Use and misuse of the concept energy

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Abstract

The concept 'energy' if often distorted in the literature. In the following its meaning is discussed by comparing its definition and properties with some false energies that can be found in some places and lead to pseudoscience. There are three different meanings which are easily mixed up: 1. A rigorously defined energy in physics and other natural sciences (kinetic, potential). 2. To specify where are kept or stored some of the energies described in (1), without these concepts being themselves additional energies (eolic energy, nuclear energy) 3. The third meaning describes a particular volitive attitude or state of mind. Is used freely by common people and some psychologists but, obviously, it has no relation at all with physics. These facts should always be taken into account when mentioning the concept 'energy', recalling that any energy in physics must be measurable and have associated numerical values.

Keywords: Physics education, teacher training, energy sources of.

Resumen

A menudo el concepto de energía aparece distorsionado en la literatura. A continuación se discute su significado, comparando su definición y propiedades con algunas falsas energías que se pueden encontrar en diversos lugares y que conducen a la pseudociencia. Existen tres acepciones diferentes para la energía que se confunden fácilmente: 1. Una energía rigurosamente definida en la física y otras ciencias naturales (cinética, potencial). 2. Para especificar donde se mantienen o guardan las energías descritas en (1), sin que estos conceptos constituyan energías adicionales (energía eólica o nuclear) 3. El 3er significado describe una actitud volitiva particular o un estado mental. Se usa liberalmente en el habla popular y por algunos psicólogos pero, obviamente, no tiene relación alguna con la física. Estas particularidades deben ser siempre tomadas en cuenta cuando se menciona el concepto 'energía', recordando que en la física cualquier energía debe ser mesurable y poseer valores numéricos asociados.

Palabras clave: Enseñanza de la Física, formación docente, fuentes de energía.

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I. INTRODUCTION

It is customary to group the human knowledge in two main streams; Sciences in one side and Humanities on the other. Humanities like Art, Literature, Philology or Linguistic study particular cases; they do not attempt to find laws or universal postulates. Sciences, usually divided in Natural, Social and Medical, try to find the *laws* that guide events or phenomena in their specific field of application. A law is a stable and repeatable association between different phenomena; laws are universal relations of cause-effect, holding in specific conditions. There are many laws and principles such as the Law of Universal Gravitation (Newton, Physics), the Law of Definite Proportions (Proust, Chemistry), the Laws of Inheritance (Mendel, Biology) and the 20/80 Law (Pareto, Economy).

Natural Sciences study the non human, physical aspects of the world; they include Chemistry, Physics and Biology among others. Social Sciences study the behaviour and activities of human beings, not studied by the Natural Sciences. To this group belong Economy, Psychology, Law and Archaeology. Medical Sciences include some natural and social sciences, besides other specific ones such as Anaesthesiology or Surgery; up to about 30 specialities. It should be noticed than some sciences, such as Geography, are sometimes considered natural sciences and others as social ones. Besides, some Social Sciences which do not show definite general laws recognized for all, are being questioned at present. There is doubt about if they really are Sciences or should be better described as Humanities.

In what follows we will circumscribe to Natural Sciences. Mathematics will not be considered because, even though sometimes is described as the 'Queen of Sciences", others think that is a form of *art,* because is devoted to the study of abstract concepts and structures that have a proper logic, without the need to realize experiments to make progress.

This discussion is also valid for any engineering. Jean Dausset, Nobel Prize in Physiology, stated: "The simple enunciation of the subject 'science and technology' exhibits

the opposition between these two concepts: Science is related to knowledge, but technology is better referred to their application". However, in both cases the knowledge is the same and, in this sense, what is true for one it will be also for the other.

II. SCIENCE AND THE SCIENTIFIC METHOD

It is possible to find many definitions of Science in the literature. A review of several, applied to Natural Sciences, is the following: Field of the human activity pointed to the acquisition of new knowledge, resumed in laws and explanations of the natural processes. According to Hewitt, Science is the study of natural laws and reality. It is a way of thinking as well as body of knowledge [1]. Mario Bunge is more specific: he considers that any science, natural or not, is a cognitive field that cannot be described in a few words; instead, it is labelled by ten specific elements very well defined, which will not be considered here [2]. If some of these elements are not present, the corresponding cognitive field is not a science, even though its supporters may state the contrary.

In science, the gathering of new knowledge came from the Scientific Method, which is a procedure derived from the practice and experience of many generations (Fig. 1). It is also applied regularly in Medical Sciences, but when patients are involved, instead of experiments is usual to talk about clinical trials.

