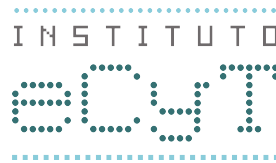


LA COMPRENSIÓN A TRAVÉS DE LA EXPERIENCIA

UNA PROPUESTA PRAGMATISTA-INFERENCIAL PARA LAS CIENCIAS
BIOLÓGICAS



TESIS DOCTORAL

Departamento de Filosofía, Lógica y Estética
Instituto Universitario de Estudios de la Ciencia y la Tecnología (iECyT)

Universidad de Salamanca, España

PRESENTADA POR:

MARIANO MARTÍN VILLUENDAS

Directora: Dr.^a Ana Cuevas Badallo
Programa de Doctorado: Lógica y Filosofía de la Ciencia

Salamanca, 2024

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UNDERSTANDING THROUGH EXPERIENCE
A PRAGMATIST-INFERENTIALIST ACCOUNT FOR THE LIFE SCIENCES

Tesis presentada por: Mariano Martín Villuendas
Dirigida por: Ana Cuevas Badallo

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Esta tesis doctoral opta a la Mención de Doctorado Internacional

A mis Padres

A mi Abuelo Mariano

“Every thinker puts some portion of an apparently stable world in peril and no one can wholly predict what will emerge in its place”

John Dewey
Experience and Nature

RESUMEN

La presente tesis doctoral persigue dos objetivos fundamentales. El primer objetivo consiste en mostrar que muchos de los problemas conceptuales que actualmente afectan a la investigación biológica tienen su raíz en cuestiones de naturaleza metacientífica. En la tesis muestro que el marco metacientífico comúnmente adoptado a la hora de conceptualizar, tanto descriptiva como normativamente, la práctica científica ha sido el onto-representacionalismo. A través de una consideración detallada de los presupuestos que lo estructuran –ontológico, epistemológico y (meta)semántico– muestro que este enfoque, además de enfrentar problemas internos sumamente difíciles de resolver, conduce a una serie de paradojas conceptuales en su aplicación a la práctica científica efectiva que terminan por dificultar el avance de nuestra comprensión de la realidad biológica. Ilustro estas consideraciones a través del análisis de dos debates actuales. El primero se encuadra dentro de las investigaciones llevadas a cabo en el campo de la biología evolutiva. A saber, la cuestión en torno a la naturaleza de la herencia. El segundo está asociado a la investigación biomédica. Véase, el debate en torno a los mecanismos que definen el proceso carcinogénico. El segundo objetivo no es otro más que articular una alternativa metacientífica a través de la cual resolver los problemas que enfrenta el onto-representacionalismo. Denominaré a este marco “enfoque Pragmatista-Inferencial” (PrInf). Para ello, articularé unos presupuestos –ontológico, epistemológico y (meta)semántico– alternativos sirviéndome de las reflexiones establecidas por la corriente filosófica del pragmatismo y del inferencialismo. Concluiré mostrando que la mejor forma de articular una práctica científica efectiva que impulse nuestra comprensión de la realidad pasa por abrazar un proyecto de ciencia plural en clave pragmatista.

PALABRAS CLAVE: Modelos Científicos; Pragmatismo; Comprensión Científica; Representación Científica; Artefactualismo; Realismo Científico; Factivismo; Veritismo; Representacionalismo; Cáncer; SMT; TOFT; Síntesis Moderna; Síntesis Evolutiva Extendida; Epigenética; Herencia.

ABSTRACT

The aim of this dissertation is twofold. First, to show that many of the conceptual problems that currently pervade biological research are rooted in meta-scientific issues. In the dissertation, I show that the meta-scientific framework commonly adopted in conceptualizing, descriptively and normatively, scientific practice has been onto-representationalism. Through a detailed analysis of the assumptions that structure it—ontological, epistemological and (meta)semantic—I show that this approach faces internal problems that are extremely difficult to overcome and leads to a series of conceptual paradoxes in its application to scientific practice that eventually hinder the advancement of our understanding of biological reality. I illustrate the aforementioned remarks through a detailed analysis of two contemporary debates. The first one is framed within the research carried out in the field of evolutionary biology, the controversy surrounding the nature of inheritance. The second is related to biomedical research, the debate on the mechanisms defining the carcinogenic process. The second goal of the dissertation is to articulate a meta-scientific alternative to solve the problems faced by onto-representationalism. I will name this framework “the Pragmatist-Inferentialist approach” (PrInf). To do so, I will articulate alternative assumptions—ontological, epistemological and (meta)semantic—by drawing on the reflections established by the philosophical schools of pragmatism and inferentialism. I conclude by showing that the best way to articulate an effective scientific practice that promotes our understanding of reality is to embrace a project of plural science from a pragmatist standpoint.

KEYWORDS: Scientific Models; Pragmatism; Scientific Understanding; Scientific Representation; Artifactualism; Scientific Realism; Factivism; Veritism; Representationalism; Cancer Research; SMT; TOFT; Modern Synthesis; Extended Evolutionary Synthesis; Epigenetics; Heredity.

NOTA SOBRE LA TESIS DOCTORAL

Algunas de las ideas aquí presentadas han sido publicadas en diversos artículos y capítulos de libro:

- Martín-Villuendas, M. (en prensa). A Pragmatist View of Heredity: Putting Epigenetics in its Context. En C. Guerrero-Bosagna (ed.), *Epigenetics and Evolution*. Academic Press.
- Fábregas-Tejeda, A. y Martín-Villuendas, M. (2023). What is the Philosophy of Organismal Biology? *ArtefaCToS. Revista de Estudios sobre la Ciencia y la Tecnología*, 12(1), pp. 5-25. <https://doi.org/10.14201/art2023121525>
- Martín-Villuendas, M. (2023). Una articulación de la epidemiología epigenética. *Tópicos, Revista de Filosofía* (67), pp. 411-452. <https://doi.org/10.21555/top.v670.2411>
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- Martín-Villuendas, M. (2021). Una reconsideración pluralista del concepto de herencia. *Contrastes. Revista Internacional de Filosofía*, XXVI(3), pp. 25-47. <https://doi.org/10.24310/Contrastescontrastes.v26i3.10251>
- Martín-Villuendas, M. (2021). No somos nuestros genes: consideraciones en torno a la definición molecular de gen. *Disputatio. Philosophical Research Bulletin*, 10(16), pp. 103-137. <https://doi.org/10.5281/zenodo.4678992>

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INTRODUCCIÓN A LA TESIS DOCTORAL

Introducción. Dos marcos metacientíficos para un problema común: el onto-representacionalismo y el enfoque Pragmatista-Inferencial (PrInf)

Uno de los problemas que enfrenta la actual práctica biológica consiste en tratar de dar sentido a la existencia de una pluralidad de modelos que nos proveen de explicaciones que dibujan una descripción diferente –y en ocasiones contradictoria– de un mismo fenómeno natural. En pocas palabras, cómo dar sentido a la pluralidad de modelos presente en las distintas ramas que componen la empresa científica. Esta cuestión, ciertamente global, engloba una serie de preguntas mucho más específicas: ¿qué explica que distintos modelos proporcionen una descripción diferente o contradictoria de una misma realidad natural? ¿Es esta situación el reflejo de una ciencia inmadura? ¿Es esta epistémicamente beneficiosa? ¿Deberíamos promover políticas científicas que apuesten por tal pluralidad? A modo de ilustración, en la tesis consideraré dos casos de estudio. El primero concierne al debate que ha tenido lugar en los últimos años en torno a la naturaleza de la herencia. Aquí es posible identificar tres posturas marcadamente diferenciadas: aquellos autores que han defendido que la herencia constituye un fenómeno de naturaleza esencialmente genética; los que han propuesto ampliar la noción de herencia para incluir las alteraciones epigenéticas, manteniendo, eso sí, los presupuestos conceptuales que subyacen al concepto tradicional –transgeneracionalidad y línea germinal–; y los que han abogado por un concepto extendido que rompa con todo remanente teórico asociado al concepto estándar de raigambre genocentrista. El segundo caso de estudio que consideraré será el relativo al debate en torno a las características y mecanismos que definen el proceso carcinogénico. Aquí examinaré dos teorías que han realizado afirmaciones marcadamente contradictorias sobre el cáncer: los defensores de la Teoría Somática Mutacional (*the Somatic Mutation Theory*) han sostenido que el cáncer es una enfermedad celular producida por determinadas alteraciones genéticas o epigenéticas; los partidarios de la Teoría del Campo de la Organización de Tejidos (*the Tissue Organization Field Theory*) han argumentado que el cáncer es una enfermedad del tejido que tiene lugar debido a la disrupción de los campos morfogenéticos/morfostáticos que orquestan y mantienen su organización.

Aunque ciertos autores han abogado activamente por revestir a esta pluralidad de una significación positiva (Cartwright, 1999; Chang, 2022; Dupré, 1993; Galison y Stump, 1996; Kellert et al., 2006; Longino, 2013; Mitchell, 2003, 2009; Plutynski, 2018; Ruphy, 2016), la visión mayoritariamente adoptada ha sido la contraria. En la tesis argumento que la incomodidad con esta pluralidad responde a razones de carácter metacientífico, no científico. Por metacientífico entiendo el conjunto de presupuestos teóricos o filosófico-conceptuales que se emplean a la hora de definir cómo ha procedido (plano descriptivo) y/o cómo debería proceder (plano normativo) el quehacer científico. Un análisis detallado de la práctica científica revela que no existe ninguna consideración genuinamente científica que nos lleve a concluir que los diversos modelos aquí examinados dibujan una descripción excluyente o contradictoria del fenómeno estudiado. Tampoco que esta pluralidad de modelos se traduzca en un obstáculo epistémico a la hora de guiar una práctica científica eficiente que permita avanzar en la comprensión de la realidad biológica. Estas conclusiones son el resultado, más bien, de la adopción de un marco metacientífico sumamente particular: el *onto-representacional*.

Más concretamente, son el producto de la *reificación ontológica* llevada a cabo por el mismo. Los presupuestos que lo estructuran –ontológico, epistemológico y (meta)semántico– han motivado que los científicos terminen por reificar ontológicamente los modelos con los que trabajan. El concepto de reificación será central a lo largo de la tesis. Por reificación entiendo considerar que los resultados revelados por los modelos son un reflejo de las propiedades constitutivas del fenómeno estudiado. Esta reificación conduce a creer que solo existe una descripción adecuada del objeto científico analizado: o bien la provista por el modelo manejado; o bien una a la que todavía tenemos que aspirar. Esto se cifra en una consideración axiológica sobre el pluralismo existente en la actual investigación biológica: este es el reflejo de una práctica científica inadecuada o inmadura. Para solventar este problema, los investigadores han adoptado dos estrategias diferentes. O bien han abrazado una suerte de pensamiento paradigmático, en donde se considera que solo uno de los modelos en disputa provee la descripción adecuada de las características constitutivas del fenómeno, por lo que solo este es capaz de otorgar comprensión fáctica. O bien se ha abogado por un pensamiento de unificación, en donde se percibe que los modelos dibujan una descripción incompleta de las características constitutivas del fenómeno, por lo que el objetivo debe consistir en construir un modelo más completo y preciso capaz de proporcionarnos una genuina comprensión fáctica del fenómeno. Un proyecto de ciencia eficaz pasa por unificar las distintas visiones parciales que tenemos del *explanandum*, mostrando cuáles son los patrones generales que subsumen los distintos casos particulares, así como las relaciones que existen entre las explicaciones que ponen el foco en distintas escalas de regulación o niveles de análisis.

