# Mechanisms and science denialism: explaining the global lung cancer epidemic

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ABSTRACT

Explanation is one of the main aims of science. Scientists frequently seek to explain scientific phenomena. This paper addresses the relationship between scientific explanation and science denialism. In it, explanatory wars are introduced. An explanatory war is a situation in which the standard scientific explanation of a phenomenon is systematically denied by a group of people. It is argued that the mechanistic account of scientific explanation is helpful in order to face this kind of science denialism. Mechanistic explanations are resistant to the arguments usually raised by denialists. The relevant role of mechanistic explanations is illustrated by the case of tobacco disease denialism during the second half of twentieth century.

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# Mechanisms and science denialism: explaining the global lung cancer epidemic

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## §1. Introduction

EXPLANATION IS ONE OF THE MAIN AIMS of science. As Ylikoski accurately claims, science could be considered "the business of explaining things" (2013, p. 277). Scientists frequently seek to explain scientific phenomena. The explananda can be regularities (e.g. the movement of planets), events (e.g. the cracking of a car radiator) or properties (e.g. the hardness of diamonds). The central role of explanation in science has not gone unnoticed by philosophers. Scientific explanation has been a subject of philosophical reflection since Pre–Socratic times —although the modern discussion began with the development of the covering–law model (Hempel 1965). Philosophers of science have not only discussed the nature of scientific explanation. They have also addressed related issues such as the notion of explanatory value, the relation between explanation and other epistemic goals (e.g. prediction), the role of models in explanation, etc.

The aim of this paper is to address the relationship between scientific explanation and science denialism. The structure of the paper is as follows. Section two analyses science denialism and introduces explanatory wars. An explanatory war is a situation in which the standard scientific explanation of a phenomenon is systematically denied by a group of people. Section three presents the mechanistic account of scientific explanation and argues that it is helpful in order to face explanatory wars. Mechanistic explanations are resistant to the arguments usually raised by denialists. Section four illustrates the relevance of mechanistic explanations to face explanatory wars by means of analysing a paradigmatic example (i.e. tobacco disease denialism during the second half of twentieth century). Finally, section five concludes.

## § 2. Science denialism and explanatory wars

Two forms of pseudoscience have been identified: science denialism and pseudotheory promotion (Hansson 2017). While pseudotheory promotion's main aim is to promote a specific theory (e.g. homeopathy, i.e., the claim that a substance that causes certain symptoms in healthy people would in highly diluted form cure similar symptoms in sick people), science denialism is focused on denying certain scientific claims (e.g. Earth is warming because of greenhouse gas emissions). Science denialism consists in the systematic rejection of a claim on which a scientific consensus exists (Diethelm and Mckee 2009; Liu 2012; Hansson 2017). It is usually targeted at scientific claims that damage people's lifestyle or worldviews, or that threaten corporate interests (Lewandowsky *et al.* 2016). Some prominent examples of science denialism are tobacco disease denialism, evolution denialism, climate change denialism, holocaust denialism, aids denialism, and relativity theory denialism.

In spite of their dissimilarities, there are five epistemological characteristics that are present in all cases of science denialism (Liu 2012; Hansson 2017; 2018a). Firstly, cherry–picking of data is systematically employed in their argumentations. Only a small part of the available evidence in taken into account.[1] Secondly, refuted claims are not always given up. Denialists are reluctant to give up ideas and arguments even when they have been refuted. Thirdly, fake controversies are fabricated. It is claimed that a certain issue is subject to a genuine scientific controversy, although an overwhelming consensus exists among scientists. Fourthly, deviant criteria of assent are introduced. Denialists set unrealistic standards for evidence, which hardly can be met by current scientific research. And fifthly, the opposed viewpoint is misrepresented. The scientific claim is distorted by means of logical fallacies (e.g. the strawman fallacy), taking quotes out of context, focusing on what is unknown and ignoring what is known, etc.