The scheme in Fig. 1 shows an outline of the procedure in physics and other natural sciences. It tells us that whenever we have notions of a given event of phenomenon (observation), we usually assume a supposition about why it happens and its possible cause (hypothesis). Then it is necessary repeat it under controlled conditions (experiment) to avoid any interference of external agents that could affect the object of study and obtain trusty and repeatable numerical values. This last point is of main importance. If the results of an experiment can not be repeated in other laboratories and with other instruments, it will not be possible to state nothing about the results. It means that this particular result, if not erroneous, was got by chance. Is a strong indication that the experiment was not controlled enough, and there were unidentified factors affecting the results.

Once you have a result –than can confirm o deny de hypothesis- it becomes necessary to find some rational explanation based on it. We arrive in this way to the theory. And when you have a theory, always is possible try to predict what will happen in some other similar situation, and devise some other experiment that will be useful to check the former result, and also the theory (hence de double arrow in Fig. 1).

In this way a continuous interaction between theory and experiment is established, undoubtedly the essential core and 'driving power' of the scientific method. Associated to the theory-experiment interaction there is also a process of international spreading of results in science journals, criticisms, errors and amendments. And it is not very uncommon that well established theories must be changed or generalized when detecting some new fact that the existing theory can not adequately explain.

When the theory is broad and solid enough, when is able to explain a great deal of phenomena and cause-effect connections, and also can rationally refute any critics, we arrive to the law. Laws are not eternal; often must be generalized to explain previously undetected new phenomena. There are many laws in physics, chemistry, biology and other sciences: All come from the described process.

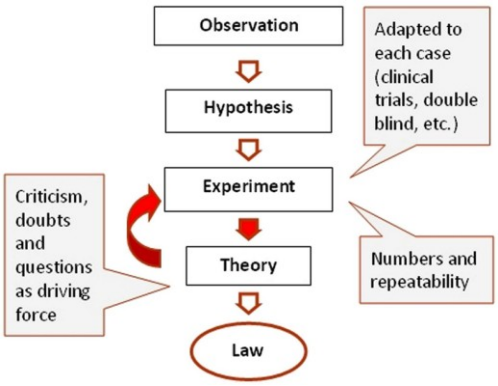

FIGURE 1. The scientific method.

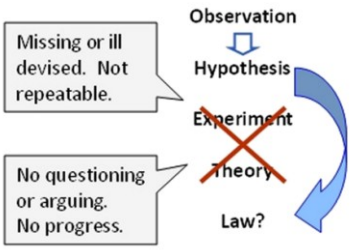

FIGURE 2. The pseudoscience.

In fact, the former statement is not strictly true, because in some natural sciences it is not always possible to carry out controlled experiments to analyze some observable fact. It happens, for instance, in geology or astronomy, whose methods of analysis and research are not being considered. However, in these cases the precise and repeatable observation is a substitution for the experiment, and theories are considered valid when:

a) They are able to rationally link facts which apparently are independents and,

b) Can predict the existence of connections and events not detected before.

Before further analysis, it is necessary to mention that hand in hand with science also exists the false science or

pseudoscience. This one, with the facade of science, actually lacks the essential of the scientific method, jumping from some hypothesis to a certain middle point between theory and law, without carrying out experiments as they should be (Fig. 2). In this way, the assumptions of some visionary and his (or her) followers are declared as laws, without going through the fine sieve of the theory-experiment interaction. The false assumptions and statements, profusely using scientific terms in their descriptions, may easily deceive to anyone unfamiliar with the science work, even those with scientific experience in other fields. Most times the experiment is completely absent, and the hypothesis is taken as an absolute truth. Other times a few ill-devised experiments are carried out, and some unproved theory is proposed and accepted as it comes. When there is some favourable experimental result, is by pure chance, not reproducible for other people. Since the power force of science is just the critics and the theory-experiment interaction, the pseudoscience can not advance; its false 'laws' and 'theories' are always given once and forever.

There is some similarity between pseudoscience and religious believes; some pseudosciences even invoke those believes, but masked with scientific concepts, as it is shown below. Mario Bunge, in his aforementioned book about pseudoscience, classifies knowledge in two big fields. One includes the 'investigation fields' where he groups Humanities, Basic and Applied Sciences, Mathematics and Technology, also including Medicine and Law. In the other field includes the 'believing field', where together with religions and politic ideologies includes pseudotechnologies and pseudosciences. He adds up to a total of 19 typical differences in the behaviour of scientists and pseudoscientists (Table I).