La cuestión que debiéramos preguntarnos es si estas consideraciones metacientíficas conducen a una práctica científica más eficiente y exitosa o si no es el caso. En la tesis trato de mostrar que la reificación ontológica ocasionada por la adopción del onto-representacionalismo genera una serie de problemas conceptuales y empíricos que terminan por dificultar una comprensión adecuada del fenómeno investigado. En lo relativo al debate sobre la herencia, esta reificación desemboca en un empobrecimiento epistémico y en una vaguedad explicativa. El primero tiene que ver con el oscurecimiento de todos los mecanismos que no se ajustan a la visión de la herencia planteada. La segunda tiene que ver con la imposibilidad de desarrollar criterios normativos a través de los cuales evaluar si los resultados revelados en torno a las potenciales contribuciones causales de los distintos mecanismos considerados en la reconstrucción de los fenotipos son adecuados o no. En el caso del cáncer, la reificación conduce a paradojas conceptuales, como tener dos teorías contradictorias, pero exitosas, sobre un mismo fenómeno y a estancamientos teóricos en donde se pierde la dinámica de intercambio y de constreñimiento teórico y experimental.

Para mostrar que la reificación ontológica es el producto directo de la adopción del onto-representacionalismo analizaré los presupuestos metacientíficos que lo estructuran. Los presupuestos son los siguientes. Presupuesto epistemológico –veritismo: la comprensión fáctica, que constituye el objetivo de la práctica científica, se estructura en torno a relatos explicativos verdaderos más ciertas condiciones adicionales. Presupuesto ontológico –interpretación osada de la tesis ontológica del realismo científico: la comprensión científica fáctica se deriva de la captación de (ciertos aspectos de) la estructura óptica de la realidad, la

cual es preexistente, objetiva, independiente de la mente y accesible. Presupuesto (meta)semántico –representacionalismo y teoría de la correspondencia: los sistemas modelo constituyen la fuente a través de la cual se estructura la comprensión fáctica de los fenómenos. El valor semántico de la información obtenida radica en su carácter referencial. En otras palabras, los elementos del modelo (las proposiciones que componen las descripciones del sistema modelo o las que estructuran las explicaciones que extraemos a través de su empleo –*truthbearers*–) guardan una correspondencia con los componentes que articulan la estructura óptica de los sistemas objetivo –*truthmakers*–, al menos en lo relativo a los elementos que son causalmente centrales en el surgimiento del comportamiento o aspecto considerado –*difference-makers*. Además de ilustrar hasta qué punto la aplicación de este marco a la práctica científica real conduce a los problemas ya mencionados, mostraré que este es presa de una serie de tensiones conceptuales. Localizaré las mismas en el presupuesto (meta)semántico. Con ello evidenciaré hasta qué punto el onto-representacionalismo constituye un marco metacientífico inadecuado: además de ser una propuesta inconsistente, es incapaz de racionalizar de manera adecuada el desarrollo científico, así como guiar una práctica científica eficiente capaz de impulsar una comprensión adecuada de la realidad biológica.

Con el objetivo de suplir el vacío dejado por el onto-representacionalismo, articularé una alternativa que denominaré “enfoque Pragmatista-Inferencial” (PrInf). Argumentaré que una reconceptualización en clave pragmatista de los presupuestos metacientíficos constituye la estrategia más adecuada a la hora de acomodar descriptivamente la dinámica de desarrollo histórico de las disciplinas científicas y guiar una práctica científica adecuada que nos permita comprender de manera eficiente los fenómenos naturales. Este marco reemplazará los tres presupuestos metacientíficos del onto-representacionalismo por los siguientes. Presupuesto ontológico –experiencia diacrónica: el sujeto no aprehende una estructura óptica preexistente y objetiva. Más bien, experimenta un mundo sobre la base de una historia de relaciones de transacción con su respectivo entorno o ambiente epistémico. Presupuesto epistemológico –comprensión no fáctica: un sujeto comprende cuando es capaz de formular una declaración de inteligibilidad de manera eficiente. Presupuesto (meta)semántico –inferencialismo pragmatista y criterio de efectividad: el contenido semántico de los ítems lingüísticos se deriva de las conexiones inferenciales que mantienen con los restantes ítems lingüísticos que articulan la estructura epistémica diacrónicamente edificada dentro de un curso particular de experiencia. La declaración de inteligibilidad sobre la que se cimenta la comprensión es correcta y es legítimo adscribir comprensión al agente cognitivo si y solo si la articulación conceptual es efectiva, donde la efectividad se determina por una condición empírica y otra normativa. Apoyándome en el marco PrInf y en una serie de consideraciones históricas relativas al desarrollo de los modelos encuadrados en sendos casos de estudio mostraré que la afirmación sobre la supuesta incompatibilidad de estos modelos es descriptivamente falsa y que la unificación es normativamente indeseable. En otras palabras, no se trata solo de que no existan problemas a la hora de reconocer la existencia de influencias recíprocas. La cuestión central es que es necesario retener esta pluralidad de perspectivas si queremos articular una investigación científica eficaz capaz de contribuir al avance de nuestra comprensión de la realidad biológica.

Hipótesis y objetivos de la tesis doctoral

La hipótesis central de la presente tesis doctoral es que una adecuada conceptualización de la práctica científica pasa por abrazar un pluralismo en clave pragmatista. Para demostrar este punto, perseguiré dos objetivos.

En primer lugar, ilustraré que las reticencias expresadas en contra de este proyecto de ciencia plural hunden sus raíces en consideraciones de carácter metacientífico, no científico. Más concretamente, se derivan de la adopción de un marco metacientífico sumamente particular a través del cual conceptualizar el proceder científico: el onto-representacionalismo. A través de un análisis detallado de los presupuestos que lo estructuran, ilustraré cómo este enfoque, además de enfrentar una serie de problemas teóricos sumamente difíciles de resolver, conduce a ciertas paradojas conceptuales en su aplicación a la práctica científica efectiva, las cuales están relacionadas con el fenómeno de la reificación ontológica. Ejemplificaré esto último a través de dos casos de estudio: el debate en torno a la naturaleza de la herencia y del cáncer. Concluiré sosteniendo que es preciso articular un marco metacientífico alternativo que reemplace al onto-representacional.

En segundo lugar, afrontaré la tarea de formular una propuesta metacientífica innovadora. Denominaré a esta última “enfoque Pragmatista-Inferencial” (PrInf). A través de una consideración detallada de los presupuestos que lo estructuran esclareceré cómo este enfoque disuelve las paradojas conceptuales generadas por el onto-representacionalismo al tiempo que permite estructurar una práctica científica más efectiva. Ilustraré esto último aplicando este marco a los debates anteriormente considerados. Concluiré mostrando cómo el marco PrInf muestra que una posible forma de articular una práctica científica eficiente que promueva una comprensión adecuada de la realidad biológica pasa por abrazar un proyecto de ciencia plural en clave pragmatista.

Estructura de la tesis doctoral

La tesis se divide en tres Partes. En la Parte I (capítulo I) analizaré los presupuestos que estructuran el marco metacientífico comúnmente adoptado a la hora de ejercer y entender el quehacer científico, así como sus problemas asociados. En la Parte II (capítulos II y III) mostraré la preeminencia de este marco dentro de la actual investigación biológica y analizaré los problemas resultantes de su adopción. Para ello, presentaré los dos casos de estudio ya reseñados. El relativo a la biología evolutiva –el debate sobre la herencia– y el concerniente a la biomedicina –el debate sobre el cáncer. En la Parte III (capítulos IV y V) presentaré la propuesta metacientífica a través del cual planteo afrontar los problemas de los que es presa la perspectiva onto-representacional, el enfoque Pragmatista-Inferencial (PrInf).

Más concretamente, la estructura de la tesis doctoral será la siguiente. En el capítulo I identificaré y analizaré los presupuestos metacientíficos que estructuran el onto-representacionalismo. Asimismo, ilustraré cuáles son las principales dificultades y tensiones

internas que afronta. Localizaré el problema en el aspecto (meta)semántico. Con ello, pretendo mostrar que, desde un plano estrictamente teórico, el onto-representacionalismo es presa de una serie de problemas conceptuales que lo invalidan a la hora de ser considerado como una alternativa adecuada a través de la cual entender y conceptualizar la práctica científica.

En los capítulos II y III mostraré la preeminencia de este marco dentro de la actual investigación en biología e ilustraré cuáles son los problemas que se derivan de su implementación. Para ello, analizaré dos debates. El primero, relativo a la biología evolutiva, será el debate sobre la herencia. El segundo, concerniente a la biomedicina, consistirá en la disputa en torno a la naturaleza del cáncer. Mostraré que el estancamiento teórico al que se han visto conducidos sendos debates es el producto de la adopción de este marco metacientífico.

En los capítulos IV y V estableceré las bases teóricas necesarias para construir un marco metacientífico alternativo e innovador con el que superar los problemas que afectan al onto-representacionalismo. En un primer término, analizaré los intentos llevados a cabo por aquellos autores que se han opuesto a este último. Esta será la tarea que me ocupará en el capítulo IV. Argumentaré que estas propuestas fallan al no haber tenido por objetivo construir una visión global que integre aspectos ontológicos, epistemológicos y (meta)semánticos. Tras reseñar las virtudes y deficiencias de estos primeros intentos por dejar el onto-representacionalismo atrás, presentaré mi propia propuesta metacientífica en el capítulo V, el marco Pragmatista-Inferencial (PrInf). Para ello, examinaré de manera analítica los presupuestos que lo estructuran. Conforme vaya explicando las características de estos presupuestos, iré mostrando cómo este marco permite resolver los problemas reseñados.

Metodología de la tesis doctoral

Para cumplir con los objetivos propuestos he adoptado una estrategia metodológica consistente en tres puntos: 1. Un análisis conceptual de naturaleza descriptiva y explicativa. 2. Una lectura sistemática de la literatura científica relativa a los casos de estudio analizados. 3. Un análisis histórico sobre el desarrollo de los modelos considerados.

En primer lugar, he realizado un análisis conceptual de naturaleza descriptiva y explicativa. Esta estrategia metodológica se ha implementado de manera estructural a lo largo de toda la tesis. He identificado y descrito exhaustivamente cuáles son los principales puntos de discusión relativos a los debates sobre la herencia y el cáncer. Para ello, me he servido de las reflexiones realizadas por los principales científicos involucrados en ambas disputas. Asimismo, he presentado de manera crítica cuáles han sido las posiciones adoptadas por los filósofos de la biología. A través de un análisis conceptual, he propuesto una forma novedosa de conceptualizar este debate, argumentado que es posible situar la raíz del problema en el plano metacientífico. Valiéndome de las consideraciones teóricas llevadas a cabo por los autores encuadrados dentro de la tradición de la filosofía general de la ciencia y del pragmatismo he tratado de articular una posición novedosa que ofreciese una forma de

superar el *impasse* al que se han visto sometidos estos debates. A saber, el marco PrInf. He mostrado cómo esta propuesta es capaz de armonizar la investigación experimental con la teórica, pavimentando el camino para la estructuración de una práctica científica más eficiente.

Un segundo aspecto metodológico clave ha sido el rastreo y la lectura sistemática de los principales estudios experimentales relacionados con cada uno de los casos de estudio analizados. Esta estrategia, implementada en la Parte II, me ha permitido respaldar, desde un plano estrictamente científico, la hipótesis fundamental que articula la tesis doctoral: que los aparentes casos de incompatibilidad no responden a razones científicas, sino metacientíficas. Un examen detallado de la literatura científica demuestra que no existe una inconmensurabilidad semántica. Los científicos encuadrados en bandos enfrentados se han servido de los descubrimientos llevados a cabo por la otra facción para articular sus investigaciones de manera más eficaz. No solo eso, este análisis me ha servido para poner de manifiesto hasta qué punto es posible, e incluso necesario, mantener esta pluralidad de líneas de investigación, poniendo así en cuestión la idea de integración. Son las particularidades que diferencian a cada modelo las que han permitido obtener ciertos resultados a través de los cuales hemos avanzado en nuestra comprensión de la realidad estudiada.