There are also several sociological characteristics that are usually present in science denialism (Diethelm and Mckee 2009; Liu 2012; Hansson 2017; 2018a). Science denialism often has strong political connections (e.g. evolution denialism is related with Christian right wing) and is supported mostly by men. Its main advocates use to be fake experts who, although they may be competent in a certain field, are not qualified researchers in the pertinent area. Besides, denialists appeal to complex and secretive conspiracies to account for the

[1] It should be noted that, although denialists often ignore unfavourable evidence, they could hardly ignore the target scientific claim itself. The main aim of scientific denialism is to undermine and deny that claim. Consequently, ignoring it would go against their own purposes.

scientific consensus on the denied claim and their inability to publish in mainstream peer–reviewed journals. Other sociological characteristics that are often present in science denialism are attacking individual scientists personally and professionally, pretending to have a significant support within science, and addressing laypeople instead of scholars.

Several characteristics of science denialism are also present in pseudotheory promotion (Hansson 2018a; 2018b). In both forms of pseudoscience, cherry–picking is used, refuted claims are not always given up, and criteria of assent almost impossible to satisfy are introduced. Other shared traits are: appealing to fake experts, directly addressing the public, and pretending to have a significant support within science. Nonetheless, there are relevant differences between science denialism and pseudotheory promotion. The main difference concerns their approaches to conflicts with genuine science (Hansson 2018a). Pseudotheory promotors tend to avoid conflicts with genuine science. To increase the acceptability of the promoted theory, they want to give the impression that it is compatible with mainstream science. However, science denialists have a conflict seeking attitude to genuine science. Their aim is to defeat a certain part of mainstream science, and opposing it is an important step to achieve that goal. Another relevant difference is that fabrication of fake controversies, which has an important role in science denialism, is not present in pseudotheory promotion (Hansson 2017). Furthermore, strong political connections, male dominance, and fierce attacks on individual scientists characterize science denialism, but not in general pseudotheory promotion.

It is important to note that science denialism is not a form of genuine scientific scepticism (Liu 2012; Prothero 2013; Lewandowsky *et al.* 2016). Scientific scepticism consists in not believing things just because someone claims them, but being cautious and test claims against evidence. If a claim is eventually widely supported by evidence, the sceptic must accept it. However, science denialism consists in being ideologically committed to reject a scientific claim. The denialist will hardly change their mind, whatever the evidence says. Furthermore, science denialism's characteristics such as fabricating fake controversies, invoking conspiracies, and personally and professionally attacking scientists, are not proper to genuine scientific scepticism. In fact, science denialism is a misrepresentation of scientific method.[2] As Rosenau explains, "[b]y dismissing the knowledge produced by scientific processes and

[2] Science denialism is not an anti–science movement (Rosenau 2012). Actually, it often presents itself as science in order to take advantage of the cultural and epistemic authority of science. Science denialists establish research institutions, launch journals, organize conferences, etc.

touting ideas that are untestable or have failed such tests, science denial misleads the public about how science works, opening the door to other pseudoscientific beliefs" (2012, p. 567).

A relevant kind of science denialism, which has not been previously addressed, is explanatory war. An *explanatory war* is a situation in which (i) there is an undisputed phenomenon (e.g. an increasing incidence of a disease), (ii) in the scientific community there is a broad consensus on its explanation, and (iii) the standard scientific explanation is systematically denied by a group of people. In this kind of science denialism, denialists do not question that the explanandum exists. It is accepted that certain phenomenon is the case and that it requires an explanation. However, they reject the explanans to which mainstream science appeals to account for the phenomenon. In order to fight down the mainstream science's explanation, two strategies are usually followed by denialists. On the one hand, they directly attack the standard explanation. For instance, they claim that the causal link between explanans and explanandum has not been proved with one hundred percent certainty (Proctor 2011; Prothero 2013). On the other hand, denialists propose and promote alternative explanations, which are presented as being as legitimate as the standard explanation, to increase the controversy and make their case more credible (Proctor 2004; Proctor 2011; Pearl and Mackenzie 2018).[3] For example, they support private research to study every minimally plausible alternative explanation. They also demand equal time and space in the media for alternative proposals (Hansson 2018a). In explanatory wars, science denialism's distinctive characteristics are present. For example, the introduction of deviant criteria of assent and the fabrication of fake controversies have a central role in the offensive against the standard explanation. Cherry–picking evidence is also relevant; denialists often ignore part of the evidence in support of the standard explanation.

