English version of *Educación y Pseudociencias,* El Escéptico, anuario 2021, p. 10-17.
https://www.researchgate.net/publication/350194099_EDUCACION_Y_PSEUDOCIENCIA

# Education and Pseudosciences

Arnaldo González Arias
Havana University

Many people, even with university degrees, often accept (and promote) pseudoscientific practices due to ignorance about the basic principles of Natural and Health Sciences.

## 1. Introduction

For instance, in our country (Cuba) a clear distinction between science and pseudoscience has not been established in any of the existing educational levels; much less this is a recurring subject in the educational system, as it should be. Recent alert calls, due to the covid-19 pandemic, are attracting attention on the threat of pseudosciences at people's health (Caulfield, 2020).

*Pseudoscience* means 'false science' and not something else such 'same', 'similar' or 'future'. Also, there is no such thing as local or regional science; science has always been universal, and even more so today, thanks to contemporary media. To know what pseudoscience is first it is necessary to have a clear notion of what science is; hence the following items are analyzed.

- What is science? The demarcation problem.
- Science classification: formal and factual; natural, social and health sciences.
- The scientific method.
- Examples of pseudosciences and how they can be recognized.

## 2. What is science? The demarcation problem

This question is not trivial, since there is no universal consensus on the formal definition of science. In fact, it is part of the so-called «demarcation problem» in philosophy, which consists in setting clear borders between what is scientific knowledge and what is not, between science and metaphysics, between science and religion and between science and pseudoscience.

Here we only analyze how it is possible to differentiate science from pseudoscience, without going further into the philosophical problem.

The matter becomes even more complex because there are two clearly distinguishable types of science: formal and factual. Formal sciences study abstract subjects, created in the human mind (mathematics, computer science, statistics, logic and algebra) and do not depend on the experimental evidence. They stand on themselves, based on propositions, axioms and deductions. The rest (physics, chemistry, biology, geography, economics, health sciences, etc.) are factual; are based on facts and depend on observation and interaction with the real world. In what follows, we only refer to factual sciences.

At the moment there is no some simple rule to differentiate science from what is not. There are at least two main and non-coincident criteria: Karl Popper's and Mario Bunge's. Popper introduced the criterion of *falsability*, which holds that a proposition is scientific if it is refutable*;* that is, if experiments or trials can be devised to refute it, regardless of whether the results support or reject the proposition. And if there is no way to find out how to disprove it, then the proposition is not scientific (Popper, 1934). However, this principle has been considered insufficient and criticized by several authors, including Bunge and some of own Poppers' disciples.

Instead, to define science Mario Bunge introduces the concept of *field* of *research* with the following characteristics (which appear somewhat simplified for the benefit of the reader):

• Each field is made up of a community of researchers with specialized training, able to communicate with each other.

• Society harbors and encourages (or allows) the activity of this community.

• Real entities are investigated and not ideas that «float» in the air.

• Everything changes according to certain laws; there is nothing immovable or miraculous.

• Knowledge reflects reality; it is not subjective.

• Research is developed from updated, not obsolete, logical and mathematical theories.

• Reasonably well-confirmed data and theories are used, along with research methods from other areas.

• Is based on verifiable previous knowledge (although not definitive, because science is always perfectible).

• Its direct objective is to find laws and trends, systematize general hypotheses and refine methods of research.

• The methodology used consists only of procedures that can be scrutinized (analyzed, open to criticism) and justifiable (explainable), first of all by means of the scientific method – which will be seen later. ahead.

• for eachfield of research, there is at least one adjacent field with sharing elements, or one of them is included within the other.

• The composition of the above elements changes – usually very slowly – due to research in one's own field and in related others.

According to these criteria, any field of research that does not meet all of the above conditions is *nonscientific,* and any field of knowledge that is nonscientific but advertises itself as such is a *pseudoscience.*

**3. Science classification: formal and factual; natural, social and health sciences.**

A generally accepted classification of the areas of human knowledge appears in Table 1, while Table 2 shows how the sciences are subdivided.

There is something common to all sciences: they look for the *laws* that rule the events or actions in their specific field of application. A law is a stable and recurring connection between events; the laws are universal cause-effect relationships, which exist under certain conditions, and allow the prediction of future events (González and Horta, 2012). There are many laws or principles; by example:

▪ Law of universal gravitation (Newton); Physics.