En tercer lugar, he examinado el desarrollo histórico de los modelos de herencia y del cáncer considerados. A través del análisis de las fuentes primarias y de los estudios secundarios he reforzado la hipótesis fundamental de la tesis: la conceptualización negativa de la pluralidad científica es el producto de una reificación ontológica que hunde sus raíces, no en consideraciones de carácter propiamente científico, sino en la adopción de ciertos presupuestos metacientíficos. Una consideración histórica muestra cómo estos modelos se desarrollaron constriñéndose de manera recíproca. Han sido los presupuestos metacientíficos adoptados los que han conducido a una reificación de los modelos dominantes. Esto ha ocasionado que los defensores de modelos alternativos adopten una estrategia similar a la hora de defender sus afirmaciones teóricas, motivando una ruptura en la dinámica de interacción. Con ello, se ha obstaculizado el progreso de la investigación y el avance en nuestra comprensión. Un análisis histórico ilustra, por tanto, hasta qué punto el onto-representacionalismo constituye un marco inadecuado a través del cual estructurar una práctica científica eficaz. Además de ser inoperante a la hora de canalizar una comprensión adecuada de la realidad biológica, desvirtúa a nivel descriptivo la historia del desarrollo científico.

Limitaciones de la tesis doctoral

Antes de comenzar, considero necesario reseñar algunas de las posibles limitaciones de la presente tesis doctoral. Aquí señalaré únicamente cuatro.

En primer lugar, se podría argumentar que no he considerado explícitamente marcos filosóficos alternativos al pragmatismo a la hora de estructurar una alternativa metacientífica al onto-representacionalismo. No niego que existan, o que puedan existir, otra clase de

propuestas teóricas sumamente valiosas. En la tesis, empero, he decidido priorizar el aspecto propositivo sobre el descriptivo, dedicando todos mis esfuerzos a estructurar, de la manera más precisa posible, una propuesta de carácter personal que ofrezca una posible respuesta a una cuestión que considero extraordinariamente relevante. A saber, ¿cómo es posible que exista una pluralidad de modelos que conceptualicen ciertos aspectos de un mismo fenómeno de maneras radicalmente diferentes? ¿Qué explica tal pluralidad? ¿Tiene esto beneficios epistémicos? Nótese que el objetivo que he perseguido al formular el marco PrInf no ha sido ofrecer una solución *definitiva* a estas cuestiones. Al contrario, lo que me ha impulsado ha sido tratar de aportar los recursos conceptuales necesarios para poder evaluar estas cuestiones desde una óptica alternativa a la dominante, la onto-representacional. No niego, de esta manera, que el marco PrInf sea objeto de ciertas inespecificidades o tensiones internas. Tampoco que existan otras propuestas o incluso que los autores encuadrados dentro del onto-representacionalismo sean capaces, en determinado punto, de articular una respuesta que dé cuenta de las críticas aquí esbozadas.

En segundo lugar, se podría argumentar que los problemas aquí abordados y los marcos metacientíficos considerados se restringen exclusivamente al terreno de la biología. Esto limitaría el alcance de la hipótesis aquí manejada y del marco presentado. Ciertamente, en esta tesis he prescindido de cualquier apelación a debates que no estén directamente relacionados con las ciencias biológicas. Si bien mi intuición es que las reflexiones aquí presentadas son extrapolables a las restantes disciplinas científicas y que la aplicabilidad del marco PrInf excede los contornos de la biología, queda todavía por dirimir hasta qué punto esto es efectivamente así o no.

En tercer lugar, debido a su carácter profundamente interdisciplinar, es posible que ciertos problemas o enfoques hayan sido pasados por alto al tiempo que algunas de las caracterizaciones y análisis realizados sean parciales o incompletos. Son cuatro las áreas en las que esto último ha podido ocurrir.

La primera disciplina que es preciso considerar es la historia de la biología. En la tesis he considerado pertinente realizar ciertas consideraciones de índole histórico para ilustrar hasta qué punto el onto-representacionalismo constituye una perspectiva descriptivamente inadecuada del proceder científico. En los capítulos II y III muestro que, lejos de ser incompatibles, los modelos de herencia y del cáncer se desarrollaron a través de constreñimientos recíprocos. Con ello ilustro hasta qué punto la reificación ontológica desvirtúa la historia relativa al desarrollo de estos modelos. Soy consciente, empero, de que la aproximación histórica aquí presentada puede resultar insuficiente o imprecisa a los ojos de un historiador de la biología. Sea como fuere, es preciso tener en mente que esta tesis no pretende realizar una contribución a la historia de la biología, sino a la filosofía general de la ciencia y a la filosofía de la biología. Una consideración detallada sobre el desarrollo histórico de los modelos aquí analizados excede por completo los objetivos de la tesis.

La segunda es la filosofía de la biología. El tratamiento realizado de los problemas conceptuales que rodean a la Síntesis Moderna, la Síntesis Extendida y la investigación del cáncer no logra reflejar con total precisión las complejidades subyacentes a dichos programas

de investigación. Algunos de los debates que he dejado fuera en mi caracterización son los siguientes: la noción de agencia, de individualidad biológica, de organismo, de teleología, de nicho ecológico o de causalidad recíproca; la epidemiología del cáncer, la biología de sistemas o las implicaciones político-sociales del cáncer. Ciertamente, incluir estas consideraciones constituye una *conditio sine qua non* a la hora de dibujar una imagen completa de la realidad de estos programas científicos. No obstante, he considerado que tal nivel de detalle podría comprometer la claridad conceptual de la tesis. Este es el motivo por el que, deliberadamente, he decidido dejar a un lado los mismos.

La tercera es la filosofía de la ciencia. Se podría afirmar que mi caracterización del realismo y de las diversas posturas que lo integran es exigua. No he entrado en más detalle porque esto habría llevado la discusión demasiado lejos, pudiendo llegar a comprometer la legibilidad de la tesis. Igualmente, se podría argumentar que no analizo en detalle algunas propuestas de carácter onto-representacional que podrían dar un sentido positivo al pluralismo de modelos al tiempo que afrontan los problemas que rodean a este enfoque metacientífico. Un ejemplo sería el perspectivismo (Massimi, 2022; Massimi y McCoy, 2020). *Grosso modo*, los partidarios de esta postura teórica sostienen que el pluralismo es la consecuencia inevitable de nuestras limitaciones cognitivas, de la complejidad del mundo y/o del carácter socio-contextual del quehacer científico. Eso sí, aunque se acepte un pluralismo de perspectivas, existen criterios objetivos para evaluar la corrección dentro de esas perspectivas. Una de las tareas que resta por analizar es si el perspectivismo es capaz de aportar una razón que justifique de manera positiva –y no solo negativa– la existencia de múltiples modelos, así como superar el problema (meta)semántico al tiempo que se retienen los compromisos realistas y veritistas. En último lugar, se podría sostener que es necesario realizar un examen de ciertos enfoques sumamente populares en la actualidad que aportan interesantes recursos conceptuales a la hora de superar los problemas que afectan al onto-representacionalismo. Considérese, a modo de ejemplo, las perspectivas sistémicas (Green, 2021), procesualistas (Nicholson y Dupré, 2018) o pluralistas (Kellert et al., 2006; Longino, 2006, 2013; Mitchell, 2003, 2009, 2022). Aunque discutir las virtudes y deficiencias teóricas de estos enfoques hubiese sido sumamente enriquecedor, he preferido reservar ese espacio para formular mi propia propuesta personal, el marco PrInf. Evaluar cuáles son las potenciales relaciones que existen entre estas perspectivas es una tarea que es preciso abordar en el futuro. De particular interés sería analizar las conexiones que existen entre el marco PrInf y las distintas propuestas pluralistas de carácter no onto-representacional.

La cuarta es la filosofía analítica. Al igual que en los casos anteriores, considero que hay determinados temas y enfoques que podrían haber sido tratados con mayor profundidad. Considérese, como ejemplo, los siguientes: las diferencias existentes entre la metasemántica y la semántica, las características de las distintas teorías de la correspondencia, las diferentes propuestas deflacionistas o las particularidades de las diversas propuestas inferencialistas. La razón por la que no he considerado más en detalle estos debates no tiene que ver únicamente con la extensión. Más bien, tiene que ver con las particularidades de la disciplina dentro de la cual se encuadra esta tesis doctoral: la filosofía general de la ciencia. Entrar en disquisiciones altamente específicas en torno a estos temas es algo que cae fuera del foco de la misma. Por ello, he considerado pertinente buscar un delicado equilibrio entre la necesidad

de incorporar ciertos recursos de la filosofía analítica al tiempo que mantengo incólume el problema central que vertebra la tesis, el cual está ligado a la filosofía general de la ciencia.

La última limitación que mencionaré tiene que ver con un aspecto estrictamente formal: la extensión de la tesis doctoral. Considero que esta es el resultado colateral de abordar un problema basal: cuál es la manera más correcta en la que deberíamos conceptualizar la práctica científica. Esto exige abordar problemáticas sumamente dispares que, en ocasiones, exceden los mismos contornos de la filosofía de la ciencia: cuestiones históricas, ontológicas, (meta)semánticas o epistemológicas. Ciertamente, muchos de los aspectos aquí abordados podrían haber sido caracterizados de manera mucho más sintética. Sin embargo, debido a la relativa novedad –el problema de la comprensión, de la representación o la perspectiva metasemántica inferencial– y complejidad –problema de la herencia, del cáncer o de la reproducibilidad– de algunos de los temas aquí tratados me he visto obligado a realizar una caracterización detallada. No solo eso, debido a la originalidad del marco metacientífico aquí propuesto, ha sido necesario mostrar que este tiene una amplia aplicabilidad dentro de la biología. Esto me ha forzado a presentar dos casos de estudio pertenecientes a disciplinas relativamente diferentes: la biología evolutiva y la biomedicina. Asimismo, la extensión se ha incrementado por las consideraciones históricas, las cuales han sido necesarias para ilustrar la inadecuación descriptiva de la reificación ontológica llevada a cabo por el onto-representacionalismo. Para compensar la deficiencia relativa a la extensión, he tratado de emplear un lenguaje analítico, simple y accesible.

Para concluir, me gustaría clarificar que, debido a la cantidad de autores y propuestas tratadas, es posible que puedan existir ciertos errores de interpretación. Me disculpo, de antemano, si he desvirtuado las consideraciones teóricas de algún autor o autora. Quisiera poner en claro que cualquier fallo que pudiera haber no es el producto de una acción intencional o deliberada.

INTRODUCTION TO THE DISSERTATION

Introduction. Two metascientific frameworks for a common problem: onto-representationalism and the Pragmatist-Inferentialist approach (PrInf)

Contemporary life sciences face the challenge of making sense of the existence of a plurality of models that provide us with explanations that offer different—and sometimes contradictory—descriptions of the same natural phenomenon. In a nutshell, we have to account for the plurality of models pervading the current scientific practice. This question, admittedly broad, encompasses much more specific ones: What explains that diverse models provide different or contradictory descriptions of the same natural reality? Is this situation a symptom of an immature science? Is it epistemically beneficial? Should we promote scientific policies that support such plurality? I will present two case studies to illustrate this situation. The first concerns the debate on the nature of heredity. Here, it is possible to identify three clear-cut positions: Those authors who have defended that heredity is essentially a genetic phenomenon; Those who have proposed broadening this notion to include epigenetic alterations while maintaining the conceptual assumptions underlying the traditional concept—transgenerational and germline/material overlap conditions—; and those who have advocated an extended concept that moves away from any theoretical remnants associated with the standard genocentric concept. The second case study materializes in the debate on the characteristics and mechanisms underlying cancer. Here, I will analyze and discuss two theories that have made contradictory claims about the carcinogenic process: On the one hand, advocates of the Somatic Mutation Theory have argued that cancer is a cellular disease caused by certain genetic or epigenetic alterations; On the other hand, proponents of the Tissue Organization Field Theory have contended that cancer is a tissue disease that results from disruption of the morphogenetic/morphostatic fields that orchestrate and maintain the organization of cells.