A paradigmatic example of explanatory war is tobacco disease denialism during the second half of twentieth century (i.e. the tobacco wars) (Proctor 2011). In that period, it was generally accepted that the incidence of lung cancer had dramatically increased during the twentieth century. Furthermore, since the mid–1950s, there was a broad consensus among scientists that the increase in tobacco consumption accounted for this phenomenon (Proctor 2011; 2012). However, the tobacco industry systematically denied the standard

[3] In explanatory wars, a certain form of pseudotheory promotion is often present. Denialists introduce and promote alternative explanations to increase the controversy. Nonetheless, this promotion has only a subsidiary relation to the denial of the standard explanation.

explanation of the lung cancer epidemic (Proctor 2011; Prothero 2013; Pearl and Mackenzie 2018). Although they accepted that the frequency of lung cancer had increased and that this required an explanation, they rejected the explanation that linked the lung cancer epidemic with their product. In order to fight down the standard explanation, the tobacco industry attacked it (e.g. it was argued that the statistical evidence that linked explanans and explanandum was not conclusive) and promoted alternative explanations (e.g. industrial air pollution is responsible for the lung cancer epidemic).

Science denialism is a form of pseudoscience whose main aim is to deny certain scientific claim. A particular kind of science denialism is explanatory war. An explanatory war is a situation in which the standard scientific explanation of a phenomenon is systematically denied by a group of people. This kind of explanatory denialism is especially relevant because it undermines one of the main aims of science, i.e., explaining phenomena, insofar as shared criteria concerning how good an explanation is are challenged. Furthermore, given the central role of explanation in understanding, it is prejudicial for the public understanding of science. In the following section, it will be argued that the mechanistic account of scientific explanation can help to face explanatory wars.

## § 3. The mechanistic account of scientific explanation

The mechanistic account of scientific explanation has recently been developed within the framework of the new mechanical philosophy (Machamer, Darden and Craver 2000; Bechtel and Abrahamsen 2005; Glennan 2017). Nevertheless, its main principles were previously proposed by authors such as Rom Harré (1972) and Wesley Salmon (1984). The mechanistic approach is based on the idea that a phenomenon is explained by means of identifying the mechanism that is responsible for it. Within the new mechanical philosophy, there is no consensus on the notion of mechanism (Hedström and Ylikoski 2010). Nonetheless, some basic aspects are shared by most proposals. A mechanism is usually characterized as an organized constellation of entities and activities (Machamer, Darden and Craver 2000; Glennan 2017). It is considered that a mechanism is always a mechanism for a phenomenon (Glennan 2017). The phenomenon for which a mechanism is responsible is the main reference for its identification, delimitation, and decomposition. New mechanists also agree that mechanisms are nested and form a hierarchy (Machamer, Darden and Craver 2000). A component of a mechanism is often a mechanism itself. For example,

a heart is both a mechanism and a component of a mechanism (e.g. circulatory system).

Mechanistic explanations can be causal or constitutive (Ylikoski 2013). The relation between a mechanism and the phenomenon for which it is responsible may be causal or constitutive. Consequently, depending on the relation between the identified mechanism and the phenomenon of interest, an explanation is either a causal mechanistic explanation or a constitutive mechanistic explanation. Mechanistic explanations are often presented by means of mechanistic models. A mechanistic model has two components: a phenomenal description and a mechanistic description (Glennan 2017). The phenomenal description is a model of the phenomenon of interest, while the mechanistic description is a model of the mechanism responsible for that phenomenon. In this kind of explanations, the phenomenal description is (or represents) the explanandum and the mechanistic description is (or represents) the explanans (Glennan 2005).