▪ Law of definite proportions (Proust); Chemistry.

**Table 1. Areas of human knowledge**

| Sciences | Look for laws ruling incidents or events |
|---|---|
| Humanities | Differ from social sciences in only studying peculiarities, without attempting to find universal laws or statements.*<br>***Art and Art history***<br>***Literature***<br>***History***<br>***Religion and Theology***<br>***Philology***<br>***Linguistic***<br>***Semiotic, semiology and several more*** |

*** Some are on discussion.**

**Table 2. Science classification**

| | | |
|---|---|---|
| **Formals**<br>***Based on ideas: Mathematics, Logic***<br>**Are auto sufficient, without need to compare with reality** | | |
| **Factuals**<br>***Based on facts*** | **Natural** | **Study nature, physical aspects (not human) of the world**<br>***Chemistry, physics, biology…*** |
| | **Social** | **Study behavior and activities of human beings, not studied by natural sciences**<br>***Economy, anthropology, sociology…*** |
| | **Health** | **Natural + social + specific**<br>***Surgery, pediatric, toxicology…*** |

- Laws of heredity (Mendel); Biology.
- Pareto principle and Gresham's law; Economy.

However, there is controversy about some social disciplines such as the one mentioned in figure 1: are they really sciences or not? That is, there exist or not the corresponding social laws? (Dark, 2008). In what follows, we refer exclusively to natural and health sciences and the application of their concepts to several pseudosciences.

Before going any further, it is worth noting an important difference: according to Jean Dausset, Nobel Prize in Physiology in 1980: *«The simple enunciation of the subject "science and technology" reveals the antagonism between these two concepts: science has to do with knowledge, while technology is more about its use."*

From this it follows that the training received by scientists and technologists are not equivalent, something that is sometimes forgotten and has led some to pseudoscience.

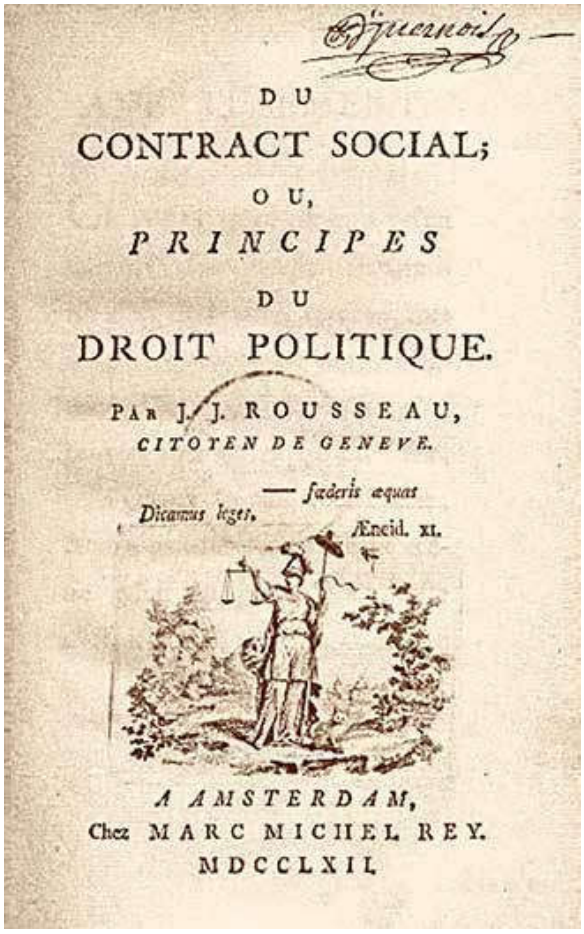
DU
CONTRACT SOCIAL;
OU,
PRINCIPES
DU
DROIT POLITIQUE.
PAR J. J. ROUSSEAU,
CITOYEN DE GENEVE.
— fœderis æquas
Dicamus leges.
Æneid. XI.
A AMSTERDAM,
Chez MARC MICHEL REY.
MDCCLXII.

Figure 1. Rousseau's social contract.

**4. The scientific method**

The main characteristics of the scientific method and the pseudoscientific distortion appear in figure 2. It is important to stress that, to avoid external influences, in any experiment it is necessary to control *all* the parameters that affect the event or process studied. There are sciences in which this is not possible (for example, astronomy, geology and archaeology). In those cases, theories are considered valid if:

a. They can associate apparently independent events.

b. They manage to predict relationships or phenomena not previously found.

