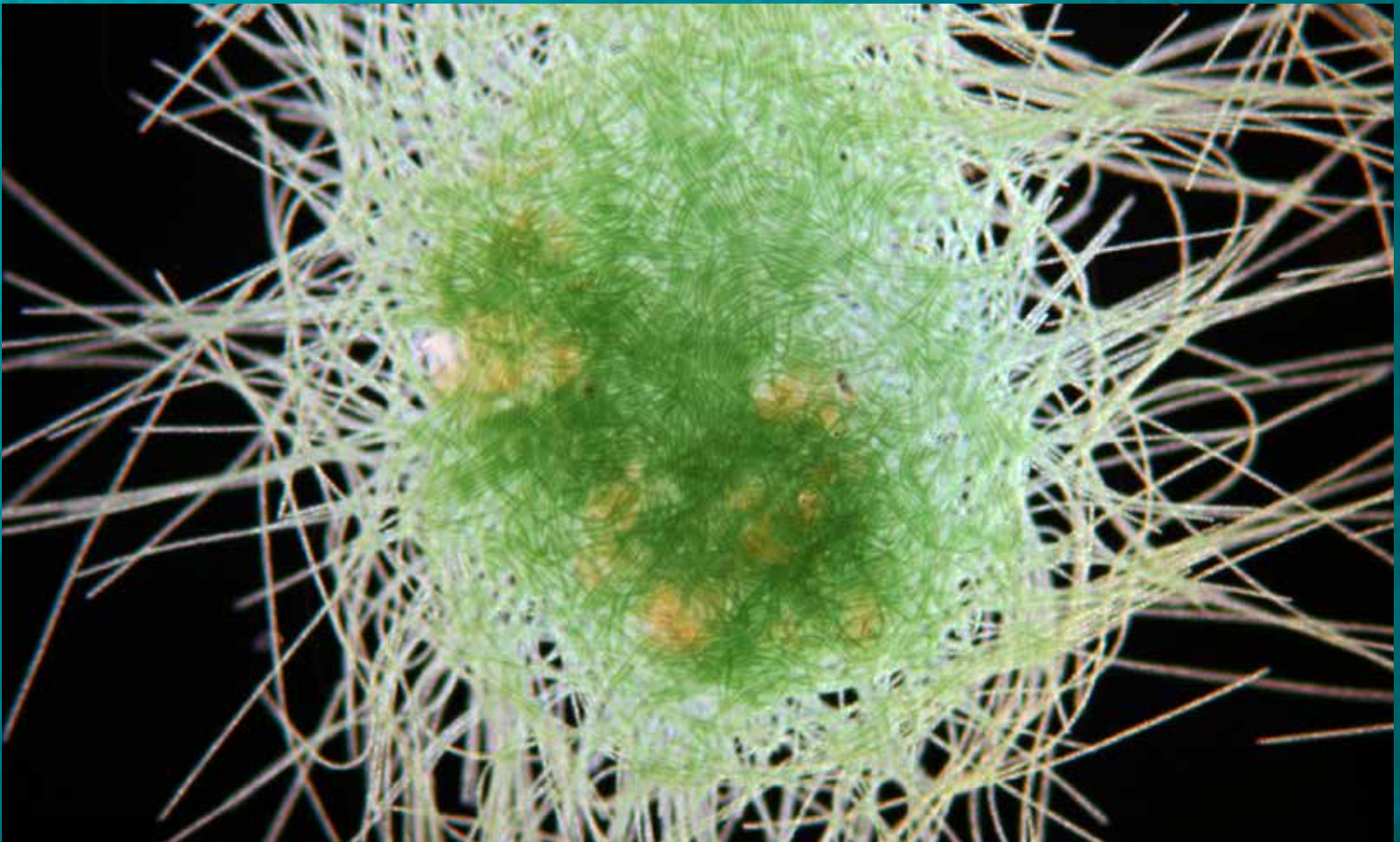


Vol. 11 Nos. 2-3 (2025)  
ISSN: 2448-8100

## *Cymbella* Revista de investigación y difusión sobre algas

Advancing cancer therapeutics: a mini-review of the challenges and opportunities in exploring dinoflagellate-derived bioactive molecules through human cancer cell models