While some authors have welcomed this plurality (Cartwright, 1999; Chang, 2022; Dupré, 1993; Galison and Stump, 1996; Kellert et al., 2006; Longino, 2013; Mitchell, 2003, 2009; Plutynski, 2018; Ruphy, 2016), the prevailing view has been the opposite. In the dissertation, I claim that the unease with this plurality responds not to scientific reasons but to metascientific ones. By metascientific, I mean the set of theoretical or philosophical-conceptual assumptions used to understand the inner workings of scientific practice (descriptive level) and to canalize its proper unfolding (normative level). A detailed analysis of scientific practice reveals that no scientific reasons would lead us to conclude that the aforementioned models provide an exclusive or contradictory description of the phenomena studied. Likewise, this plurality does not constitute an epistemic obstacle in order to promote a more efficient scientific practice that allows us to advance in our understanding of biological reality. Rather, these ideas stem from the adoption of a very particular metascientific framework: the onto-representationalism. More specifically, they are the byproduct of the ontological reification carried out by such a metascientific framework. The assumptions that structure it—ontological, epistemological, and (meta)semantic—have motivated scientists to ontologically reify the models they work with. The concept of reification will be central throughout the dissertation. By reification, I mean to consider that

the results revealed by the models are a projection of the supposed “constitutive characteristics” of the studied phenomenon. This reification leads to the belief that there is only one adequate description of the scientific phenomena. Either the one provided by the model handled or one we have yet to aspire to. As can be appreciated, an axiological stance emerges therefrom: pluralism is a manifestation of inadequate or immature scientific practice. To tackle this situation, researchers have adopted two different strategies: either they have embraced a kind of paradigmatic thinking, or they have advocated unification thinking. Regarding the former, it is assumed that only one of the models in dispute provides an adequate description of the constitutive characteristics of the phenomenon, thus being in a position to canalize factive understanding. Concerning the latter, models are perceived as drawing an incomplete description of the constitutive characteristics of the phenomenon, so the goal should consist of building a more complete and accurate model capable of providing us with a genuine factive understanding of the phenomenon. Therefore, it is necessary to unify the partial views we have of the explanandum, thus identifying the general patterns that subsume the different particular cases and the relationships between explanations that focus on different scales of regulation or levels of analysis.

The question we should address is whether these metascientific considerations lead to a more efficient and successful scientific practice or not. In the dissertation, I argue that the ontological reification caused by the adoption of onto-representationalism generates a series of conceptual and empirical problems that eventually hinder an adequate understanding of the phenomena under investigation. Regarding the debate on heredity, this reification leads to epistemic impoverishment and explanatory vagueness. The first involves obscuring all mechanisms that do not fit the proposed view of heredity. The second relates to the impossibility of developing normative criteria through which to assess whether the results revealed about the potential causal contributions of the different mechanisms considered in the reconstruction of phenotypes are adequate or not. In the case of cancer, reification leads to conceptual paradoxes, such as having two contradictory but successful theories about the same phenomenon, and to theoretical stalemates where the dynamics of theoretical and experimental feedback is eroded.

To prove that ontological reification is the immediate consequence of adopting onto-representationalism, I will analyze the metascientific assumptions that structure it. The assumptions are the following. Epistemological assumption—veritism: factive understanding, which is the goal of scientific practice, is structured around true explanatory accounts plus certain additional conditions. Ontological assumption—bold interpretation of the ontological thesis of scientific realism: factive scientific understanding is derived from the grasping of (certain aspects of) the ontic structure of reality, which is pre-existent, objective, mind-independent, and accessible. (Meta)semantic assumption—representationalism and correspondence theory: model systems constitute the source through which factive understanding is gained. The semantic value of the information obtained lies in its referential character. In other words, the elements of the model (the propositions that compose the descriptions of the model system or those that articulate the explanations that we obtain through its use—truthbearers) bear a correspondence with the components that articulate the ontic structure of the target systems—truthmakers—, at least

with those elements that are causally central in the emergence of the behavior or aspect considered—difference-makers. Apart from illustrating to what extent the implementation of this metascientific framework to real scientific practice leads to the aforementioned problems, I will contend that it is prey to several conceptual tensions. I will locate them in the (meta)semantic assumption. Hence, I will evidence how onto-representationalism constitutes an inadequate metascientific framework. Besides being an inconsistent proposal, it is unable to adequately rationalize the historical trajectory of the various scientific disciplines and to guide an efficient scientific practice capable of boosting our understanding of biological reality.

In order to fill the gap left by onto-representationalism, I will articulate an alternative that I will call the “Pragmatist-Inferentialist approach” (PrInf). I will argue that a pragmatist reconceptualization of the metascientific assumptions is the most appropriate strategy to descriptively accommodate the historical dynamics of scientific development and guide an adequate scientific practice that allows us to efficiently understand natural phenomena. This framework will replace the three metascientific assumptions of onto-representationalism by the following. Ontological assumption—diachronic experience: the subject does not apprehend a pre-existing and objective ontic structure. Rather, he experiences a world on the basis of a history of transactional relations with his respective epistemic environment. Epistemological assumption—non-factive understanding: a cognitive agent understands when he is able to formulate a statement of intelligibility in an effective manner. (Meta)semantic assumption—pragmatist-inferentialism, and criterion of effectiveness: the semantic content of the linguistic items is derived from the inferential connections they hold with the remaining linguistic items that articulate the epistemic structure diachronically built within a particular course of experience. The statement of intelligibility on which the understanding of an agent is grounded is correct and it is legitimate to ascribe him understanding if and only if the conceptual articulation is effective, where effectiveness is determined by an empirical and a normative condition. Drawing on the PrInf framework and several historical considerations regarding the development of the models framed in the two case studies, I will show that the claims of alleged incompatibility are descriptively false and that unification is a normatively undesirable goal. In other words, it is not just that there are no problems in recognizing the existence of reciprocal influences. The central issue is that it is necessary to retain this plurality of perspectives if we intend to articulate effective scientific research capable of advancing our understanding of biological reality.

Hypothesis and goals of the dissertation

The hypothesis around which this dissertation revolves is that to adequately conceptualize scientific practice we need to embrace a pragmatist pluralism. In order to prove this point, I will pursue two goals.

First of all, I will show that the reluctance raised against this project of plural science is rooted in metascientific considerations, not scientific ones. More specifically, they derive from

adopting a very particular metascientific framework to conceptualize scientific practice: onto-representationalism. Through a fine-grained analysis of the assumptions that structure it, I will illustrate how this framework, apart from facing a series of theoretical problems that are extremely difficult to solve, leads to certain conceptual paradoxes in its application to scientific practice. The latter being related to the phenomenon of ontological reification. I will exemplify them through two case studies: the debate on the nature of heredity and cancer. I will conclude by arguing that it is necessary to articulate an alternative metascientific framework that replaces the onto-representational one.

Secondly, I will face the task of formulating an innovative metascientific approach. I will call the latter the “Pragmatist-Inferentialist approach” (PrInf). Through a detailed consideration of the assumptions that structure it, I will enlighten how this approach overcomes the conceptual paradoxes generated by onto-representationalism while paving the way for building a more effective scientific practice. To demonstrate the latter, I will discuss the implementation of this framework to the discussions previously addressed. Thus, I will conclude by showing how the PrInf framework reveals that *a possible way* to articulate an efficient scientific practice that promotes an adequate understanding of biological reality involves embracing a pluralistic science project from a pragmatist standpoint.

Structure of the dissertation

The dissertation is organized in three parts. In Part I (chapter 1), I analyze the assumptions that structure the metascientific framework commonly adopted to conceptualize scientific practice, as well as its associated problems. In Part II (chapters 2 and 3), I illustrate the preeminence of this framework within current biological research and analyze the problems resulting from its implementation. To do so, I will introduce the two case studies already mentioned. The one concerning evolutionary biology—the debate on heredity—and the one concerning biomedicine—the debate on cancer. In Part III (chapters 4 and 5), I discuss the metascientific proposal through which I propose to face the problems that onto-representationalism is prey to, the Pragmatist-Inferentialist approach (PrInf).

More specifically, the structure of the doctoral thesis will be as follows. In chapter 1, I will identify and analyze the metascientific assumptions that structure onto-representationalism. I will also illustrate the main difficulties and internal tensions it faces. I will locate the problem in the (meta)semantic level. Thus, I intend to show that, from a strictly theoretical point of view, onto-representationalism is prey to a series of conceptual problems that preclude it from being considered as an adequate alternative through which to understand and conceptualize scientific practice.

In chapters 2 and 3, I will show the preeminence of this framework within current research in biology and illustrate what problems arise from its implementation. To do so, I will analyze two debates. The first, concerning evolutionary biology, will be the debate on heredity. The second, related to biomedicine, will be the dispute over the nature of cancer. I will show that

the theoretical stalemate reached in both is the product of the adoption of such a metascientific framework.

In chapters 4 and 5, I will establish the theoretical foundations to build an alternative and innovative metascientific framework to overcome the problems affecting onto-representationalism. In chapter 4, I will analyze the attempts made by those authors who have opposed onto-representationalism. I will argue that these proposals fail because of their unwillingness to construct a global vision that integrates ontological, epistemological, and (meta)semantic aspects. After outlining the virtues and shortcomings of these attempts to leave onto-representationalism behind, I will present my own metascientific proposal in chapter 5: the Pragmatist-Inferentialist account (PrInf). To do so, I will analytically examine the assumptions that structure it. As I explain the characteristics of these presuppositions, I will enlighten how this framework allows us to solve the problems previously identified.

Methodology of the dissertation

In order to fulfill the proposed goals, I will adopt a methodological strategy consisting of three points: 1. A conceptual analysis of a descriptive and explanatory nature. 2. A systematic review of the scientific literature related to the case studies analyzed. 3. A historical analysis of the development of the models considered.

First, I will conduct a conceptual analysis of a descriptive and explanatory nature. This methodological strategy will be implemented structurally throughout the dissertation. I will identify and discuss in depth the main points of discussion related to the debates on heredity and cancer. To do so, I will draw on the insights of the main scientists involved in both disputes. I will also critically present the positions adopted by philosophers of biology. Through a theoretical analysis, I will propose a novel way of conceptualizing this debate. I will contend that it is possible to locate the heart of the problem at the metascientific level. Drawing on theoretical considerations carried out by authors framed within the tradition of the general philosophy of science and pragmatism, I will articulate an innovative position that offers a way to overcome the impasse reached. I will show how this proposal can harmonize experimental and theoretical research, paving the way for structuring a more efficient scientific practice.

A second key methodological aspect will be the systematic review of the main experimental studies related to the case studies analyzed. This strategy, implemented in Part II, will allow me to back up, from a scientific point of view, the fundamental hypothesis that articulates the dissertation: that the apparent cases of incompatibility do not respond to scientific reasons but to metascientific ones. A detailed examination of the scientific literature shows that there is no semantic incommensurability. Scientists framed in opposing parties have made use of the discoveries made by the other faction to articulate their research more effectively. But not only that, this analysis will enable me to show that it is possible, and even necessary, to maintain this plurality of lines of research, thus calling into question the idea of

integration. The particularities that differentiate each model allow us to obtain certain results through which we have advanced in our understanding of the reality studied.

Third, I will examine the historical development of the models of heredity and cancer here examined. Through an analysis of primary sources and secondary studies, I will reinforce the fundamental hypothesis of the thesis: the negative conceptualization of a scientific plurality is the product of an ontological reification rooted not in scientific considerations but in the adoption of certain metascientific assumptions. A historical consideration shows how these models developed by constraining each other. What has caused such reification has been the metascientific assumptions adopted. This has motivated the advocates of alternative models to adhere to a similar strategy when defending their theoretical claims, causing a rupture in the dynamics of interaction. In doing so, the progress of research and the advancement of our understanding has been hindered. A historical analysis illustrates to what extent onto-representationalism constitutes an inadequate framework to structure effective scientific practice. In addition to being inoperative in canalizing an adequate understanding of biological reality, it distorts the history of scientific development at the descriptive level.

Limitations of the dissertation

Before starting, I consider it necessary to outline some of the possible limitations of this dissertation. Here I will mention only four of them.

First, it could be argued that I have only considered pragmatism when structuring a metascientific alternative to onto-representationalism. I certainly admit that there are, or could be, other highly valuable theoretical frameworks. However, I have decided to prioritize the propositive aspect over the descriptive one, dedicating all my efforts to articulate, as accurately as possible, a personal account that may offer a possible answer to a question that I consider extraordinarily relevant. Namely, how is it possible the existence of a plurality of models that conceptualize certain aspects of the same phenomenon in radically different ways? What explains such plurality? Does this have epistemic benefits? Note that the goal I have pursued in formulating the PrInf account has not been to provide a definitive solution to these questions. Quite the contrary, I have aimed to provide the appropriate conceptual resources to evaluate these questions from an alternative point of view to the dominant one: the onto-representationalism. Therefore, I do not dispute that the PrInf framework may be susceptible to certain inespecificities or internal tensions. Nor that there may be other proposals or that authors framed within onto-representationalism will eventually be capable of articulating a response that addresses the criticisms outlined here.