An example of a mechanistic explanation is Schnitzer's (2005) explanation of global patterns of liana abundance and distribution. Unlikely trees and shrubs, lianas correlate negatively with annual precipitation. There is a higher abundance of lianas in forests with low precipitation and high seasonality than in aseasonal wet forests. Schnitzer explains that phenomenon by means of identifying the mechanism responsible for it, i.e., "the extensive root and efficient vascular systems of lianas" (Schnitzer 2005, p. 274). He argues that "[l]ianas have extremely deep and efficient root and vascular systems and thus may be able to tap water and nutrients that many trees and shrubs are unable to access during drought conditions" (Schnitzer 2005, p. 266). During dry seasons, because of their constant supply of water, lianas are not water stressed. They capitalize on solar radiation, which is more abundant in dry seasons, and grow more than trees and shrubs. Lianas' dry season growth advantage results in a high abundance of them in seasonal forests. However, in aseasonal wet forests, where water is rarely limiting, lianas cannot benefit from their dry season growth advantage. They face a fiercer competition from other plants. Consequently, lianas are less abundant in aseasonal wet forests.

Mechanistic explanations have been developed as an alternative to covering–law and statistical explanations (Salmon 1984; Hedström 2005). Covering–law and statistical explanations are "black–box explanations" (Hedström and Swedberg 1998). They connect initial conditions with final output by means of universal laws or statistical generalizations. However, the processes through which explanans and explanandum are actually linked are

not addressed by them. They consider that the link between explanans and explanandum is devoid of structure or that its structure is explanatorily irrelevant. On the contrary, mechanistic explanations are "how–explanations". They show "how some phenomenon comes about" (Glennan 2017, p. 228). Mechanistic explanations open the black box between explanans and explanandum and detail the processes that give rise to the latter. The mechanistic account of scientific explanation also addresses other problematic aspects of covering–law and statistical approaches. One of the main problems of the covering–law model is its narrow scope (Scriven 1959). Given that few or no laws are known in several fields of science (e.g. sociology, biology, economics…), it has a very limited scope of application. Nevertheless, many mechanisms are often known in those fields where laws are not available. The mechanistic account of scientific explanation, which does not require laws, has a broader scope. It can be adopted in those fields where few or no laws are known. With regard to statistical explanations, their main problem is that "[s]tatistical regularities are rarely (if ever) as unequivocal and easily interpretable in causal terms as this view would seem to suggest" (Hedström 2005, p. 23). On the contrary, mechanisms do offer unequivocal information about causal relations (Steel 2004; 2008). On the positive side, from knowing the causal mechanism through which X influences Y, it can be inferred that X is a cause of Y. And on the negative side, if no plausible causal mechanism running from X to Y can be conceived, it can be concluded that X is not a cause of Y.

The mechanistic account of scientific explanation is helpful to face explanatory wars.[4] In an explanatory war, the standard scientific explanation of a phenomenon is denied by a group of people. Nonetheless, if the standard explanation is mechanistic, denialists' offensive is less effective. Mechanistic explanations are resistant to the arguments usually raised by denialists. In order to fight down the mainstream science's explanation, two strategies are followed by denialists. Firstly, they directly attack the standard explanation. Denialists' attacks often focus on arguing that the standard explanation does not satisfactorily prove the causal link between explanans and explanandum. For