In Medical Sciences is not hard to find elaborated false statements, constructed with the only purpose of deceive the patients to justify the validity of one or another pseudotherapy. This possibility should be always taken into account when receiving offers of marvellous therapies able to heal many different illnesses. Those therapies may include the treatment of several types of cancer with essentially pure water (homeopathy) or healing at a distance using a pendulum and a patient's photo [3].

There are three fundamental reasons to expose and condemn pseudoscience:

1. Its falsehood. All pseudosciences state notions contrary to those recognized by science.

2. They represent a waste of time, effort and resources, and something similar to what economists call 'opportunity cost'. That is, additional to the losses described before, appears the loss of what could be gained if those efforts and resources were spent in some other inversion really productive.

3. When pseudoscience is linked to a false therapy, the possibility of damage to the patient is always present, directly or indirectly when the patient does not take care of his problem in time, losing time with the pseudotherapy without receiving the truly effective treatment.

III. ¿WHAT IS ENERGY?

It is possible to find in the literature varied definitions of the energy concept, most of them easily rejected. Some definitions mix physics with philosophy, trying to give the concept a more extended meaning than that provided by physics. Other times the definitions are too much abstracts or ambiguous. It is also common to find differences among the definitions of energy in mechanic courses and those appearing in thermodynamics ones. You can find definitions where energy is… anything that moves from one to another system. Other definitions easily reveal its intrinsic confusing character when you analyze some given example.

TABLE I

Typical actions and activities of scientists and pseudoscientists	Scientists		Pseudoscientists		
	Yes	No	Yes	No	Op*
Admits his own ignorance and hence, the need for further research	x			x	
Feel that his field of knowledge is difficult and full of gaps	x			x	
Move forward by finding and solving new problems	x			x	
Receive new hypothesis and methods gratefully	x			x	
Propose and try new hypothesis	x				x
Try to find and apply laws	x			x	
Appreciate the unicity of science**	x			x	
Rests on logics	x				x
Uses mathematics	x				x
Looks for or use data, specifically quantitative	x				x
Try to find counterexamples	x			x	
Devise or apply objective control procedures	x			x	
Solve dissensions by means of experiment or calculus	x			x	
Systematic recurrence to the authority		x	x		
Suppress or distort unfavourable data		x	x		
Updates the information	x			x	
Looks for the criticism of others	x			x	
Write papers that can be understood for any person		x	x		
It is possible that could get immediate fame		x	x		

* Optional
** Meaning that any science has contact points with other sciences that can not be ignored.

For instance, consider the following statement: 'A body has energy when is able to produce changes or transformations in other bodies or in itself', suggesting that after the change stops, the energy disappears [4]. (Besides, forces could also be described as able to produce changes in other bodies)[a].

It is true that the chemical energy spent in a vehicle can not produce further changes or transformations in it, it has been degraded. But according to the first principle the energy remains, converted in another type (essentially as useless heat or thermal energy in this example). Further, energy is not a fundamental magnitude of the International System of Units, and in the mentioned definition do not even appear an attempt to associate it to other physical magnitudes or to the results of some measurement.

In regard to the essential significance of measurements in Natural Sciences, it is worth to recall the words of William Thomson (Lord Kelvin), one of the fathers of modern Thermodynamics.

'I often repeat that only when is possible to measure and express in numbers the matter we are talking about, we know something about it; our knowledge will be deficient an unsatisfactory if we are not able to translate it to numbers. In any other case, whatever the subject, maybe we are in the threshold of knowledge, but our concepts barely will have attained the level of science'.

Other definitions such as 'the energy is the measure of movement', introduced by philosophers of the XIX century, contradicts the modern texts of physics where, among other examples, it is possible to find energies, found later, not associated to movement. For instance, in reference to the famous Einstein's relation between mass and energy (1905), a known physics text states: '…we can state that a body at rest has an energy $E_o = mc^2$ due to its mass. This quantity is called the rest mass' … (*additional to the energy associated to the movement of the particle*).

Three different meanings. Usually the problem becomes more complicated because the word *energy* is used regularly with al least 3 different meaning.

First meaning. As a physical energy, real and measurable: Kinetics, potential electrostatic, gravitational, bond energy, magnetostatic, rest energy, from radiation $\Delta E = h\nu$ and so on. All of them have an analytic expression and are associated to numbers. Hence:

a) They may be compared unambiguously.

b) It can be verified that they transform one into another and check that the first principle of Thermodynamics hold.

Bond energies usually do not have a specific analytic expression but, however, they have precise numerical values, determined from the experiment.