Publicado en línea enero 2026  
Sociedad Mexicana de Ficología  
[www.somfico.org](http://www.somfico.org)

# COMITÉ EDITORIAL

## EDITOR EJECUTIVO:

**Dr. Eberto Novelo**

Facultad de Ciencias, Universidad Nacional Autónoma de México  
enm@ciencias.unam.mx

## EDITORES ADJUNTOS:

**Dr. Abel Sentfies**

Universidad Autónoma Metropolitana-Iztapalapa, México  
asg@xanum.uam.mx

**Dr. Juan Manuel Lopez-Bautista**

Universidad de Alabama, United States of America  
jlopez@biology.as.ua.edu

## ASISTENTE EDITORIAL:

**M. en C. Alejandra Mireles Vázquez**

Fac. Ciencias, Universidad Nacional Autónoma de México  
alemirelesv@ciencias.unam.mx

## EDITORES ASOCIADOS (COMITÉ EDITORIAL TEMÁTICO)

[Florística, Taxonomía, Filogenia y sistemática, Biogeografía y distribución:](#)

**Dr. Erasmo Macaya**

Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Chile  
emacaya@oceanografia.udec.cl

**M. en C. Gloria Garduño Solórzano**

Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México  
ggs@servidor.unam.mx

**Dr. Luis E. Aguilar Rosas**

Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California  
aguilarl@uabc.edu.mx

**Dr. Visitación Conforti**

Facultad de Ciencias Exactas y Naturales Universidad de Buenos Aires, Argentina  
conforti@bg.fcen.uba.ar

[Biología celular y Bioquímica, Fisiología y Ecofisiología:](#)

**Dr. Pilar Mateo Ortega**

Departamento de Biología, Universidad Autónoma de Madrid, España  
pilar.mateo@uam.es

[Algas tóxicas y FANs:](#)

**Dr. Marina Aboal Sanjurjo**

Facultad de Biología, Universidad de Murcia, España  
maboal@um.es

**Dr. Yuri Okolodkov**

Instituto de Ciencias Marinas y Pesquerías, Universidad Veracruzana, México  
yuriokolodkov@yahoo.com

[Ecología de poblaciones y comunidades algales:](#)

**Dr. Ligia Collado Vides**

School of Environment, Arts and Society, Florida International University, United States of America  
Ligia.ColladoVides@fiu.edu

**Dr. Rosaluz Tavera**

Facultad de Ciencias, Universidad Nacional Autónoma de México  
r\_tavera@ciencias.unam.mx

[Ficología aplicada y biotecnología:](#)

**Dr. Eugenia J. Olguín Palacios**

Instituto de Ecología, Centro CONACYT  
eugenia.olguin@inecol.mx

**Dr. Marcia G. Morales Ibarria**

División de Ciencias Naturales e Ingeniería, Universidad Autónoma Metropolitana – Cuajimalpa, México  
mmorales@correo.cua.uam.mx

[Nomenclatura:](#)

**Dr. Francisco F. Pedroche**

Depto. Ciencias Ambientales, División CBS, UAM-Lerma  
fpedroche@correo.ler.uam.mx

Esta publicación es financiada totalmente por el Editor Ejecutivo. No recibe subsidios ni pagos.

## CINTILLO LEGAL

*Cymbella* Revista de investigación y difusión sobre algas. – Vol. 11, Núms 2-3, mayo – agosto, septiembre – diciembre 2025, es una publicación cuatrimestral editada por la Universidad Nacional Autónoma de México, Ciudad Universitaria, Alcaldía Coyoacán, C.P. 04510, Ciudad de México, México, a través del Laboratorio de Algas Continentales, Ecología y Taxonomía de la Facultad de Ciencias, Circuito exterior s/n, Ciudad Universitaria, Col. Copilco, Alcaldía Coyoacán, C.P. 04510, Ciudad de México, Tel. (55) 56225430, <https://cymbella.ciencias.unam.mx/>, enm@ciencias.unam.mx. Editor responsable: Dr. Eberto Novelo Maldonado. Reserva de Derechos al Uso Exclusivo: 04-2016-112410454200-203. ISSN: 2448-8100. Responsable de la última actualización de este número, Laboratorio de Algas Continentales, Ecología y Taxonomía de la Facultad de Ciencias, Dr. Eberto Novelo Maldonado, Circuito exterior s/n, Ciudad Universitaria, Col. Copilco, Alcaldía Coyoacán, C.P. 04510, Ciudad de México, fecha de la última modificación, 11 de enero de 2025.