New drugs and therapies deserve a separate comment. Here, in addition to cell and animal experiments, clinical trials are mandatory. These must meet a series of scientific and ethical standards (for example, informed consent) (González, 2014). In Figure 2, a biased experiment means that some basic rules have not been fulfilled from the beginning, so any subsequent results are invalid and should be ignored. Another type of bias refers to a biased way, conscious or not, of evaluating the results of the experiment. There are clinical trials of many kinds; in *Google Scholar,* in 2017-2018 alone, appeared 13,800 entries. Ordinary people do not usually handle this type of information; students, much less.

Any branch of knowledge that is not scientific,
but advertises as such, is a pseudoscience

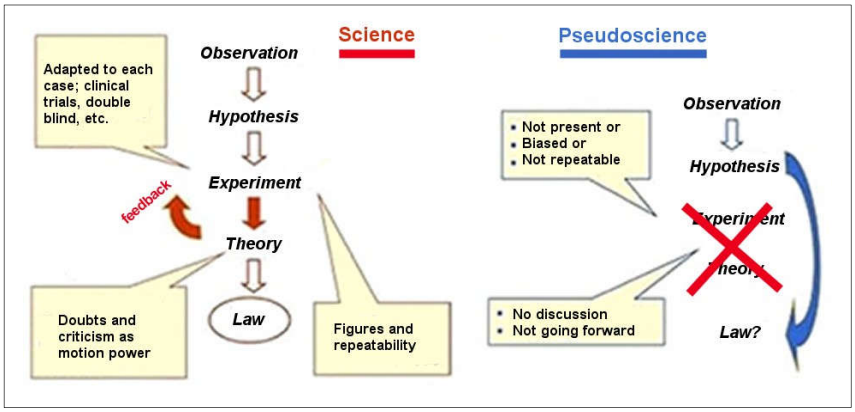


Figure 2. Science and pseudoscience. In the latter, the use of scientific terminology is common. no real evidence to back it up. (Gonzalez, 2012).

**5. Examples of pseudosciences and how to recognize them**

Some popular pseudosciences are the following:

***Astrology.*** As early as 1727 appeared serious criticism on astrology (Figure 3); however, today many people still consider it true. In 1985, a statement reproving astrology signed by 18 Nobel laureates and 168 other scientists was published in *Nature* (Shawn, 1985).

***Homeopathy and nosodes.*** These two are related to a doctrine devised by Samuel Hahnemann (1755-1843), which implies the dissolution of organic or inorganic compounds that cause *symptoms* of diseases (*notice*, not the disease itself) that should be administered as a medicine for diseases with similar *symptoms* (i.e., *any illness* with similar symptoms). The degree of dilution it is so great that none of the original substance remains in the final product. Theoretical or empirical scientific basis? None (Álvarez, 2008; Editorial, 2005). In recent years, homeopathy has been officially condemned or disavowed in US, Russia, England, Spain, and Australia (Rationalis, 2020). Nosodes, the so-called homeopathic vaccines, are just as fraudulent; in this case the diluted products can be contaminated human tissues, rabid dog saliva, menstrual blood and the like. Otherwise, the product in Figure 3 is not specifically promoted as a nosode, but that "strengthens the immune system", but without giving any detail about how itdoes.

***Magnetotherapy (healing with magnets).*** There is a great amount of reports exposing the falsehood of magnetic therapies. An important paper came from of one of the main hospitals in Europe (Le Charité, in Berlin) where XIX century German doctors performed research for many years about the assumed healing properties of permanent magnets, without results ( Engstrom, 2006).

However, much before very solid arguments against magnetic therapies had surged. One of the more convincing came from France, in 1785, thanks to the report of a commission formed by the North American Scientific Benjamin Franklin, the chemist Antoine Lavoisier, the astronomer Jean Sylvain Bailly and the physician Joseph Ignace Guillotin, all notable characters of that time. The report was the result of carrying out the instructions of Luis XVI about inspecting the «magnetic cures» applied by Dr. Franz Antony Mesmer to members of the French nobility, with negative results.