[4] Mechanistic explanations are also relevant for public understanding of science (Lewandowsky and Oberauer 2016). Recent experimental studies show that a brief mechanistic explanation of global warming significantly increases climate change acceptance (Ranney and Clark 2016). Nonetheless, it should be noted that pseudoscience (particularly pseudotheory promotion) may also take advantage of the compelling nature of mechanistic explanations (for a real case, see Holman 2017). The seductive allure effect of mechanistic explanations holds even when the reductive information is logically irrelevant (Hopkins, Weisberg and Taylor 2016).

example, they claim that statistical methods are inadequate for identifying causal relations. Their arguments are based on "an extraordinarily narrow and mechanical conception of causation" (Proctor 2011, p. 275). Secondly, denialists propose and promote alternative explanations to increase the controversy. Alternative explanations usually rely on statistical correlations between the explanandum phenomenon and variables not included in the mainstream science's explanation (Proctor 2004; 2011). Those explanations are presented as being as legitimate as the denied standard explanation. However, the strategies followed by denialists are hardly effective against mechanistic explanations. On the one hand, mechanistic explanations prove the (causal or constitutive) link between explanans and explanandum. They show how the phenomenon of interest comes about. On the other hand, alternative explanations raised by denialists would not be legitimate explanations on the same footing than the standard explanation. They are rarely mechanistic explanations, but black–box explanations that do not address the link between explanans and explanandum, and are not supported by the same kind of evidence that supports standard mechanistic explanations.[5]

The mechanistic account of scientific explanation, which is based on the idea that a phenomenon is explained by means of identifying the mechanism that gives rise to it, is helpful to face explanatory wars. Mechanistic explanations are resistant to denialists' attacks. Consequently, if the standard explanation is mechanistic, denialism's offensive is less effective. In the next section, the relevant role of mechanistic explanations will be illustrated by analysing the explanatory war regarding the global lung cancer epidemic. In order to address that case, the work by the historian of science Robert Proctor (2001; 2004; 2006; 2011; 2012) will be taken as reference.

## § 4. The tobacco wars

At the beginning of the twentieth century, lung cancer was an extraordinarily rare disease (Proctor 2001; 2011; 2012). It was so uncommon that "[o]nly 140

[5] Denialists could, given the ease with which humans come up with mechanistic narratives, propose alternative mechanistic explanations with little actual evidence in favour. Nevertheless, it is doubtful that they could successfully use them against a standard mechanistic explanation. In order to increase the controversy and make their point more credible, denialists must propose alternative explanations that can be widely considered as legitimate as the standard explanation. However, hardly could alternative mechanistic explanations invented by denialists be considered as legitimate as the standard mechanistic explanation. They, unlike the standard explanation, would be neither supported by evidence of mechanisms nor compatible with the available evidence of mechanisms.

cases had been reported in the world medical literature by 1898, and only 374 were known to [Isaac] Adler when he composed his 1912 review" (Proctor 2001, p. 83). When a case was discovered, physicians were called to observe it because they may never see another (Proctor 2001). However, during the first decades of the twentieth century, an increased incidence of lung cancer was noted in several countries (e.g. USA, Germany…). The disease "began showing up more often, both clinically and at autopsy, prompting head scratching and, eventually, alarm" (Proctor 2004, p. 374). This dramatic change in the incidence of lung cancer begged for an explanation. Scientists started considering what might be responsible.

During the following decades, several possible explanations of the lung cancer epidemic were proposed. Among the diverse factors that were taken into account were atmospheric pollution, asphalt dust emissions from newly paved roads, occupational exposures, X–rays, genetic predispositions, poison gas from First World War, the 1918–1919 flu pandemic, aluminium dishware, the fashion of eating tomatoes, racial intermarriage, and the growing popularity of cigarettes (Proctor 2004; 2011). In that period, cigarettes were considered just one of many possible causes of the global lung cancer epidemic.