Los artículos firmados son responsabilidad de los autores y no necesariamente reflejan la opinión de los Editores ni de la Sociedad Mexicana de Ficología. El material publicado puede reproducirse total o parcialmente siempre y cuando exista una autorización de los autores y se mencione la fuente completa y la dirección electrónica de la publicación.

# Advancing cancer therapeutics: a mini-review of the challenges and opportunities in exploring dinoflagellate-derived bioactive molecules through human cancer cell models

Avances en la terapia contra el cáncer: una mini revisión sobre los retos y las oportunidades en la exploración de moléculas bioactivas derivadas de dinoflagelados a través de modelos de cultivo celular con células de cáncer humano

María del Carmen Osorio-Ramírez<sup>1</sup> & Lorena M. Durán-Riveroll<sup>2</sup>

<sup>1</sup>Departamento de Biotecnología Marina, Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California, Ensenada, México. ORCID 0000-0002-3467-5941

<sup>2</sup>SECIHTI-Departamento de Biotecnología Marina, Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California, Ensenada, México. ORCID 0000-0001-8805-7228

Email: lduran@secihtl.mx

Osorio-Ramírez, M.A. & L.M. Durán-Riveroll. 2025. Advancing cancer therapeutics: a mini-review of the challenges and opportunities in exploring dinoflagellate-derived bioactive molecules through human cell culture models. *Cymbella* 11 (2-3): 138-142

DOI: <https://doi.org/10.22201/fc.24488100e.2025.11.2.4>

## ABSTRACT

This review outlines a critical segment of the integration process involved in the discovery of compounds with biological activity as well as pharmacological and biotechnological potential, specifically those derived from dinoflagellates. It discusses the challenges and opportunities in exploring these bioactive molecules in pharmacological research. The objective is to detail some key cell culture techniques, which involve the precise control of experimental conditions and the monitoring of cellular response parameters—including viability, proliferation, cytotoxicity, and cell death—and the appropriate selection of cancerous and non-cancerous human cell lines. Furthermore, this review explores the im-

pact of the various limitations associated with the large-scale biomass production required to obtain pure compounds. The integration of these approaches through specific *in vitro* assays enables the biological characterization of bioactive compounds or active fractions, underscoring the essential role of cell culture as a strategic tool in the search for novel anticancer agents from marine dinoflagellates.

*Keywords: bioactive compounds; cell viability; in vitro assay; marine biotechnology*

## RESUMEN

La presente revisión muestra una parte crítica del proceso de integración que implica el descubrimiento de compuestos con actividad biológica con poten-

cial farmacológico y biotecnológico, específicamente aquellos derivados de dinoflagelados. En esta se discuten algunos de los retos y las oportunidades en la exploración de moléculas bioactivas. El objetivo es detallar algunas técnicas clave del cultivo celular, que involucran el control preciso de las condiciones experimentales y el monitoreo de los parámetros de respuesta celular, como la viabilidad, la proliferación, la citotoxicidad y la muerte celular, así como la selección adecuada de líneas celulares humanas, tanto cancerosas como no cancerosas. Además, esta revisión explora el impacto de las diferentes limitaciones asociadas a la producción de la biomasa de dinoflagelados necesaria para la obtención de compuestos puros. La integración de estas aproximaciones mediante ensayos *in vitro* específicos permite la caracterización biológica de los compuestos o fracciones bioactivas sobre células cancerosas y no cancerosas. Es de esta manera que se resalta la importancia del cultivo celular como herramienta estratégica en la búsqueda de nuevos agentes anticancerosos derivados de dinoflagelados marinos.