Figure 4 shows a drawing taken from a magazine of the epoch where Franklin, president of the commission, appears on the left holding the conclusions while Mesmer, with donkey ears, is forced out the room together with his assistants (Gonzalez, 2013). Much more recently, in 2006, based on a study by the Mayo Clinic, the US judge Morton Denlow pronounced that the made-up therapeutic claims of a magnetic bracelet, promoted as curative, were "more fiction

Figure 3. Left.: Critique of astrology, by Dr. Don Martín Martínez, 1727. Right. Homeopathic-nosodic mixture against covid-19, Aica Laboratories, 2020


JUICIO FINAL
DE LA ASTROLOGIA,
EN DEFENSA
DEL THEATRO CRITICO UNIVERSAL,
DIVIDIDO EN TRES DISCURSOS.
DISCURSO PRIMERO.
QUE LA ASTROLOGIA ES VANA, Y RIDICULA en su Nombre.
DISCURSO SEGUNDO.
QUE LA ASTROLOGIA ES FALSA, Y PELIGROSA en su Modo.
DISCURSO TERCERO.
QUE LA ASTROLOGIA ES INUTIL, Y PERJUDICIAL en su Fruto.
POR EL DOCTOR DON MARTIN MARTINEZ,
DEDICADO
AL EXCMO SEÑOR MARQUES DE SANTA CRUZ
CON LICENCIA:

than science." Among other benefits, the supplier claimed that the bracelets controlled hypertension. Sales amounted to approximately $20 million. Judge Denlow sanctioned the distributor to return their money to 100,000 buyers (Figure 5).

***Ozone therapy.*** It consists of blowing ozone ($O_3$) into various parts of the body: mouth, eyes, spine, vagina, anus, skin, blood, etc. It works for everything! But, how does it do it? Nobody knows. However, what is acknowledged is that ozone is a well-known irritant and aggressive pollutant (González and Rangel, 2017). According to the US Food and Drug Administration (FDA): «*Ozone is a poisonous gas with no known medical applications in specific, adjuvant or preventive therapies. For ozone to be effective as a germicide, it must be present in a concentration much higher than safe tolerance for people and animals* ».

The FDA Code of Federal Regulations in Title 21, Vol. 8, 2016, (Code FR, 2016) prohibits generating or disseminating ozone:

1. In hospitals or other establishments where there are patients present.
2. Under any medical condition without evidence of safety and effectiveness.
3. In any other situation where would be possible to reach a level of 0.05 parts per million in the air passing through the device.

***Other pseudotherapies.*** There are many pseudo-therapies, some more absurd than others, so it would take too much space if we only name them. Hence we merely cite some of the more popular in our country, together with some related images (figure 6).

These are flower therapy or Bach therapy (Ernst, 2002, Gonzalez, 2010); pyramid therapy (González, 2013); dowsing (pseudodiagnosis) (Enright, 1999); bioenergetics therapies, reiki or therapeutic touch (Rosa et al, 1998), chrome therapy and laser therapy (Tate, 2005); naturism (all natural products are good for the mere fact of coming from nature) (González and Horta, 2015); and acupuncture (there are some very specific results of minor impact, and


Figure 4. Franklin puts the mesmerists to flight in *Magnetism Unveiled,* National Library of France.

in conflict with other studies); (López, 2003, Horta and González, 2014). Figure 7 shows a sketch of the experiment of Emily Rosa, designed to verify the supposed perceptive abilities of Japanese reiki practitioners (therapeutic touch). A total of 280 trials were carried out, but only 123 (44%) were correct, a figure even lower than a random selection (Rosa et al., 1998).

However, despite its falsehood, many people state that they feel better when receiving some pseudo-medication or some pseudo-therapy. Why this happens? Simply because most people have no knowledge about the *placebo effect,* and pseudotherapists never take it into account – on purpose or due to ignorance –. Most of the time the supposed improvement can be attributed to this effect, and also to the spontaneous remission of the illness, something that often takes place.