Nevertheless, during the 1950s, the idea that tobacco consumption explained the lung cancer epidemic took the lead (Proctor 2011). Experts in the field considered that smoking indeed caused lung cancer. The causal link between cigarettes and lung cancer was established by four distinct lines of evidence: population studies, animal experimentation, cellular pathology, and chemical analytics (Proctor 2012). Scientific agreement regarding the causal relationship between smoking and lung cancer was expressed "in medial editorials, reviews, and textbooks; in annual reports of medical associations; and in 'white papers' and resolutions issued by public health authorities" (Proctor 2011, p. 232). As a result of this causal knowledge, a broad consensus emerged among experts that tobacco consumption accounted for the global lung cancer epidemic (Proctor 2011; 2012). It was widely considered that the growing popularity of cigarettes explained the high incidence of lung cancer.

By the mid–1950s, there was a consensus among scientists that tobacco consumption explained the lung cancer epidemic. However, the tobacco industry systematically denied that explanation. They admitted that the frequency of lung cancer had increased and that it required an explanation, but they rejected the explanation that linked the lung cancer epidemic to tobacco consumption. Part of the diverse evidence in support of the standard explanation was ignored by them, although this did not suffice to significantly

threaten it (Proctor 2011). In order to fight down the explanation of mainstream science, the tobacco industry followed two strategies. Firstly, they directly attacked the standard explanation. Their main argument was that the causal link between tobacco and lung cancer was not conclusively established and more research was needed (Proctor 2011). They adopted a narrow and mechanistic account of causality and "developed an elaborate strategy by which each new proof of a hazard would be met by insinuations of doubt and calls for endlessly more research" (Proctor 2004, p. 374). Despite the broad consensus in the scientific community, the tobacco industry claimed that the case was not yet closed and that it would be dangerous to hastily jump to conclusions. A great part of their efforts focused on undermining the statistical evidence that linked tobacco consumption to lung cancer (Pearl and Mackenzie 2018). For example, in "A Frank Statement to Cigarette Smokers" (1954), it was argued that "statistics purporting to link cigarette smoking with the disease could apply with equal force to any one of many other aspects of modern life".[6] Secondly, the tobacco industry promoted alternative explanations of the global lung cancer epidemic (Proctor 2004; 2011). By means of bodies such as the Tobacco Industry Research Committee (renamed as Council for Tobacco Research in 1964) and the Tobacco Institute, they funded and publicised research focused on investigating possible causes of lung cancer other than tobacco (e.g. stress, pesticides, industrial air pollution…). As Proctor claims, "'open controversy' was a key pillar in the industry's conspiracy, and the CTR [Council for Tobacco Research] always professed its 'openness' to alternate hypotheses when it came to disease causation" (2011, p. 273). A well–known alternative explanation publicised by the tobacco industry was that a "smoking gene" both caused people to smoke cigarettes and made them more likely to develop lung cancer (Fisher 1957; 1958).

[6] "A Frank Statement to Cigarette Smokers" is a full–page advertisement by the Tobacco Industry Research Committee that was published in 448 US newspapers on January 4, 1954. It marked the beginning of tobacco industry's denialist approach (Proctor 2011).