*Palabras clave: compuestos bioactivos; biotecnología marina; ensayo in vitro; viabilidad celular*

## INTRODUCTION

Dinoflagellates (Dinophyceae) are a taxonomic group of photosynthetic organisms that play different roles in freshwater and marine ecosystems as primary producers and some build symbiotic relationships with other organisms (De Vera *et al.* 2018; Orefice *et al.* 2023). These organisms are well-known producers of toxins such as the saxitoxins, amphidinols, ciguatoxins, brevetoxins, and cooliatoxin. However, these microalgae have been reported as producers of other secondary metabolites with different biological activities and pharmacological potential, because these microorganisms are found in various environmental conditions. Hence, these compounds are produced through several metabolic pathways; therefore, they have diverse molecular targets for illnesses like cancer (Assunção *et al.* 2017; Cousseau *et al.* 2020).

These compounds acquire a significant relevance in today's world due to their cytotoxic, antineoplastic, and antitumor activities, given that cancer is a growing problem of global concern (Assunção *et al.* 2017). Despite advances in treatments, the incidence of new cases has increased considerably in recent decades, and this group of diseases remains one of the leading causes of death worldwide. One

of the most substantial challenges in its treatment is the resistance of cells to standard chemotherapy drugs. This need has driven research to find new molecules with cytotoxic activity, and marine dinoflagellates are a promising source of bioactive compounds (Abd El-Hack *et al.* 2019). In fact, despite massive research identifying over 300 marine algal toxins, the gaps remain in understanding their mechanisms of action (Gao *et al.* 2024).

## OBTAINING BIOACTIVE COMPOUNDS FROM DINOFLAGELLATES

The search for bioactive compounds in marine and limnological organisms, such as dinoflagellates, represents a complex challenge. This process involves culturing, harvesting, and processing biomass (preferably by freeze-drying), and the use of purified solvents according to the potential components in the mix. The most common solvents are ethanol, methanol, acetone, and water. The reason for using these solvents is that they are polar solvents and they can extract a variety of non-polar and polar compounds with high efficiency. However, the best or optimal solvent depends on the compounds' polarity in the crude extract (Lee *et al.* 2024). Once extracts are dry, to ensure the complete removal of any solvent residues, bioassay-guided fractionation is a common approach to discovering natural products. This method involves a series of steps requiring extract fractionation and purification based on biological activity (Kildgaard *et al.* 2017; Reverter *et al.* 2020).

However, there are numerous challenges in obtaining bioactive compounds. One of the main obstacles is the amount of available biological material, as the cultivation times are often long, and yields are often low. The efficiency of cell disruption methods is critical to ensure the release of all target compounds (López Rodríguez *et al.* 2020). In addition, other technical factors can hinder the process, for example, co-extraction of other compounds, use of large volumes of one or more solvents, or poor selection of these (Getachew *et al.* 2020). Once a pure (or fairly purified) compound is obtained, advanced spectroscopic techniques, such as mass spectrometry (MS), infrared spectroscopy (IRS), and nuclear magnetic resonance (NMR), are used for structural identification. For instance, NMR is a sensitive technique for determining chemical structures, as it is effective with small quantities such as micrograms or even nanograms for analysis. However, it has a significant limitation: the compound must be pure and available for its correct identification (Reverter *et al.* 2020). A promising strategy to overcome these challenges involves the adoption of high-throughput technologies capable of detecting molecular targets within

minimal sample volumes. Notably, the development of omics approaches — Including genomics, transcriptomics, and metabolomics — has revolutionized the study of secondary metabolites. These techniques facilitate not only the comprehensive analysis of low molecular weight compounds (<2 000 Da) but also enable the mapping of vast chemical diversity through metabolomic and proteomic profiling. Simultaneously, genomic and transcriptomic analyses elucidate the underlying biosynthetic pathways and regulatory mechanisms governing metabolite production (Reverter *et al.* 2020; Rochfort 2005).

### PRINCIPLES OF HUMAN CANCER CELL CULTURE AS RESEARCH MODELS

Human cell culture is one of the most important techniques for cellular and molecular biology research. The process consists of the growth of cells under controlled conditions (*in vitro*), e.g., temperature, pH, and nutrients. The use of cultured cells is linked to creating model systems of several diseases that have led to studying basic cell biology, mechanisms of action, investigating the toxicity of novel drug compounds (Segeritz & Vallier 2017), and to screen novel chemicals, cosmetics, and other compounds for efficacy and to assess drug cytotoxicity (Gilmor *et al.* 2023).