The training that receive scientists and technicians is not equivalent, something sometimes forgotten that had led some people to pseudoscience

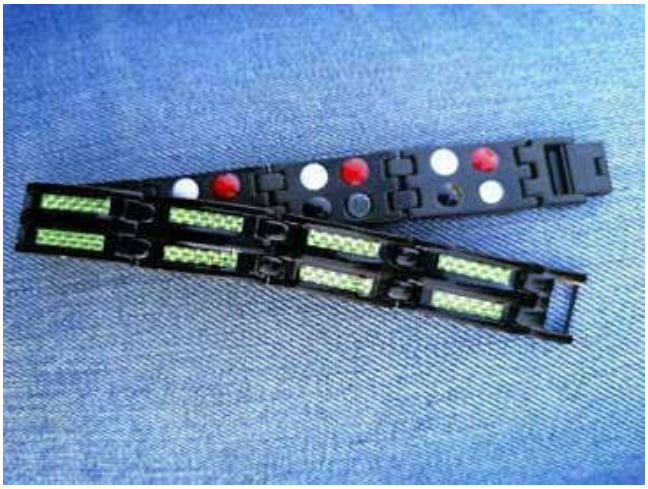

Figure 5. Fraudulent magnetic wrist. Photo of Innovato Design: https://www.flickr.com/photos/185005651@N04/48902470416/

Since the middle of the 20th century the placebo effect has been very well known in the medical literature; it is described as that many people (not everybody!) reports feeling better when given some bogus drug or therapy. It has been written about the placebo effect that "*it can be used to benefit the patients, but it provides an easy route for unscrupulous quacks of all kinds* " (Tavel, 2014).

There are dozens of recent experimental articles in peer-reviewed medical journals about the placebo effect. Today is essential to consider this effect in any clinical trial of therapies or drugs, where a control group receiving some inert substance is included together with the test group to compare results. Magnetic Resonance Imaging MRI and Positron Emission Tomography PET (Zubieta et al., 2005) have been used with excellent results to study the biochemical effects of placebos in the brain and other organs (figure 8). In addition to the already considered Bunge's criterion, there are additional signs that allow the recognition of pseudotherapies, because pseudosciences freely use the terminology of science, but always lack its essence (see Table 3). The first indication is that many pseudoscientific remedies often claims to be universal nostrums. They are supposed to cure many different diseases: eyesight, bones, stomach, any pain, or "strengthen the natural defenses" (without adding more details), and so on. Of course, no one knows the mechanism involved in healing or strengthening. When someone says that a drug or therapy "is good" for many things, it is wise to doubt; it is very likely to be of no use at all. The criteria in Table 3 have been taken and simplified from González and Horta (2012) and González (2012).

## 6. Conclusions

The aforementioned arguments seem to be adequate to emphasize that it is not enough to teach the right ideas, but it is also necessary to teach the wrong ones when scientific evidence has shown them to be false. Pseudoscientific practices have caused, are causing and will cause a lot of damage in the future if they are not criticized at all levels; experience says that there will always be people confused. More than 2,500 years ago, Cleobulus of Lindos, one of the seven wise men of Ancient Greece (c. 600 BC), left us the following statement, which remain valid today: «There is nothing as common in the world as ignorance and charlatans». However, we can significantly reduce the negative numbers by warning students in a timely manner. Therefore, educational programs at all levels should at least comprise the scientific method and criticism of the most popular pseudosciences. The problems linked to pseudosciences are important enough for not leaving the subject unattended. These problems range from direct damage to the loss of time, efforts and valuable financial resources.

Figure 6. From left to right; floral therapy, pyramid therapy (Pinterest), dowsing.

As Einstein said, "That which surpasses the test of experience is true". None of the pseudosciences aforementioned have passed this test; but those are not the only ones: there are lots of others. More information and pseudoscience criticism appears in many sources; one of them can be found at www.geocities.ws/rationalis/.

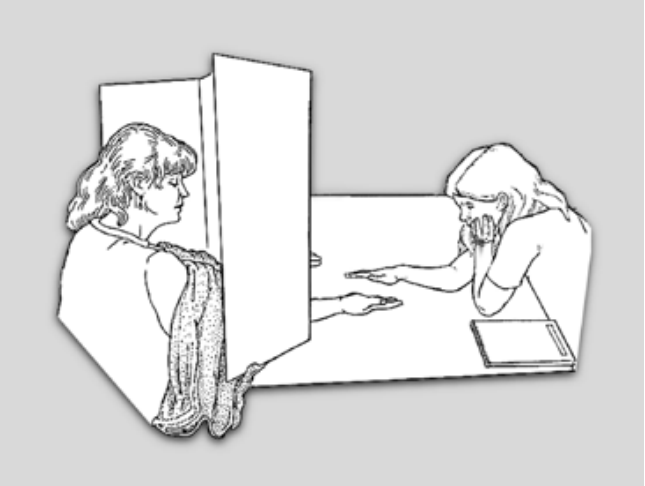

Figure 7. The experiment of E. Rosa

**References:**

(verified links as of April 2022)