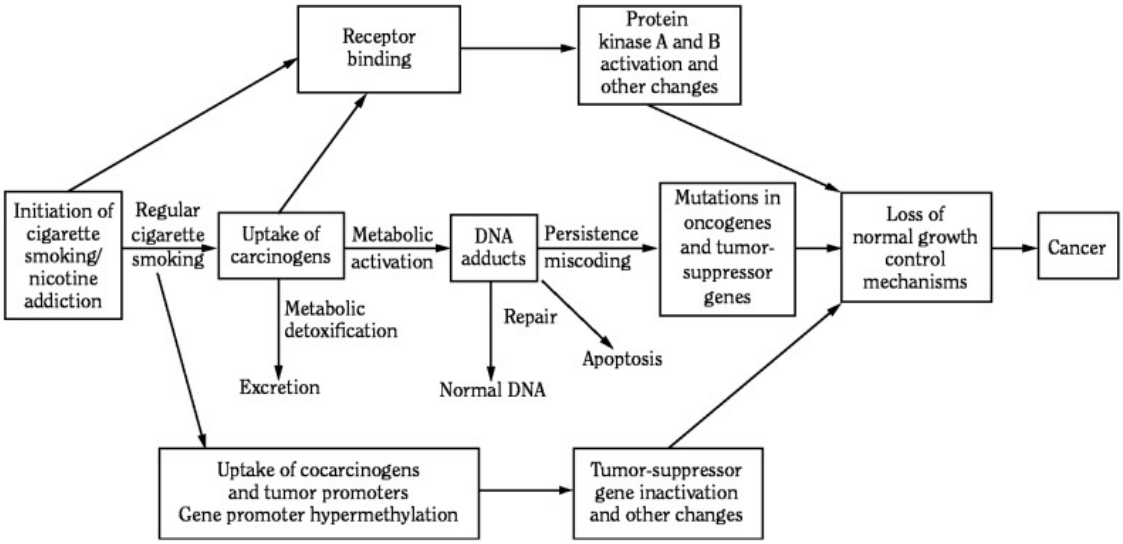


*Figure 1.* Link between cigarette smoking and cancer through carcinogens in tobacco smoke (U.S. Department of Health and Human Service 2010).

In the 1990s, the mechanisms through which smoking causes lung cancer were discovered (Proctor 2001). For instance, Denissenko *et al.* (1996) provided "a direct link between a defined cigarette smoke carcinogen and human cancer mutations" (1996, p. 274). Mainstream science's explanation of the lung cancer epidemic became a causal mechanistic explanation (Russo and Williamson 2007). It detailed the mechanisms through which smoking brings about lung cancer (see figure 1). At the same time, there was a radical change in the tobacco industry's approach (Proctor 2001; 2006; 2011). They stopped denying the standard explanation of the global lung cancer epidemic. They accepted that tobacco was a risk factor in the development of lung cancer and that tobacco consumption accounted for the high incidence of lung cancer. This change has been evidenced in trials against tobacco companies (Proctor 2001; 2006; 2011). Their legal strategy is not anymore denying the causal link between smoking and lung cancer, but arguing "that the risks of smoking have been well–known for decades, and that people therefore voluntarily assume such risks when they take up the habit" (Proctor 2001, p. 84). Historians of medicine are hired by tobacco companies to "re–narrate the past, creating an account for judges and juries that make it appear that 'everyone has always known' that cigarettes are harmful" (Proctor 2006, p. iv117). Historians hired by tobacco companies also argue that there was no conclusive evidence that cigarettes are harmful until quite late, thereby justifying industry's extreme caution to accept cigarettes' hazards.

Tobacco denialism during the second half of twentieth century is a representative case of explanatory war (see section 2). It was generally accepted that the incidence of lung cancer had dramatically increased during the twentieth century and there was a broad consensus among scientists that tobacco consumption accounted for that phenomenon. However, the tobacco industry systematically denied the standard explanation of the lung cancer epidemic. This paradigmatic example of an explanatory war illustrates the relevance of mechanistic explanations to face them.

From the mid–1950s to the 1990s, the standard scientific explanation of the global lung cancer epidemic was not mechanistic. It was a non–mechanistic causal explanation based on statistical evidence (Russo and Williamson 2007). During that period, the tobacco industry denied the standard explanation. They followed two strategies to undermine it. Firstly, they claimed that it was not a satisfactory explanation. They argued that it did not conclusively establish the causal link between smoking and lung cancer. Statistical evidence was considered insufficient for supporting a causal claim. Secondly, the tobacco industry promoted alternative explanations (e.g. the "smoking gene" explanation), which were presented as being as legitimate as the standard explanation. They were compatible with the available evidence. Furthermore, many of them were supported by the same kind of evidence as the explanation used in mainstream science (i.e. statistical evidence).[7]