Secondly, it could be argued that the problems tackled here and the metascientific frameworks discussed are confined exclusively to the life sciences. Certainly, I have omitted any reference to debates that are not directly related to the biological sciences. Although my intuition is that the ideas presented here can be extrapolated to other scientific disciplines

and that the applicability of the PrInf framework goes beyond the contours of biology, it remains to assess whether this is indeed the case or not.

Third, due to the interdisciplinary character of the dissertation, it is possible that some problems or approaches may have been overlooked and that some characterizations and analyses may be partial or incomplete. There are four areas or disciplines in which this may be the case.

The first discipline is the history of biology. In the dissertation, I have considered it appropriate to make certain considerations of a historical nature to illustrate to what extent onto-representationalism constitutes a descriptively inadequate perspective of scientific practice. In chapters 2 and 3, I show that, far from being incompatible, the models of heredity and cancer developed through a dynamic of reciprocal constraints. This illustrates how ontological reification distorts the reality of the historical development of these models. However, I am well aware that the historical approach presented here may be insufficient or inaccurate in the eyes of a historian of biology. Be that as it may, it should be kept in mind that the present dissertation does not intend to contribute to the history of biology but to the general philosophy of science and the philosophy of biology. Therefore, a detailed consideration of the historical development of these models is beyond of its scope.

The second is the philosophy of biology. The analysis conducted on the conceptual issues surrounding the Modern Synthesis, the Extended Evolutionary Synthesis, and cancer research fails to accurately reflect the complexities underlying these research programs. Some of the debates that I have deliberately left out are the following. On the one hand, the notions of agency, biological individuality, organism, teleology, ecological niche, or reciprocal causality. On the other hand, the epidemiology of cancer, systems biology, or the socio-political implications of cancer. Certainly, including these considerations constitutes a *conditio sine qua non* when it comes to drawing a complete picture of the reality of these scientific programs. However, such a level of detail could jeopardize the conceptual clarity of the dissertation. This is why I have deliberately decided to leave them aside.

The third is the philosophy of science. It could be said that the characterization made of realism and its various positions is meager. I have not gone into more detail because this would have taken the discussion too far and could have compromised the readability of the dissertation. Likewise, it could be argued that I have not analyzed in detail some onto-representationalist proposals that could give a positive sense to model pluralism while overcoming the problems associated with this metascientific approach. One example might be perspectivism (Massimi, 2022; Massimi and McCoy, 2020). Roughly speaking, proponents of this theoretical position argue that pluralism is the inevitable consequence of our cognitive limitations, the complexity of the world and/or the socio-contextual nature of scientific practice. While accepting a pluralism of perspectives, these authors argue that there are certain objective criteria for assessing correctness within those perspectives. A task that remains to be analyzed is whether perspectivism is able to provide a positive—and not only a negative—rationale for the existence of multiple models, as well as to overcome the (meta)semantic problem while retaining the realistic and veritistic commitments. Finally, it

could be argued that examining other currently popular non-onto-representational conceptual platforms would be necessary. Consider, by way of example, the systemic (Green, 2021), processualist (Nicholson and Dupré, 2018) or pluralist (Kellert et al., 2006; Longino, 2006, 2013; Mitchell, 2003, 2009, 2022) perspectives. Although discussing the theoretical virtues and shortcomings of these approaches would have been extremely enriching, I have preferred to put all my efforts into formulating my own personal proposal, the PrInf account. Assessing what potential relationships exist between these perspectives is a task that needs to be addressed in the future. Of particular interest would be to analyze the connections between the PrInf account and the various pluralist and non-onto-representationalist proposals.

The fourth is analytical philosophy. As in the previous cases, certain topics and perspectives could have been discussed in greater depth. Consider, as an example, the following: the differences between metasemantics and semantics, the characteristics of the various correspondence theories, the different deflationist proposals, or the particularities of the various inferentialist proposals. The reason why I have not considered these debates in more detail has not only to do with extension. Rather, it has to do with the particularities of the discipline within which this dissertation is framed: the philosophy of general science. To engage in highly specific digressions on these issues is something that is beyond its scope.

The last limitation I will highlight is strictly formal. It is related to the length of the dissertation. This is the collateral result of addressing a fundamental issue: What is the correct way to conceptualize scientific practice? This requires addressing extremely disparate issues that sometimes exceed the very contours of the philosophy of science: historical, ontological, (meta)semantic, or epistemological questions. Certainly, many of the topics discussed here could have been characterized in a much more synthetic way. However, due to the relative novelty—the problem of understanding, of representation or the inferential metasemantic perspective—and complexity—the problem of inheritance, cancer, or reproducibility—of some of them, I have been forced to make a detailed presentation. Also, due to the originality of the metascientific framework formulated here, it has been necessary to prove its broad applicability within life sciences. This is why I have introduced two case studies of relatively different disciplines: evolutionary biology and biomedicine. Also, historical considerations have increased the extension, which has been necessary to illustrate the descriptive inadequacy of the ontological reification carried out by onto-representationalism. To make up for the deficiency related to length, I have tried to use analytical, simple, and accessible language.

I would like to conclude with a caveat. Due to the number of authors and proposals covered, there may be certain errors of interpretation. I apologize in advance if I have distorted the theoretical considerations of any author. I would like to make it clear that any misreading that may exist is not the product of intentional action.

CONCLUSIÓN DE LA TESIS DOCTORAL

HACIA UNA CIENCIA PLURAL EN CLAVE PRAGMATISTA

La hipótesis central que ha articulado la presente tesis doctoral es que una adecuada conceptualización de la práctica científica pasa por abrazar un pluralismo en clave pragmatista. Para demostrar este punto he perseguido dos objetivos fundamentales: 1. he tratado de identificar cuáles son los motivos por los que no se ha considerado pertinente o adecuado adoptar tal pluralismo; 2. he ofrecido un argumento positivo en favor del mismo.

En relación con el primer objetivo, he mostrado que las reticencias expresadas en contra de este proyecto de ciencia plural hunden sus raíces en consideraciones de carácter metacientífico, no científico. Las consideraciones metacientíficas engloban todos aquellos presupuestos empleados a la hora de conceptualizar el proceder científico, tanto desde un plano descriptivo –cómo ha procedido– como normativo –cómo debería proceder. En la tesis he argumentado que los recelos desplegados en contra de este pluralismo se derivan de la adopción de un marco metacientífico específico, el onto-representacional. Más concretamente, se derivan de la reificación ontológica ocasionada por la adopción de este último. He argumentado que la reificación se traduce en considerar que los resultados revelados por los modelos son un reflejo de las propiedades constitutivas del fenómeno estudiado. Esta reificación genera la creencia de que solo existe una descripción adecuada del objeto científico analizado: o bien la provista por el modelo manejado, o bien una a la que todavía tenemos que aspirar.

En la Parte I de la tesis he presentado de manera analítica cuáles son los presupuestos que estructuran el onto-representacionalismo y he mostrado cómo estos conducen a dicha reificación. Los presupuestos son los siguientes:

Presupuesto epistemológico del onto-representacionalismo –veritismo. La comprensión fáctica constituye el objetivo de la práctica científica. Para obtenerla, es preciso que los científicos obtengan información verdadera sobre ciertos aspectos considerados relevantes y que estructuren dicha información en relatos explicativos que permitan responder a las cuestiones que articulan la investigación. La comprensión será adecuada en la medida en la que se haya confirmado la validez –pertinencia para el objetivo considerado– y la solidez –verdad– de las explicaciones sobre las que se estructura y en tanto en cuanto se cumplan con ciertos criterios adicionales, como haber considerado otras explicaciones y haber establecido una comparación sistemática entre ellas.

Presupuesto (meta)semántico del onto-representacionalismo (I) –representacionalismo. Los sistemas modelo constituyen la fuente a través de la cual se estructura la comprensión fáctica de los fenómenos. Es a través de la manipulación de los sistemas modelo como los científicos son capaces de extraer información con la que articular esos relatos explicativos sobre los cuales se erige la comprensión fáctica. Para ser sólidas –verdaderas–, los elementos proposicionales que estructuran dichas explicaciones deben representar con precisión cierta clase de aspectos/elementos, mecanismos/procesos o comportamientos de la estructura óptica del fenómeno,

aquellos que dan cuenta de la emergencia del aspecto considerado relevante –*difference-makers*.

Presupuesto ontológico del onto-representacionalismo –interpretación osada de la tesis ontológica del realismo científico. La realidad cuenta con una estructura preexistente, objetiva, independiente de la mente y accesible. Los fenómenos –sistemas objetivos– del mundo que estudian los científicos poseen una estructura óptica ya definida que es independiente de cualquier consideración pragmática que puedan realizar los agentes. La comprensión científica fáctica se deriva de la captación de (ciertos aspectos de) esa estructura. Es esta estructura la que garantiza las condiciones de posibilidad para que pueda existir una conexión representacional (PC) entre nuestros modelos y el mundo. No solo eso, es la que establece las condiciones necesarias para que los científicos puedan configurar un criterio objetivo a través del cual diferenciar, a nivel epistemológico, los modelos o explicaciones verdaderas de las falsas (PP).

Presupuesto (meta)semántico del onto-representacionalismo (II) –teoría de la correspondencia. El valor epistémico de los modelos –de sus descripciones– o de los productos derivados de su empleo –de las explicaciones– reside en que los elementos que los estructuran corresponden a los elementos que articulan la estructura óptica de los sistemas objetivo –*truthmakers*–, al menos los causalmente centrales (PP) (cuasifactivismo). Dado que los *truthbearers* son siempre elementos lingüísticos, es preciso apelar a una teoría de la correspondencia. Esta es la única forma de establecer una correspondencia entre estos ítems lingüísticos y los correspondientes ítems no lingüísticos por los que permanecen –*truthmakers*. Cuando se produce una correspondencia precisa entre los aspectos, causas o mecanismos relevantes y nuestras representaciones, entonces obtenemos comprensión fáctica del fenómeno y avanzamos en la construcción de una imagen más verdadera de la realidad.

Aplicando estas consideraciones al E-RC, para el onto-representacionista los modelos son adecuados y las representaciones científicas derivadas de los mismos proveen comprensión fáctica cuando se cumplen las siguientes condiciones:

Esquema Representación Científica (E-RC). Identifiqué dos posturas dentro del onto-representacionalismo. Una vertiente clásica y otra sofisticada. A pesar de que cada una conceptualiza PC de manera diferente, ambas enfrentan el desafío de articular una teoría de la correspondencia para dar cuenta de PP.

Problema de la Representación Científica (PRC).

1. Problema de la Coordinación (PC).

Onto-representacionalismo clásico: similitud o -morfismo. Los sistemas modelo representan a sus correspondientes sistemas objetivo y proporcionan comprensión fáctica si y solo si existe cierta correspondencia directa, sea esta material o formal, al menos en lo

relativo a ciertos componentes o características causalmente centrales para el surgimiento del fenómeno estudiado (*difference-makers*).

Sofisticado: inferencias contrafácticas. Los sistemas modelo representan a sus correspondientes sistemas objetivo y proporcionan comprensión fáctica si y solo si revelan patrones universales de comportamiento. Es decir, si nos permiten obtener información sobre las relaciones de (in)dependencia contrafáctica que existen entre ciertas características/parámetros que se consideran relevantes.

2. Problema de la Precisión (PP). Aquí he demostrado que, a pesar de los intentos realizados, ambas vertientes del onto-representacionalismo enfrentan la tarea de delinear una teoría de la correspondencia.

Clásico: teoría de la correspondencia.

Sofisticado: teoría de la correspondencia.