Álvarez González JL (2008) Homeopathy: an illusion beyond Avogadro's number. *Rev.Cub. Phys.,* 25, 1, 38-44

Benedetti Fabrizio, Mayberg Helen S., Wager Tor D., Stohler Christian S. and Zubieta Jon-Kar (2005) Neurobiological mechanisms of the placebo effect, *The J. of Neurosc.,* 25(45), 1039-1040.

Bunge, M. *Las pseudociencias, ¡vaya timo!,* Laetoli: Pamplona, 2010. See also https://web.archive.org/web/20150411044420/http://www.galilean-library.org/site/index.php/page/index.html/_/essays/philosophyofscience/falsificationism-r52

Caulfield T., "Pseudoscience and COVID-19 – we've had enough already." https://www.nature.com/articles/d41586-020-01266-z?utm_source=twt_nnc&utm_medium=social&utm_campaign=naturenews

Code of Federal Regulations 2016; available at http://www.ecfr.gov/cgi-bin/text-idx?SID=3ee286332416f26a91d9e6d786a604ab&mc=true&tpl=/ecfr-browse/Title21/21tab_02.tpl

Editorial 2005, *The Lancet,* 366, 690. Engstrom E.J. (2006) Magnetic trials in Berlin, 1789-1835: On the disembodiment of magnetic credibility. *Medizinhistorisches Journal,* 41, 3-4

Enright Jim T. (1999) *Skeptical Inquirer,* 23.1 (Jan-Feb); Also A. González Arias, Brief History *of Alternative Therapies in Cuba,* online at www.researchgate.net and www.geocities.ws/rationalis/index-libros.htm

Ernst, E. (2002) Flower remedies: a systematic review of the clinical evidence" *Wien Klin Wochenschr.,*114 (23-24), 963-966.

González Arias, A. (2012) Use and misuse of the energy concept . *The t. Am. J. Phys. Educ.,* Vol. 6, Suppl. I, 394-402

González Arias, A. and Horta Rangel, FA (2012) Science, pedagogy and scientific culture. *Elements, 87,* 3-11.

González Arias, A. and Horta Rangel, FA (2015) Naturism in the light of contemporary science. *The Skeptic,* 42, 50-57.

González Arias, A. and Horta Rangel, FA (2017) Ozone, environmental pollution and evidence-based medicine. *Rev.Cub. Phys* ., 34, 70-79.

González Arias, A. (2013) Notes for a history of alternative medicine in Cuba. II. Magnetic and electromagnetic therapies, Annals of the Cuban Academy of Sciences, 2013, 3, 2.

González Arias, A. (2013) Notes for a history on alternative medicine in Cuba - I. Pyramid Therapies. *Annals of the Cuban Academy of Sciences,* 2013, 3, 1.

González Arias, A. (2014) Ethics in research with people. *The Skeptic,* 34, 34-39.

González Arias, A. (2010) Another energetic remedy co ; flower energy. *Elements,* 77, 57-58,

Horta Rangel, FA and González Arias, A. (2014) Acupuncture in the light of contemporary science. *The Skeptic,* Jul-Sept 2014, 55-59.

When someone says that a drug or therapy "is good" for many things, It's wise to doubt; very likely it will be of no use for anything

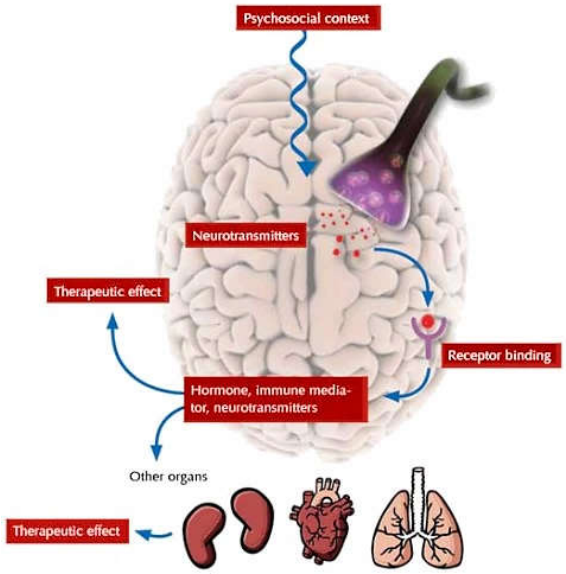


Figure 8. Neurobiological mechanisms of the placebo effect (Nicola Graf, scienceinschool.org)