In this review we are focused on the research on cancer cells, because this group of illnesses is a leading cause of incidence and death in the world, and the search for new molecules continues to be a challenge (Gilmor *et al.* 2023). For this reason, exploring bioactive compounds of dinoflagellates can be used to determine the potential of those that possess biological activity against cancer (Pradhan & Ki 2022).

In this context, we will expand on important aspects of human cell cultures and cancer to evaluate secondary metabolites of dinoflagellates as potential treatments. Depending on the cell type (i.e., the cancer type), some of the discussed parameters may vary. This is particularly true for protocols involving activation, maintenance, and cryopreservation. In this context, cell viability is considered the most critical factor, as experimental results and their reproducibility, the number of passages, and the activation process post-thaw all depend on cells being in optimal condition (Geraghty *et al.* 2014).

### IMPLEMENTING BEST PRACTICES FOR OPTIMAL HUMAN CELL CULTURE

Good practices in the cell culture laboratory are necessary to evaluate different biological activities. These include: 1) safe handling of human cell lines; 2) safe and reliable experimental designs and

procedures; 3) aseptic technique in the handling of cells, an organized work environment, and sufficient reagents and media for cell culture; 4) the correct selection of cell lines to be used; and 5) the proper conditions under which cells are maintained, and the know-how of subculture maintenance and cell cryopreservation processes (Dubovi & Rankin 2023; Gilmor *et al.* 2023; Segeritz & Vallier 2017; Weiskirchen *et al.* 2023; Zhao 2023).

In addition to these considerations, it is important to record the number of passages performed from the start of the culture. The consequence of not having these records is that some cell lines are unsuitable for experimental work beyond a certain number of passages, such as a high number of passages and a prolonged time between subcultures, which can lead to mutations, duplications, and epigenetic changes. For this reason, it is important to certify the cells from the start of the experiment, as these changes can alter the morphology and proliferation rate and increase or decrease the cell divisions over time, affecting cell behavior and overall cell health. Consequently, these changes could affect reproducibility in experiments and results (Geraghty *et al.* 2014). Another problem is cell misidentification or contamination. This includes the use of illegible labels and mislabeling of cell culture vessels during manipulation. The misidentification of cell lines has resulted in erroneous results, interpretations and publications (Babic *et al.* 2019).

The correct selection of cell lines is important for experimental design. Understanding the fundamental classification of cell types is essential, as cells are broadly categorized into three groups:

- a) stem cells are considered undifferentiated cells capable of self-renewal and multilineage differentiation, e.g. embryonic stem cells (Zumwalt & Reddy 2020);
- b) primary cells or fine cell lines: these cells are directly taken from a body or tissue. As the name implies, they can only be cultured for a finite number of passages, e.g., fibroblasts (Godbey 2014);
- c) immortalized cells or continuous cell lines: these are primary cells that have been genetically modified for infinite culture, e.g., human cancer cell lines (Rahman *et al.* 2016).

### CELL VIABILITY AND PROGRAMMED CELLULAR DEATH DETECTION ASSAYS

*In vitro* studies are essential steps in the search for new therapies against cancer, and specific mechanisms of action have been found. Therefore, depending on the biological activity of interest, such as cytotoxic, antineoplastic, or antitumor, different assays are employed to determine whether these

compounds are bioactive. However, it is necessary to first define some concepts:

**Viability**, which is the capacity to perform the essential metabolic processes to maintain structural and functional integrity, is represented as the percentage of healthy cells in the population.

**Proliferation** is a process that leads to an increased number of cells through cell division.

**Cell death** refers to irreversible conditions or processes in non-viable cells, including apoptosis, autophagy, and necrosis.