En el capítulo I he argumentado que el onto-representacionalismo, tanto clásico como sofisticado, es inadecuado desde dos planos: uno teórico-conceptual —es presa de diversas paradojas conceptuales internas— y otro empírico —su aplicación conduce a una práctica científica descriptivamente inadecuada y normativamente ineficiente. En la Parte I abordé el primer punto. En la Parte II el segundo. Con respecto al primero, sostuve que una de las características distintivas del onto-representacionalismo es que los presupuestos que lo estructuran son conjuntamente necesarios. Es decir, no es posible sostener uno y renunciar a otro. Esta postura se cimienta sobre tres pilares que adquieren sentido uno a la luz del otro: si uno de ellos cae los demás lo acompañan. Sostuve que el onto-representacionalismo era presa de cinco problemas que localicé en el presupuesto (meta)semántico (II). A saber: 1. el problema de la no identidad; 2. el problema del emparejamiento; 3. el problema del criterio de verdad para una ciencia en fase embrionaria y la cuestión de los modelos inconsistentes; 4. el problema de las idealizaciones; 5. la falacia de la equivocación y el mito de lo dado. Todos estos problemas se resumían en el desafío de articular una teoría de la correspondencia adecuada que fuese armónica con los restantes presupuestos metacientíficos —ontológico, (meta)semántico (I) y epistemológico. Debido a la indisolubilidad de estos presupuestos, el onto-representacionista no puede sortear este problema adoptando únicamente los presupuestos epistemológico y/o ontológico. Tampoco formulando una teoría de la verdad deflacionaria, dado que esta no está en armonía con los restantes presupuestos. De esta forma, argumenté que los defensores de este marco enfrentaban un dilema. O bien ofrecen una solución a cada uno de los problemas reseñados, mostrando cómo es posible estructurar una teoría de la correspondencia adecuada que sustente sus restantes presupuestos —ontológico y epistemológico. O bien reconocen la inviabilidad de su enfoque. Dado que hasta el momento no se ha logrado lo primero, sostuve que no existen razones de peso para no considerar seriamente la segunda alternativa. A saber, articular un marco metacientífico alternativo.

En la Parte II de la tesis mostré la preeminencia de este marco metacientífico dentro de la actual práctica biológica y examiné los problemas descriptivos y normativos a los que conduce su aplicación efectiva. Para ilustrar lo primero presente dos casos de estudio pertenecientes a dos subdisciplinas de la biología. El primer caso de estudio, relativo a la biología evolutiva, se cifró en el debate en torno a la herencia. El segundo caso de estudio, relativo a la biomedicina, se materializó en el debate en torno a los mecanismos que definen el proceso carcinogénico. En los capítulos II y III examiné las principales posturas involucradas en cada uno de estos debates y analicé en qué medida reificaban su posición. Con respecto al primero, identifiqué tres facciones. En primer lugar, los autores que han defendido que la herencia constituye un fenómeno de naturaleza esencialmente genética. A su modo de ver, la recurrencia de los rasgos se caracteriza por dos propiedades constitutivas, la condición de línea germinal y la de transgeneracionalidad. De ahí concluyen que la reconstrucción de la similitud adaptativa dentro de un linaje debe ser entendida a través de la transmisión transgeneracional de la variación genética de línea germinal. En segundo lugar, los que han sostenido que el concepto genocentrista es extremadamente limitante. La evidencia experimental ha revelado que las alteraciones epigenéticas son capaces de participar en la reconstrucción de ciertos rasgos adaptativos, cumpliendo con las condiciones de línea germinal y de transgeneracionalidad delineadas por el concepto clásico. Estos autores han propuesto, por tanto, ampliar la noción de herencia para incluir las alteraciones epigenéticas, manteniendo, eso sí, los presupuestos conceptuales que subyacen al concepto tradicional. En tercer lugar, los que han abogado por un concepto extendido que rompa con todo remanente teórico asociado al concepto estándar de raigambre genocentrista. Para estos autores, el concepto tradicional es incapaz de dar cuenta de la naturaleza multivariada de este fenómeno. Una de las teorías más consistentemente desarrolladas ha sido la DST, que sostiene que la herencia debería entenderse como todos aquellos recursos del desarrollo —no solo el ADN— que garantizan la estabilidad de la forma. Con respecto al segundo, analicé las dos principales teorías involucradas en esta disputa: los defensores de la Teoría Somática Mutacional (*the Somatic Mutation Theory*), que han sostenido que el cáncer es una enfermedad celular producida por determinadas alteraciones genéticas o epigenéticas; y los partidarios de la Teoría del Campo de la Organización de Tejidos (*the Tissue Organization Field Theory*), que afirman que el cáncer es una enfermedad del tejido que tiene lugar debido a la disrupción de los campos morfogenéticos/morfostáticos que orquestan y mantienen su organización. Argumenté que, en ambos casos, el foco de la disputa se explica por la reificación que se ha producido de estos modelos, resultado de la adopción del onto-representacionalismo: se ha considerado que solo existe una forma adecuada a través de la cual comprender las características constitutivas del fenómeno científico analizado. Para el onto-representacionista, un agente comprende fácticamente un fenómeno cuando es capaz de derivar explicaciones que representen con precisión determinados aspectos o comportamientos de su estructura óptica, los *difference-makers*. Dado que esa estructura óptica es objetiva e inmutable, el onto-representacionista concluye que es imposible o inadecuado derivar explicaciones “mutuamente inconsistentes o excluyentes” de un mismo fenómeno. Solo existe *una* forma adecuada de comprenderlo fácticamente. En otras palabras, resulta imposible disponer de explicaciones que establezcan las causas constitutivas del surgimiento del aspecto o comportamiento considerado en distintos factores o mecanismos.

Para demostrar la inadecuación normativa del onto-representacionalismo analicé cuáles han sido las principales propuestas de resolución que se han puesto sobre la mesa, así como los problemas a los que estas conducen. Argumenté que se han adoptado fundamentalmente dos estrategias. O bien se ha abrazado una suerte de pensamiento paradigmático, en donde se considera que solo uno de los modelos en disputa provee la descripción adecuada de las características constitutivas del fenómeno, por lo que solo este es capaz de otorgar comprensión fáctica. O bien se ha abogado por un pensamiento de unificación, en donde se argumenta que los modelos dibujan una descripción incompleta de las características constitutivas del fenómeno, por lo que el objetivo debe consistir en construir un modelo más completo y preciso capaz de proporcionarnos una genuina comprensión fáctica del fenómeno. En el caso de la herencia, el proponente de la transmisión genética ha adoptado la primera estrategia, el de la herencia epigenética gamética ha vacilado entre las dos y el de la DST ha adoptado la segunda: los primeros sostienen que el único mecanismo que da cuenta de la estabilidad de los rasgos es la transmisión genética; los segundos afirman que es preciso incluir la herencia epigenética transgeneracional de línea germinal dentro del marco dibujado por la transmisión genética; y los terceros proponen reinterpretar el proceso de reconstrucción de los rasgos bajo la óptica del desarrollo. En el caso del cáncer se ha adoptado, esencialmente, la primera estrategia: la SMT+ concibe el cáncer como una enfermedad celular y lo explica apelando a eventos genéticos y epigenéticos; la TOFT+ considera que es una enfermedad tisular ocasionada por la disrupción de las señales que integran el campo morfogenético/morfostático. En ambos casos, esta reificación conducía a una serie de problemas conceptuales que dificultaban al desarrollo de una práctica científica eficiente. En el caso de la herencia, la reificación desembocaba en un empobrecimiento epistémico y en una vaguedad explicativa. El primero tenía que ver con el oscurecimiento de todos los mecanismos que no se ajustarán a la visión de la herencia planteada: los primeros excluyen todos los mecanismos que no sean genéticos; los segundos oscurecen la herencia epigenética intergeneracional externa; y los terceros reinterpretan todos los procesos bajo la óptica del desarrollo, desvirtuando las particularidades de procesos alternativos. La segunda tenía que ver con la imposibilidad de desarrollar criterios normativos a través de los cuales evaluar la adecuación de los resultados revelados en torno a las potenciales contribuciones causales de los mecanismos considerados en la reconstrucción de los fenotipos. En el caso del cáncer, esta conducía a paradojas conceptuales, como tener dos teorías contradictorias, pero exitosas, sobre un mismo fenómeno y a estancamientos teóricos en donde se perdía la dinámica de intercambio y de constreñimiento teórico y experimental.

Para demostrar la inadecuación descriptiva del marco onto-representacional realicé un análisis de la literatura científica e histórica. A través de un análisis detallado de la literatura científica, mostré que resulta descriptivamente inadecuado conceptualizar estos modelos como excluyentes o inconmensurables: no existe ninguna genuina incompatibilidad científica entre las distintas posiciones adoptadas en estos dos debates. Asimismo, ilustré cómo los partidarios de estos modelos tienen sobrados argumentos, empíricamente corroborados, para sustentar su posición. Estos modelos nos permiten derivar explicaciones sumamente exitosas y configurar estrategias de intervención práctica sobre la realidad enormemente eficientes. El examen de la literatura histórica me permitió constatar que estos modelos no son excluyentes: se han desarrollado a través de una dinámica de constreñimiento recíproco,

tanto positivo –se han servido de la evidencia y de los resultados arrojados por la otra teoría– como negativo –se han visto forzados por la otra teoría a clarificar determinadas explicaciones o hacer explícitos ciertos mecanismos.

En relación con el segundo objetivo, puesto que estas supuestas controversias científicas no constituyen sino el reflejo generado por unos principios metacientíficos que desvirtúan el quehacer científico y dado que no existen razones de peso para no considerar alternativas al paradigma dominante, enfrenté en la Parte III la labor de articular un marco metacientífico alternativo al onto-representacional. Para ello, analicé previamente en el capítulo IV los principales intentos llevados a cabo en los últimos años por superar las limitaciones de los enfoques onto-representacionales. Me focalicé en tres frentes. Primero, en las propuestas de aquellos autores que han ofrecido una noción no factivista de comprensión. Segundo, en los intentos de articular una noción no representacional de representación científica. Tercero, en los enfoques que han intentado negar la validez del E-RC y, con ello, la necesidad de articular un concepto de representación alternativo al onto-representacional. Mostré que ninguno de ellos cumple satisfactoriamente con su objetivo. Los dos primeros porque para poder articular unas nociones de comprensión y representación exitosas es preciso configurar un enfoque global que dé respuesta a las cuestiones ontológicas y (meta)semánticas. El último porque conduce a un concepto de representación descriptiva y normativamente inadecuado. Valiéndome de algunas de las intuiciones teóricas delineadas por estas aproximaciones no onto-representacionales, dediqué el capítulo V a estructurar mi propio marco metacientífico, el “enfoque Pragmatista-Inferencial” (PrInf).

A través de una consideración detallada de los presupuestos que lo estructuran esclarecí cómo este enfoque es capaz de disolver las paradojas conceptuales generadas por el onto-representacionalismo al tiempo que permite estructurar una práctica científica más efectiva. En otras palabras, este enfoque permite:

1. *Superar las tensiones internas de las que es presa el onto-representacionalismo.* El marco PrInf, a través de la reformulación del presupuesto metasemántico (II), permite superar los problemas del onto-representacionalismo. Además, este marco está libre de tensiones conceptuales dado que los presupuestos que lo integran son capaces de coexistir de manera armónica.

2. *Evidenciar que es posible sostener esta pluralidad de modelos a través de una dinámica de constreñimiento.* Es posible mantener esta pluralidad de manera interactiva por dos motivos. Primero, porque no existen razones científicas que nos lleven a pensar lo contrario. Todos los modelos han demostrado ser sumamente exitosos a la hora de aportar explicaciones que han sido refrendadas por la práctica experimental, así como propuestas de intervención sumamente exitosas sobre la realidad. Segundo, porque una consideración histórica del desarrollo de estos modelos muestra que se configuraron a través de interacciones recíprocas. Una reformulación pragmatista de los principios metacientíficos muestra que es posible sostener esta pluralidad de modelos a través de una dinámica de constreñimiento positivo y negativo.