López Borgoñoz, C. (2003) The Cochrane collaboration and alternative medicines. Is the scientific method capable of finding efficacy in acupuncture or homeopathy? *The Skeptic,* Winter 2002 and Spring 2003, 30-35.

Moreno Castillo, R. (2008) Is pedagogy a science? *Education Forum* 2008, *no. 11,* 67-83.

Popper, K. *Logik der Forschung* (1934), tr. V. Sánchez de Zavala, *The Logic of Scientific Research* ; Tecnos: Madrid, 1967. Also: http://www.letralia.com/146/essay03.htm

Rationalis 2020, http: ndications that allow//www.geocities.ws/rationalis/homeopatia/index.htm

Rose, L.; Rose, E.; Sarner, L. & Barrett, S. (1998) A Close Look at Therapeutic Touch. *JAMA,* 279(13), 1005-1010.

Shawn, C. (1985) A double blind test of astrology. *Nature, 318,* 419-425. Also: http://www.psychic-investigator.com/demo/AstroSkc.htm

Silva Ayçaguer, LC (2016) Predatory scientific publishers: an academic plague. *Cuban Journal of Information on Health Sciences,* 27(3), 420-428.

Tate Etc., (2005) Cured by colour, http://www.tate.org.uk/context-comment/articles/tate-etc-issue-4? webSyncID=e39ac7ba-b0d0-1ddb-4195-a5933058854b&sessionGUID=be8447b7-8257-1878-23d3-a07daa728b06; Also: http://www.geocities.ws/rationalis/optica/filtros-colores/ index.htm

Tavel, ME (2014) The Placebo Effect: the Good, the Bad, and the Ugly. *Am. J. of Med* ., 127, 6, 484-488.

Zubieta, JK; Bueller, JA & Jackson, LR (2005) Placebo Effects Mediated by Endogenous Opioid Activity on-Opioid Receptors. *The Journal of Neuroscience,* 25(34): 7754 –7762.

**Table 3. Main differences between science and pseudoscience results**

| | Science | Pseudoscience |
|---|---|---|
| 1 | Analyze favorable and unfavorable results. Doubt about its own achievements. Skeptic and rational. | Accept only favorable results. Ignore opposite evidence. Is credulous. |
| 2 | Criticism is its normal way of progress. | Promoters take criticism as personal attacks. |
| 3 | Describes and analyze processes and objects by means of well-defined magnitudes and concepts (chemical, physical, biological). | Produces its own vague concepts, taking them out of nothing, mixed with scientific concepts. |
| 4 | References from referred and well known science journals. | References from the web, pseudosciences congress, books from unknown editors or from journals of the same pseudoscience circle.* |
| 5 | Always show numeric or statistical repeatable results. | Gratifies itself with isolate anecdotic examples. If any experiment, is biased or not conclusive; no repeatability. |
| 6 | Works to find theories explaining facts, based on experiments and previous scientific knowledge. | Do not propose theories. If does, are not based on previous knowledge, but taken out of thin air. |
| 7 | Has nothing to do with politics or the judgement of 'personalities'. | Look for support of politics or 'personalities' without scientific knowledge or with degrees in another fields. |
| 8 | Concepts change and improve to adjust to advances in its field and others related. | Defends pre-conceived ideas that no change with time. |
| 9 | Multidisciplinary and collective. | Often come out of the 'inspiration' of a single person, without any evidence. |
| 10 | In therapies and drugs placebo effect is always taken into account. | Rarely the placebo effect is mentioned. (The crudest pseudotherapies never do). |

* At present there are a certain number of predatory science journals that, in change for authors' payment, publish practically anything in open form in the web. Some of them even provide false information about referees, impact factors or other particularities (Silva).