**Cytotoxicity** is a cellular injury that may be reversible or progress to cell death (Adan *et al.* 2016).

Cell death includes the measurement of dead cells (cytotoxicity assay), quantification of live cells (viability assay), and finally, determination of the accurate mechanisms of death (Cousseau *et al.* 2020). For this, various assays can be used, such as dye exclusion, one of the most common being trypan blue dye exclusion. Colorimetric assays, including lactate dehydrogenase, 3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium (MTS), and 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT), and luminometric assays, such as the ATP assay, are used to determine the viability of cells and proliferation assays (Aslantürk 2018). According to the many proteins involved in the apoptosis signaling cascade, there are different apoptosis assays to assess cell death. Two or more assays should be used to detect apoptosis accurately since many overlapping features exist between apoptosis and necrosis. There are six major groups of available assays to detect apoptosis: membrane alteration, mitochondrial assays, cytomorphological alterations, DNA fragmentation, detection of caspases, cleaved substrate, inhibitors and regulators, and detection of apoptosis. Among those assays, early apoptosis could be detected through annexin V or acridine orange and ethidium bromide (AO/EB), which is based on the loss of cellular membrane integrity. Also, many assays can detect the midphase of apoptosis using caspase activation and molecular processing, including the key enzyme poly (ADP-ribose) polymerase (PARP). The late phase of apoptosis could be detected with DNA fragmentation assays. Combinations of these assays allow us to identify the mechanisms of apoptosis induction after a specific stimulus (Alshiraihi & Kato 2023; Azqueta *et al.* 2022).

## FINAL CONSIDERATIONS

The exploration of secondary metabolites from dinoflagellates offers innovative opportunities for discovering novel cancer therapeutics. However, the

success of such research relies heavily on the chemical identification of the compounds of interest. As emphasized in this work, this process requires obtaining purified compounds from cell cultures, coupled with the rigorous application of human cell culture techniques to enable reliable evaluation of their biological activities and mechanisms of action. Therefore, integrating appropriate practices in metabolite extraction, handling both cancerous and non-cancerous cell lines, and employing specific assays to assess viability, proliferation, and cell death is essential to ensure reproducible results and accurately propose mechanisms of action for dinoflagellate-derived metabolites. Ultimately, cell culture serves as a critical bridge connecting marine biodiversity to the development of future pharmacology strategies based on natural products.

## REFERENCES

- Abd El-Hack, M.E., S. Abdelnour, M. Alagawany, M. Abdo, M.A. Sakr, A.F. Khafaga, S.A. Mahgoub, S.S. Elnesr, & M.G. Gebriel. 2019. Microalgae in modern cancer therapy: Current knowledge. *Biomedicine & Pharmacotherapy* 111: 42-50. <https://doi.org/10.1016/j.biopha.2018.12.069>
- Adan A., Y. Kiraz, & Y. Baran. 2016. Cell proliferation and cytotoxicity assays. *Current Pharmaceutical Biotechnology* 17: 1213-1221. <https://doi.org/10.2174/1389201017666160808160513>
- Alshiraihi, I., Kato, T.A. 2023. Apoptosis detection assays. *In: Gotoh, E. Ed. Chromosome Analysis. Methods in Molecular Biology. Springer Protocols* 2519. [https://doi.org/10.1007/978-1-0716-2433-3\\_6](https://doi.org/10.1007/978-1-0716-2433-3_6)
- Aslantürk, Ö. S. 2018. *In vitro* cytotoxicity and cell viability assays: principles, advantages, and disadvantages. *In: M. L. Larramendy & S. Soloneski. Eds. Genotoxicity – A predictable risk to our actual world. IntechOpen* 2: 64-80. <https://doi.org/10.5772/intechopen.71923>
- Assunção, J., A.C. Guedes, & F.X. Malcata. 2017. Biotechnological and pharmacological applications of biotoxins and other bioactive molecules from dinoflagellates. *Marine Drugs* 15: 393. <https://doi.org/10.3390/md15120393>
- Azqueta, A., H. Stopper, B. Zegura, M. Dusinska, & P. Møller. 2022. Do cytotoxicity and cell death cause false positive results in the *in vitro* comet assay? *Mutation Research/Genetic Toxicology and Environmental Mutagenesis* 881: 503520. <https://doi.org/10.1016/j.mrgentox.2022.503520>
- Babic, Z., A., Capes-Davis, M.E. Martone, A. Bairoch, I.B. Ozyurt, T.H. Gilespe, & A. E. Bandrowski. 2019. Incidences of problematic cell lines are lower in papers that use RRIDs to identify cell lines. *Elife* 8: e41676. <https://doi.org/10.7554/eLife.41676>