3. *Ilustrar que es necesario retener esta pluralidad de modelos.* Cada uno de estos modelos proporciona, debido a sus condiciones epistémicas de surgimiento y funcionamiento, formas particulares de comprensión. Los presupuestos metacientíficos que estructuran el marco PrInf ilustran la necesidad de retener los distintos modelos a través de una dinámica de constreñimiento recíproco. Solo de esta forma es posible estructurar una práctica científica eficiente que permita profundizar en nuestra comprensión de la realidad biológica.

En el capítulo V presenté y analicé pormenorizadamente los presupuestos metacientíficos que estructuran la propuesta Pragmatista-Inferencial (PrInf):

Presupuesto ontológico –experiencia sincrónica y diacrónica. El sujeto no aprehende una estructura óptica preexistente y objetiva. Más bien experimenta, de manera sincrónica, determinadas situaciones como significativas –los objetos de comprensión– sobre la base de una experiencia diacrónica. La experiencia diacrónica hace referencia al proceso a través del cual un sujeto y su correspondiente ambiente de investigación co-determinan el objeto de investigación científica y mantienen la coherencia del curso de acción práctica a través de una serie de relaciones de transacción temporalmente extendidas.

Presupuesto epistémico –tesis normativa (comprensión no fáctica). Un agente cognitivo comprende (1) una determinada situación que considera significativa o problemática –objeto de comprensión– cuando (2) se dan las condiciones necesarias (3) para poder implementar una estrategia epistémica (4) con la que formular una declaración de inteligibilidad (5) de manera eficiente.

Presupuesto metasemántico (I) –inferencialismo pragmatista. Para poder articular una declaración de inteligibilidad el agente debe ser capaz de revestir de significado los resultados extraídos de la manipulación experimental. Un agente está en posesión del contenido semántico de un ítem lingüístico cuando capta las conexiones inferenciales que mantiene con los restantes ítems lingüísticos que articulan la estructura epistémica diacrónicamente edificada dentro de un curso particular de experiencia. El significado original de los términos lingüísticos primitivos de la estructura epistémica no responde a condiciones referenciales. Instituir significados no es más que codificar propiedades de uso socialmente aceptadas que han demostrado ser efectivas a la hora de satisfacer determinados cursos de acción.

Presupuesto semántico (II)

Pragmatismo inferencial normativista. Los significados de los ítems lingüísticos se codifican en términos de papeles inferenciales.

Criterio de efectividad. La declaración de inteligibilidad es correcta y es legítimo adscribir comprensión al agente cognitivo si y solo si la articulación conceptual es efectiva. La articulación conceptual es efectiva si y solo si:

(1) *Condición empírica.* Los resultados experimentales apoyan la hipótesis de manera ampliativa y garantizada.

(2) *Condición normativa.* Los agentes saben cómo racionalizar la declaración de inteligibilidad a través del principio del racionalismo lingüístico, donde este último exige adoptar una actitud normativa en donde se haga explícito:

¿Cuál es el objetivo de investigación, la hipótesis propuesta y los resultados experimentales?

¿De qué manera la hipótesis especificada en conjunción con los elementos de la estructura epistémica permite satisfacer el objetivo cognitivo? Esto exige ser capaz de hacer explícito:

¿En qué medida los elementos de la red inferencial sustentan los distintos resultados obtenidos que permiten especificar la hipótesis?

¿Qué elementos de la red inferencial están en tensión con esos resultados? ¿Es posible una resolución?

¿Cuáles son las condiciones metodológicas sobre las que se estructura la construcción y manipulación del artefacto epistémico a través del cual se han derivado los resultados?

¿Qué se desprende de la declaración de inteligibilidad? ¿Qué implicaciones tiene? ¿Permite configurar nuevos espacios de significación?

Sobre la base de estas consideraciones, modifiqué el E-RC, convirtiéndolo en el E-RC bajo la interpretación PrInf (E-RC^{PrInf}). A través del mismo clarifiqué cuál es el funcionamiento epistémico de los modelos y de las representaciones. En otras palabras, ilustré cómo se conectan con el mundo y cómo se juzga la contribución que hacen a la hora de edificar una comprensión adecuada de la realidad:

Esquema Representación Científica bajo PrInf (E-RC^{PrInf}):

Problema de la Representación Científica (PRC). ¿Qué es una representación científica? Una representación científica no es otra cosa más que la hipótesis que los investigadores inicialmente manejan una vez que ha logrado un alto grado de especificación gracias a la información experimental derivada a través de sucesivas manipulaciones del artefacto epistémico. Esta representación científica, o hipótesis especificada, se emplea, en conjunción con la estructura epistémica, para articular una declaración de inteligibilidad.

1. Problema del Artefacto (PA). ¿Qué hace que algo sea un artefacto epistémico? Un artefacto es una configuración o arreglo experimental estable, material o teórico, cuyos componentes, propiedades y relaciones han sido intencionalmente delineados con el explícito objetivo de hacer inteligible un aspecto que se considera significativo dentro de un curso de experiencia. Una configuración experimental alcanza el estatus de artefacto cuando: 1. permite a un agente articular una declaración de inteligibilidad; 2. su proceso de construcción y manipulación es inteligible para los restantes agentes de la comunidad.

2. Problema de la Justificación (PJ). ¿Qué hace que un artefacto sea adecuado? Un artefacto es adecuado si se demuestra que, efectivamente, permite canalizar la comprensión. En otras palabras, un artefacto está justificado cuando la declaración de inteligibilidad articulada a partir de la manipulación del mismo satisface el criterio de efectividad.

En resumen, no existe ninguna consideración genuinamente científica que nos lleve a concluir que el pluralismo se traduce en un obstáculo epistémico a la hora de guiar una práctica científica eficiente que permita avanzar en la comprensión de la realidad biológica. Estas consideraciones son el resultado de la adopción de un marco metacientífico sumamente particular: el *onto-representacional*. Tras mostrar las inadecuaciones del mismo y presentar mi alternativa teórica, la propuesta PrInf, he sostenido que una de las *posibles* formas de estructurar una práctica científica eficiente que promueva una comprensión incrementada de la realidad biológica pasa por abrazar un proyecto de ciencia plural en clave pragmatista.

CONCLUSION OF THE DISSERTATION

TOWARDS A PLURAL SCIENCE FROM A PRAGMATIST STANDPOINT

The hypothesis guiding the dissertation is that an adequate conceptualization of scientific practice involves embracing pluralism from a pragmatist standpoint. In order to make the case for such a statement, I have focused on two fundamental goals: 1. I have analyzed why it has not been considered pertinent or adequate to adopt such a pluralism; 2. I have offered a positive argument in favor of such a pluralism.

In relation to the first goal, I have shown that the reticence expressed against this project of plural science is rooted in metascientific considerations, not scientific ones. Metascientific considerations encompass all those assumptions used to conceptualize scientific practice, both descriptively—how it has proceeded—and normatively—how it should proceed. In the dissertation, I have argued that the misgivings raised against this pluralism derive from adopting a specific metascientific framework, onto-representationalism. More specifically, they derive from the ontological reification resulting from its adoption. I have argued that reification implies considering that the results revealed by the models are a faithful representation of the supposed “constitutive properties” of the phenomena studied. This reification generates the belief that there is only one adequate description of the scientific object under analysis: either the one provided by the model handled or one to which we have yet to aspire.

In Part I, I have presented analytically the assumptions that structure onto-representationalism and shown how they lead to the aforementioned reification. The assumptions are the following:

Epistemological assumption of onto-representationalism—veritism. Factive understanding is the goal of scientific practice. To achieve it, scientists must obtain true information about certain aspects considered relevant and structure this information in explanatory accounts that allow them to answer the questions that articulate the investigation. Understanding will be adequate as long as the validity—relevance for the goal under consideration—and soundness—truth—of the explanations on which it is structured have been substantiated and certain additional criteria have been met, such as having considered other explanations and having established a systematic comparison between them.

(Meta)semantic assumption of onto-representationalism (I)—representationalism. Model systems constitute the source through which factive understanding of phenomena is structured. It is through the manipulation of model systems that scientists are able to extract information to articulate those explanatory accounts upon which factive understanding is built. To be sound—true—the propositional elements that structure such explanations must accurately represent certain aspects/elements, mechanisms/processes, or behaviors of the ontic structure of the phenomenon, those that account for the emergence of the aspect considered relevant—difference-makers.

Ontological assumption of onto-representationalism—bold interpretation of the ontological thesis of scientific realism. Reality has a pre-existing, objective, mind-independent, and accessible structure. The phenomena—target systems—of the world that scientists study possess an already defined ontic structure independent of any pragmatic considerations that agents may make. Factive scientific understanding derives from grasping (certain aspects of) that structure. The latter guarantees the conditions of possibility so that a representational connection (CP) can be established between our models and the world. But not only that, it is the one that sets the necessary conditions for scientists to be able to configure an objective criterion through which to differentiate, at the epistemological level, true from false models or explanations (PP).

(Meta)semantic assumption of onto-representationalism (II)—correspondence theory. The epistemic value of the models—of their descriptions—or of the products derived from their use—of the explanations—resides in the fact that the elements that structure them correspond to the elements that articulate the ontic structure of the target systems—truthmakers—, at least those causally central (PP) (quasi-factivism). Since truthbearers are always linguistic elements, it is necessary to appeal to a correspondence theory. This is the only way to establish a correspondence between these linguistic items and the corresponding non-linguistic items by which they stand—truthmakers. When there is a precise correspondence between the relevant aspects, causes or mechanisms and our representations, then we get factive understanding of the phenomenon and advance in the construction of a truer picture of reality.

Applying these considerations to the Scientific Representation Schema (SR-S), models are adequate and the scientific representations derived from them provide factive understanding if and only if the following conditions are met:

Scientific Representation Schema (SR-S). I identified two positions within onto-representationalism: a classical and a sophisticated one. Although each conceptualizes CP differently, both face the challenge of articulating a correspondence theory to account for PP.

Scientific Representation Problem (SRP).

1. Coordination Problem (CP).

Classical: similarity or \sim -morphism. Model systems represent their corresponding target systems and provide factive understanding if and only if there is some direct correspondence, whether material or formal, at least with respect to certain components or characteristics causally central to the emergence of the phenomenon studied (difference-makers).

Sophisticated: counterfactual inferences. Model systems represent their corresponding target systems and provide factive understanding if and only if they uncover universal patterns of behavior. That is, if they allow us to obtain information about the counterfactual (in)dependence relationships that exist between certain characteristics/parameters that are considered relevant.

2. Precision Problem (PP). Here I have shown that, despite the attempts made, both kinds of onto-representationalism face the task of delineating a correspondence theory.

Classical: correspondence theory.

Sophisticated: correspondence theory.

In Chapter 1, I have argued that onto-representationalism, both classical and sophisticated, is inadequate in two different but related senses. A theoretical-conceptual one: it falls prey to various internal conceptual paradoxes. An empirical one: its application leads to a descriptively inadequate and normatively inefficient scientific practice. In Part I, I addressed the first sense. In Part II, the second. Regarding the first, I argued that one of the distinctive features of onto-representationalism is that the assumptions that structure it are jointly necessary. That is, it is not possible to hold one and renounce the other. This position is based on three cornerstones that make sense one in the light of the other: if one of them falls, the others come with it. I argued that onto-representationalism suffered from five problems that I located in the (meta)semantic assumption (II). Namely: 1. The problem of non-identity; 2. The problem of pairing; 3. The problem of the criterion of truth for an emerging science and the question of inconsistent models; 4. The problem of idealizations; 5. The fallacy of equivocation and the myth of the given. All these problems can be summarized in the challenge of articulating an adequate correspondence theory that would be harmonious with the remaining metascientific assumptions—ontological, (meta)semantic (I), and epistemological. Due to the inseparability of these assumptions, the onto-representationalist cannot avoid this problem by adopting only the epistemological and/or ontological ones. Nor by formulating a deflationary theory of truth since this is not in harmony with the remaining assumptions. Thus, I argued that the proponents of this metascientific framework faced a dilemma. Either they offer a solution to each of the problems outlined, showing how it is possible to structure an adequate correspondence theory that supports their remaining assumptions—ontological and epistemological. Or they acknowledge the unfeasibility of their approach. Since the former has not been achieved so far, I argued that there are no compelling reasons not to seriously consider the latter alternative. Namely, to articulate an alternative metascientific framework.