Second meaning. To specify where come from or are stored some given energies: eolic energy (kinetic energy of the wind), solar energy (from the sun's electromagnetic radiation), nuclear energy, chemical energy, wave or tidal energy and others. These concepts do not have associates formulas or number. Hence, they are not energies additional to those analyzed before; they are only nouns or concepts showing where come from or are stored the real energies.

Third meaning. The popular meaning we all know. 'I have loss my energy' to express tiredness or exhaustion, or 'I feel with a lot of energy' to express the contrary. This 'energy' really is not so, but a volitive attitude or a state of mind reflecting a feeling; it can not be measured, since is it not analytically defined. It is not possible to make science thinking in the energy as this popular accept ion. To attempt an explanation of the effect of some medicines or procedures based on this non scientific meaning on persons or animals, leads immediately to pseudoscience.

When arriving at this point, it is worth to take notice that when a teacher talks about 'energy' without specifying surnames such as kinetic, eolic, etc., or without showing the corresponding analytic expression, then he or she is doing a thin favour to his listeners, even more if they are students. When this is so, the three different accept ions become mixed in the interlocutor mind, two of them not having a clear physical significance. Therefore, in teaching it is always mandatory to make clear the 'surname' of the mentioned energy and describe how its numerical values may be obtained (see Table II).

TABLE II. Analytic expressions of some energies.

Energy	Expression	Magnitude to measure
Kinetic	$\frac{1}{2}mv^2$	Mass (m) Velocity (v)
Potential gravitational	$G\frac{m_1m_2}{r}$	Mass (m) Length (r)
Potential electrostatic	$k\frac{q_1q_2}{r}$	Electric charge (q) Length(r)
From electric field (per vol. unit)	$\frac{1}{2}\varepsilon$	Permittivity Electric field E
From magnetic field (per vol. unit)	$\frac{1}{2}\mu H^2$	Permeability (μ) Magnetic field H
Rest energy (E_o)	mc^2	Mass (m), Light velocity (c)
Photon energy from energy level (ΔE)	$h\nu$	Frequency(ν)

The expression $\Delta E = h\nu$ usually refers to differences between energy levels, and not to absolute energy values. In thermodynamics some similarity exists, where the usual important values are energy differences rather than absolute values.

There are no instruments for measuring energies directly, even in the microworld, where the norm is the measurement of frequencies or wave lengths. (Notice that is possible to calibrate some instrument to measure the wave length or frequency of a radiation, and make and automatic report of the corresponding energy value; of course, this do not represent a direct measurement of the energy, since is taken from some analytic expression. A direct measurement

[a] We define force as the measure of interactions between systems.

happens when you measure a length with a rule, time with a clock or temperature with a thermometer*, without substituting in some formula).*

IV. DEFINING ENERGY

¿Then, how can we find a general definition of energy from the point of view of physics? Definitions in physics should be quantitative as well as qualitative. A possibility is trying to find some analogy with other definitions.

In physics, magnitudes are defined from some known others. (In the case of the fundamental ones, the operational criteria is used; it considers that the magnitude is fully defined when the process of its measurement is described in detail).

For instance, we define acceleration using the expression $\vec{a} = \frac{dv}{dt}$. This tells us that velocity is the time change of velocity and, at the same time, also tells us how its value must be computed. Since energy is not a fundamental magnitude, if we desire a definition not divorced from physics, it is necessary to define it from other magnitudes –in a quantitative as well as in a qualitative way-.

Then, let us consider the following. (Some of these ideas have been partially discussed and published separately in Spanish) [5, 6, 7, 8, 9, 10].

Kinetic energy comes from the Energy and Work Theorem, in the form of a certain function that do not depends on the trajectory of the work realized for the resultant force, but only from initial and final states. For a particle:

$$\Delta E_c = \int_1^2 \vec{F}_{res} \cdot d\vec{r},$$

$$E_c = \tfrac{1}{2}mv^2 = \frac{p^2}{2m}.$$

Then, in the 2nd Newton's law $\vec{F} = \frac{dp}{dt}$, p may be written as $p = \sqrt{2mE_c}$.

These two last expressions, together with the 3rd Newton's law, tell us that a particle whose kinetic energy changes in time must exert forces on another system or systems. Since any mechanical system may be thought as formed for many particles, what is true for a particle is immediately extended to any system.

But the potential energy also exists, defined from the concept of conservative force F_c. The definition leads to

$$\Delta E_p = -\int_1^2 \vec{F}_c \cdot d\vec{r}.$$

As in the former case, the result only depends from the initial and final positions, and not from the particular trajectory, allowing the definition of a potential energy function E_p. The inverse mathematical relation takes the form $\vec{F}_c = -\nabla E_p$.