- Cousseau, A., Siano, R., Probert, I., Bach, S., & Mehiri, M. 2020. Chapter 4 - Marine dinoflagellates as a source of new bioactive structures. *In: Atta-ur-Rahman. Ed. Studies in Natural Products Chemistry*. V. 65. Elsevier. pp: 125-171. <https://doi.org/10.1016/B978-0-12-817905-5.00004-4>.
- De Vera, C.R., G. Díaz Crespín, A. Hernández Daranas, S. Montalvão Looga, K. E. Lillsunde, P. Tammaña, M. Perälä, V. Hongisto, J. Virtanen, & H. Rischer. 2018. Marine microalgae: promising source for new bioactive compounds. *Marine Drugs* 16: 317. <https://doi.org/10.3390/md16090317>
- Dubovi, E.J. & S.C. Rankin. 2023. Isolation in cell culture. *In: J. E. Sykes. Ed. Greene's Infectious Diseases of the Dog and Cat*. Elsevier, London. pp. 3-10. <https://doi.org/10.1016/B978-0-323-50934-3.01001-6>
- Gao, X., H. Wang, K. Chen, Y. Guo, J. Zhou, & W. Xie. 2024. Toxicological and pharmacological activities, and potential medical applications, of marine algal toxins. *International Journal of Molecular Sciences* 25: 9194. <https://doi.org/10.3390/ijms25179194>
- Geraghty, R., A. Capes-Davis, J. Davis, J. Downward, R. Freshney, I. Knezevic, R. Lovell-Badge, J. Masters, J. Meredith, & G. Stacey. 2014. Guidelines for the use of cell lines in biomedical research. *British Journal of Cancer* 111: 1021-1046. <https://doi.org/10.1038/bjc.2014.166>
- Getachew, A.T., C. Jacobsen, & S.L. Holdt. 2020. Emerging technologies for the extraction of marine phenolics: Opportunities and challenges. *Marine Drugs* 18: 389. <https://doi.org/10.3390/md18080389>
- Gilmor, R., H. Qamar, & N. Huerta. 2023. Basic research. *In: A.E.M. Eltorai, P.C. Newel, J.A. Bakal, A.J. Osband. Eds. Translational Surgery*. Elsevier, London. pp: 15-19.
- Godbey, W.T. 2014. Cell Culture and the eukaryotic cells used in biotechnology. *In: W.T. Godbey. Ed. An introduction to Biotechnology*. Elsevier, Amsterdam. pp: 165-172. <https://doi.org/10.1016/B978-1-907568-28-2.09993-7>
- Kildgaard, S., K. Subko, E. Phillips, V. Goidts, M. De la Cruz, C. Díaz, C.H. Gotfredsen, B. Andersen, J.C. Frisvad, & K.F. Nielsen. 2017. A dereplication and bioguided discovery approach to reveal new compounds from a marine-derived fungus *Stilbella fimetaria*. *Marine Drugs* 15: 253. <https://doi.org/10.3390/md15080253>
- Lee, J., T.M.J. Jayakodge, K. Jae-II, J. Jim-Woo, C. Kyung-Min, K. Tae-Su, S. Chan, A. Iman, H. Jimin, & R. Bomi. 2024. The influence of solvent choice on the extraction of bioactive compounds from Asteraceae: A comparative review. *Foods* 12: 19. <https://doi.org/10.3390/foods13193151>
- López Rodríguez, M., M.C. Cerón, L. López-Rosales, E. Navarro-López, A. Sánchez-Mirón, A. Molina Miras, A.C. Abreu, I. Fernández, & F. García Camacho. 2020. Improved extraction of bioactive compounds from the marine dinoflagellate microalga *Amphidinium carterae* biomass. *Bioresource Technology*: 313: 123518. <https://doi.org/10.1016/j.biortech.2020.123518>
- Orefice, I., S. Balzano, G. Romano, & A. Sardo. 2023. *Amphidinium* spp. as a source of antimicrobial, antifungal, and anticancer compounds. *Life* 13: 2164. <https://doi.org/10.3390/life13112164>
- Pradhan, B. & J. S. Ki. 2022. Phytoplankton toxins and their potential therapeutic applications: A journey toward the quest for potent pharmaceuticals. *Marine Drugs* 20: 271. <https://doi.org/10.3390/md20040271>
- Rahman, N.A., A.N.H.M. Rasil, U. Meyding-Lamade, E.M. Craemer, S. Diah, A.A. Tuah, & S.H. Muharram. 2016. Immortalized endothelial cell lines for *in vitro* blood-brain barrier models: a systematic review. *Brain Research* 1642: 532-545. <https://doi.org/10.1016/j.brainres.2016.04.024>
- Reverter, M., S. Rohde, C. Parchemin, N. Tapissier-Bontemps, & P.J. Schupp. 2020. Metabolomics and marine biotechnology: coupling metabolite profiling and organism biology for the discovery of new compounds. *Frontiers in Marine Science* 7: 613471. <https://doi.org/10.3389/fmars.2020.613471>
- Rochfort, S. 2005. Metabolomics reviewed: a new "omics" platform technology for systems biology and implications for natural products research. *Journal of Natural Products* 68: 1813-1820. <https://doi.org/10.1021/np050255w>
- Segeritz, C.-P. & L. Vallier. 2017. Cell culture: Growing cells as model systems *in vitro*. *In: M.B. Mortaza Jalali. Ed. Basic science methods for clinical researchers. Elsevier*, pp: 151-172. <https://doi.org/10.1016/B978-0-12-803077-6.00009-6>
- Weiskirchen, S., S.K. Schröder, E.M. Buhl, & R. Weiskirchen. 2023. A beginner's guide to cell culture: Practical advice for preventing needless problems. *Cells* 12: 682. <https://doi.org/10.3390/cells12050682>
- Zhao, C. 2023. Cell culture: *In vitro* model system and a promising path to *in vivo* applications. *Journal of Histochemistry* 46: 1-4. <https://doi.org/10.1080/01478885.2023.2170772>
- Zumwalt, M. & A.P. Reddy. 2020. Stem cells for treatment of musculoskeletal conditions-orthopaedic/sports medicine applications. *Biochimica et Biophysica Acta - Molecular Basis of Disease* 1866: 165624. <https://doi.org/10.1016/j.bbadis.2019.165624>