In Part II, I illustrated the preeminence of this metascientific framework within current biological practice and examined the descriptive and normative problems resulting from its implementation. To shed light on the former, I presented two case studies related to two sub-disciplines of life sciences. The first case study, concerning evolutionary biology, involved the debate on heredity. The second case study, related to biomedicine, concerned

the debate on the mechanisms that define the carcinogenic process. In Chapters 2 and 3, I examined the main positions involved in these debates and analyzed to what extent they reified their position. Concerning the first, I identified three sides. First, those authors who have argued that heredity is an essentially genetic phenomenon. In their view, the recurrence of traits is characterized by two constitutive properties: the germline/material overlap condition and the transgenerational condition. They conclude that the reconstruction of adaptive similarity within a lineage must be understood through the transgenerational transmission of germline genetic variation. Secondly, those who have argued that the genocentric concept is extremely limiting. Experimental evidence has revealed that epigenetic alterations can participate in the reconstruction of certain adaptive traits, fulfilling the germline and transgenerational conditions delineated by the classical concept. Thus, these authors have suggested broadening the notion of heredity to include epigenetic alterations while maintaining the conceptual assumptions underlying the traditional concept. Thirdly, those who have advocated an extended concept that eschews any theoretical remnants associated with the standard genocentric concept. For them, the traditional concept is unable to account for the multivariate nature of this phenomenon. One of the most consistently developed theories has been DST, which holds that heredity should be understood as all those developmental resources—not only DNA—that ensure stability of form. Concerning the second, I analyzed two of the most prominent theories: the Somatic Mutation Theory, whose advocates argue that cancer is a cellular disease produced by certain genetic or epigenetic alterations; and the Tissue Organization Field Theory, whose proponents claim that cancer is a tissue disease that occurs due to the disruption of the morphogenetic/morphostatic fields that orchestrate and maintain its organization. In both cases, I argued that the debate may be explained by the reification made of these models, which is the result of the adoption of onto-representationalism: it has been considered that there is only one adequate way through which to understand the constitutive features of the scientific phenomenon under analysis. For the onto-representationalist, an agent understands a phenomenon when he or she is able to derive explanations that accurately represent certain aspects or behaviors of its ontic structure, the difference-makers. Since that ontic structure is objective and immutable, the onto-representationalist concludes that it is impossible or inadequate to derive “mutually inconsistent or exclusive” explanations of the same phenomenon.

To evidence the normative inadequacy of onto-representationalism, I examined the main suggestions advanced by onto-representationalist to cope with such pluralism and the problems to which they lead. I contended that two strategies have been adopted. First, a sort of paradigmatic thinking. Here, only one of the models in dispute is considered to provide an adequate description of the constitutive characteristics of the phenomenon, thus being in a position to provide factive understanding. Second, a unification thinking. Here it is argued that the existing models draw an incomplete description of the constitutive characteristics of the phenomenon, so the goal should be to build a more complete and accurate model capable of providing us with a genuine factive understanding of the phenomenon. Applying these considerations to the case of inheritance: the proponent of genetic transmission has adopted the first strategy; that of gametic epigenetic inheritance has vacillated between the two; and that of DST has adopted the second. The former argues that the only mechanism that

accounts for trait stability is genetic transmission. The second claims that transgenerational germline epigenetic inheritance needs to be included within the framework drawn by genetic transmission. The third proposes to reinterpret the process of trait reconstruction through the lens of development. In the case of cancer, the first strategy has been adopted: SMT+ conceives cancer as a cellular disease and explains it by appealing to genetic and epigenetic events; TOFT+ considers it to be a tissue disease caused by the disruption of the signals that articulate the morphogenetic/morphostatic field. In both cases, this reification led to a series of conceptual problems that hindered the development of an efficient scientific practice. Regarding the case of heredity, this reification resulted in epistemic impoverishment and explanatory vagueness. The first consisted in the obscuring of all mechanisms that would not fit the proposed view of inheritance: either all non-genetic mechanisms are excluded; or external intergenerational epigenetic inheritance; or the processes are reinterpreted under a developmental lens, distorting their particularities. The second was the impossibility of developing normative criteria to evaluate the adequacy of the results revealed regarding the potential causal contributions of the mechanisms considered in the reconstruction of phenotypes. In the case of cancer, this led to conceptual paradoxes, such as having two contradictory but successful theories about the same phenomenon, and to theoretical stalemates where the dynamics of interaction is lost.

To demonstrate the descriptive inadequacy of onto-representationalism, I conducted an analysis of the scientific and historical literature. Through a detailed analysis of the former, I showed that conceptualizing such models as mutually exclusive or incommensurable is far from being adequate: there is no genuine scientific incompatibility between the different positions adopted in these two debates. But not only that, I illustrated how the supporters of all these models have plenty of empirically corroborated arguments to back up their position. These models allow them to derive highly successful explanations and to configure highly efficient strategies to intervene in reality. A detailed review of the historical literature allowed me to conclude that these models are not mutually exclusive: they have developed through a dynamic of reciprocal constraint, both positive—they have made use of the evidence and results produced by the other theory—and negative—they have been forced by the other theory to clarify certain explanations or to make certain mechanisms explicit.

Considering the second goal of the dissertation, I faced the task of articulating an alternative metascientific framework. The underlying reasons for pursuing such an effort were the following. First, because the scientific controversies herein presented were nothing more than the echo of the adoption of misguided metascientific principles. Second, since there are no compelling reasons not to consider alternatives to the dominant paradigm. In order to accomplish this goal, I discussed in Chapter 4 the main attempts made in recent years to overcome the limitations of onto-representational approaches. First, the proposals of those authors who have offered a non-factive notion of understanding. Second, the attempts to articulate a non-representational notion of scientific representation. Third, the approaches that have attempted to deny the validity of SR-S and, with it, the need to articulate an alternative concept of representation to the onto-representational one. I reasoned that none of them satisfactorily fulfills their goal. The first two because in order to articulate successful notions of understanding and representation it is necessary to configure a global approach

that answers ontological and (meta)semantic questions. The latter because it leads to a descriptively and normatively inadequate concept of representation. Drawing on some of the valuable theoretical intuitions outlined by these non-onto-representational approaches, I devoted Chapter 5 to structuring my own meta-scientific framework, the “Pragmatist-Inferentialist” approach (PrInf).

Through a detailed analysis of the assumptions that structure it, I clarified how this approach is capable of dissolving the conceptual paradoxes generated by onto-representationalism while allowing structuring a more effective scientific practice. In sum, this approach allows:

1. *Overcoming the main criticisms raised against onto-representationalism.* The PrInf framework, through the reformulation of the metasemantic assumption (II), overcomes the aforementioned problems affecting onto-representationalism. But not only that, this framework is free of conceptual tensions since the assumptions that integrate it are able to coexist harmoniously.

2. *Illustrating that it is possible to sustain this plurality of models through a dynamic of constraint.* It is possible to maintain this plurality in an interactive way for the following reasons. First, because there is no scientific reason to believe otherwise. All models have proven to be highly successful in providing explanations backed up by experimental practice, as well as highly successful proposals for intervening in reality. Second, because a historical analysis of the development of these models shows that they were shaped through reciprocal interactions. A pragmatist reformulation of metascientific principles shows that it is possible to maintain this plurality of models through a dynamic of positive and negative constraints.

3. *Appreciating the necessity of retaining this plurality of models.* Due to their epistemic conditions of emergence and functioning, each of them canalizes particular forms of understanding. The metascientific assumptions that structure the PrInf framework evince the need to retain the various models through a dynamic of reciprocal constraints. Only in this way is it possible to structure an efficient scientific practice that allows us to deepen our understanding of biological reality.

In Chapter 5, I presented and analyzed in detail the metascientific assumptions that structure the Pragmatist-Inferentialist Proposal (PrInf):

Ontological assumption—synchronic and diachronic experience. The subject does not apprehend a pre-existing and objective ontic structure. Rather, he or she experiences, in a synchronic manner, certain situations as significant—the objects of understanding—on the basis of a diachronic experience. The diachronic experience refers to the process through which a subject and its corresponding research environment co-determine the object of scientific inquiry and maintain the coherence of the course of practical action through a series of temporally extended transactional relations.

Epistemic assumption—normative thesis (non-factive understanding). A cognitive agent understands (1) a certain situation that he or she considers significant or problematic—object of understanding—when (2) the necessary conditions (3) are in place to be able to implement an epistemic strategy (4) through which to formulate a statement of intelligibility (5) in an efficient manner.

Metasemantic assumption (I)—pragmatist inferentialism. In order to articulate a statement of intelligibility the agent must be able to imbue meaning to the results extracted from the experimental manipulation. An agent is in possession of the semantic content of a linguistic item when he grasps the inferential connections it maintains with the remaining linguistic items that articulate the diachronically built epistemic structure within a particular course of experience. The original meaning of the primitive linguistic terms of the epistemic structure does not respond to referential conditions. Instituting meanings is nothing more than encoding socially accepted properties of use that have proven to be effective in satisfying particular courses of action.

Semantic assumption (II)

Normative inferential pragmatism. The meanings of linguistic items should be understood in terms of inferential roles.

Criterion of effectiveness. The statement of intelligibility is correct and it is legitimate to attribute understanding to a cognitive agent if and only if the conceptual articulation is effective. The conceptual articulation is effective if and only if:

- (1) Empirical condition. Experimental results support the hypothesis in an ampliative and warranted manner.
- (2) Normative condition. Agents know how to rationalize the statement of intelligibility through the principle of linguistic rationalism, where the latter requires adopting a normative attitude where it is made explicit:

What is the research goal, the proposed hypothesis, and the experimental results?

How does the specified hypothesis, in conjunction with the elements of the epistemic structure, enable to satisfy the cognitive goal? This requires being able to make explicit:

To what extent do the elements of the inferential network support the various results obtained that enable the hypothesis to be specified?

Which elements of the inferential network are in tension with those results? Is a resolution possible?

What are the methodological conditions on which the construction and manipulation of the epistemic artifact through which the results have been derived are structured?

What follows from the statement of intelligibility? What are its implications? Does it allow for the configuration of new spaces of significance?

On the basis of these considerations, I modified the SR-S, thus becoming the SR-S under the PrInf interpretation ($SR-S^{PrInf}$). This schema makes it possible to clarify the epistemic function of models and representations. In other words, it illustrates how the latter are connected to the world and how we should evaluate their contribution to the shaping of understanding:

Scientific Representation Schema under PrInf ($SR-S^{PrInf}$):

Problem of Scientific Representation (PSR). What is a scientific representation? A scientific representation is the hypothesis initially handled once it has achieved a high degree of specification thanks to experimental information derived through successive manipulations of the epistemic artifact. This scientific representation, or specified hypothesis, is used, in conjunction with the epistemic structure, to articulate a statement of intelligibility.

1. Artifact Problem (AP). What makes something an epistemic artifact? An artifact is a stable experimental configuration or arrangement, material or theoretical, whose components, properties, and relations have been intentionally devised with the explicit aim of rendering intelligible an aspect that is considered significant within a course of experience. An experimental configuration achieves the status of artifact when: 1. it allows an agent to articulate a statement of intelligibility; 2. its process of construction and manipulation is intelligible to the remaining agents of the community.

2. Justification Problem (JP). What makes an artifact adequate? An artifact is adequate if and only if it is proven that it does enable canalizing an adequate understanding. In other words, an artifact is justified when the statement of intelligibility articulated from the manipulation of the artifact satisfies the criterion of effectiveness.

In summary, no scientific consideration leads us to conclude that pluralism constitutes an epistemic obstacle when it comes to guiding an efficient scientific practice that allows us to advance our understanding of biological reality. These considerations are the result of the adoption of a very particular metascientific framework: onto-representationalism. After

showing its inadequacies and presenting my theoretical alternative, the PrInf account, I have argued that one of the possible ways of structuring an efficient scientific practice that promotes an increased understanding of biological reality is to embrace a project of plural science from a pragmatist standpoint

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