In the 1990s, however, the standard explanation of the global lung cancer epidemic became mechanistic. It detailed the mechanisms through which smoking brings about lung cancer. Consequently, the tobacco industry's strategies against mainstream science lost their effectiveness. On the one hand, the standard explanation conclusively established the causal link between smoking and lung cancer. It suited the narrow mechanistic account of causality adopted by denialists and made the "more research" argument obsolete. On the other hand, the standard explanation clearly distinguished itself from the alternative explanations promoted by denialists. It was a causal mechanistic explanation, while the alternatives were statistical or non–mechanistic causal explanations (i.e. black–box explanations). They were not supported by the same kind of evidence either. The standard explanation was supported both by

[7] Several scientific studies, most of which were funded by the tobacco industry, offered statistical evidence in support of alternative explanations (Proctor 2011). For example, Wynder and Hammond (1962) presented statistical evidence linking general air pollutants to the development of lung cancer, and Hickey, Boyce, Harner, and Clelland (1970) identified a significant statistical correlation between certain environmental chemicals and lung cancer.

statistical evidence and evidence of mechanisms, but alternative explanations were at best supported only by statistical evidence. They did not suit the available evidence of mechanisms. Finally, in the 1990s, the tobacco industry changed its approach and stopped denying the standard explanation of the lung cancer epidemic. They accepted that tobacco was a risk factor in the development of lung cancer and that tobacco consumption explained the high incidence of lung cancer.

Tobacco disease denialism during the second half of the twentieth century is a paradigmatic example of an explanatory war. This case illustrates how the mechanistic account of scientific explanation is helpful to face this kind of science denialism. In the 1990s, mainstream science's explanation of the global lung cancer epidemic became a causal mechanistic explanation. This change made it more resistant to denialists' attacks. It satisfied denialists' demanding requirements (e.g. the mechanistic account of causality) and distinguished itself from the alternative explanations promoted by denialists. This resistance undermined the denialists' approach and, ultimately, influenced them to admit to the standard explanation.

## § 5. Conclusion

Science denialism is a form of pseudoscience. Unlike pseudotheory promotion, it does not focus on promoting a specific theory (e.g. homeopathy). Science denialism consists in the systematical rejection of a claim on which scientific consensus exists. A relevant kind of science denialism is explanatory war. An explanatory war is a situation in which (i) there is an undisputed phenomenon, (ii) in the scientific community there is a broad consensus on its explanation, and (iii) the standard scientific explanation is systematically denied by a group of people. The mechanistic account of scientific explanation is helpful to face explanatory wars. Mechanistic explanations are resistant to the arguments usually raised by denialists. Tobacco disease denialism during the second half of twentieth century, which is a paradigmatic example of an explanatory war, illustrates the relevant role of mechanistic explanations.

It should be noted that this does not imply that explanatory wars are unavoidably doomed to failure when the standard scientific explanation is mechanistic. Standard mechanistic explanations are resistant to denialists' usual attacks. However, it does not mean that they are completely immune to any possible denialists' offensive. In fact, there are cases of science denialism (although of a different kind than explanatory wars) in which it remains moderately active despite the target scientific claim being mechanistic (e.g.

AIDS denialism). Nerveless, what kinds of critiques and attacks could still be effective against standard mechanistic explanations is a question that exceeds the scope of this paper.

Several benefits of mechanistic explanations have been identified previously. They increase public understanding of science, connect different ontological levels, offer helpful possibilities of representation, do not require covering–laws... In addition, as it has been argued through this paper, they are also helpful to face a certain kind of science denialism, i.e., an explanatory war. Mechanistic explanations are more resistant to denialists' offensives than other kinds of explanations (e.g. statistical explanations). Consequently, adopting a mechanistic account of explanation is a useful tool for dealing with science denialism. Mechanistic explanations should be encouraged in those areas of science where science denialism is a major problem.

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