Sometido: 28 de abril de 2025

Revisado: 28 de mayo de 2025

Corregido: 17 de septiembre de 2025

Aceptado: 19 de septiembre de 2025

# DIRECTORIO

**SOCIEDAD MEXICANA DE FICOLOGÍA**

<https://somfico.org/>

## **COMITÉ EJECUTIVO NACIONAL 2023-2025**

### **Ileana Ortigón-Aznar**

Presidenta

Universidad Autónoma de Yucatán (UADY), Mérida,  
Yucatán

e-mail: oaznar@correo.uady.mx

### **Dr. José Antolín Aké Castillo**

Vicepresidente

Instituto de Ciencias Marinas y Pesquerías, Universidad  
Veracruzana

e-mail: aake@uv.mx

### **Dr. Julio Adulfo Acosta Calderón**

Secretario General

Universidad del Mar

e-mail: julio seaweed@gmail.com

### **Dra. Erika Fabiola Vázquez Delfín**

Secretaria Académica

CINVESTAV Mérida

e-mail: erika.vazquez@cinvestav.mx

### **Dr. Armin Tuz Sulub**

Secretario Administrativo

UADY

e-mail: tuz@correo.uady.mx

### **M. en C. Emmanuel Santos May**

Secretario de Difusión y Extensión

UADY

e-mail: miva.uam@gmail.com

## **CRÉDITO DE FOTO DE LA PORTADA**

Laberinto de *Planktothrix* sp.

Montaje semipermanente. Foto in vivo. Objetivo 10X

Kathie Monserrat Estrada Gutiérrez

Unidad Nayarit del Centro de Investigaciones Biológicas del Noroeste, S.C. (UNCIBNOR). Tepic,  
Nayarit.

Ganadora del Concurso SOMEFAN de fotografía microscópica para mujeres. VII Congreso de la  
Sociedad Mexicana para el Estudio de los Florecimientos Algales Nocivos, A.C., octubre de 2024.