The former expressions tell us that even though the position of a system do not change with time, if the possibility of exerting forces exists; *i.e.*, if the potential energy function exists, then we also have energy (potential, in this case).

Any other energy, like the bond energy, may be identified by comparing it numerically with one of these two, kinetic or potential; this is what the principle of energy conservation states. Therefore, it seems reasonable to define energy as:

> **Energy:** Capacity or ability of a body or system to exert forces on other bodies or systems, or among its own subsystems.

The energy conservation principle tell us that the definition is also quantitative, because measuring any energy can always be reduced to the measurement of forces, clearly defined in mechanics.

It is worth to remember that the conservation principle is NOT some philosophy hypothesis or assumption. Is the result of an induction process summing up the results of hundreds or thousands of experiments of any conceivable type along hundreds of years. The landmarks of this process are:

- Impossibility of creating a perpetuum mobile of first kind (some device able to provide mechanic energy without receiving another type of energy; French Academy of Science, 1775)
- The mechanic equivalent of heat **(**1 calorie ≈ 4.1868 joules; Joule, 1840).
- The Principle of Energy Conservation (1st Law of Thermodynamics; Mayer, 1842).

V. EXAMPLES OF PHONY ENERGIES

A. Vital energy

This is a concept of Hinduism and some other oriental religions (Fig. 3). It is easily confused with 'vital capacity', which is really a scientific concept used in medicine to design the quotient of two air volumes in the lungs, measured in different conditions.

Vital energy is only a name that seems scientific, but it is not, even many times is not recognized so. If you change 'vital energy' by 'essential spirit' or something similar, nothing happens, because is an 'energy' not associated to another magnitude and do not have numerical values; it is something 'spiritual'. On the other hand, the Holism mentioned in Fig. 3 is a word that comes from some word

mixing: whole and holy, meaning something like 'the sacred that is related to everything'. It was introduced 80 years ago by Jan Smuts, career soldier, statesman, amateur botanist and philosopher from the disappeared Union of South Africa in his book 'Holism and evolution', of clear idealist inclination.

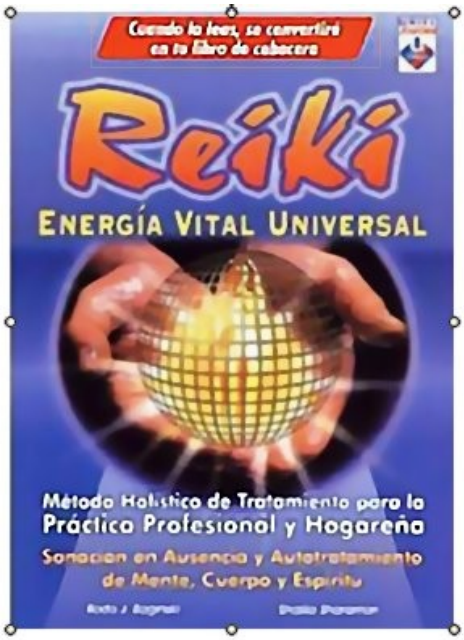

FIGURE 3. The phony vital energy.

FIGURE 4. The also phony pyramidal energy.

B. Pyramidal energy

This 'energy' attained some popularity in some places not much time ago. The main theoretical objection is that no one has measured it or shown its reality. The boom reached for this 'energy', together with the lack of supporting evidence, lead to some researchers to verify the possible assets, if any, of the 'pyramidal powers'. No one of these experiments, realized with scientific thoroughness, could find any proof of the claims spread by its supporters [11, 12, 13, 14]. Zahi Hawas, main archaeological authority in Egypt, calls 'pyramidiots' to those who believe in the magical properties of pyramids; however, pyramidal treatments are still recommended in some places (Fig. 4).

C. The bioenergy and bioenergetics forgeries

Bioenergy and bioenergetics are undoubtedly the two concepts most used in medical pseudoscience, because they really are scientific words, not 'invented' ones as vital energy or pyramidal energy are. But in pseudoscience these words are twisted and used with a false meaning, some times giving them a holy connotation.

Bioenergy is renewable energy extracted from biological sources (ethanol from sugar cane, diesel from fat residuals and similar). It is used as a synonym of biofuels extracted from renewable sources. As comparison, oil, coke and natural gas are *non renewable*; once used up, they can not be recovered.

Bioenergy can be measured without any problem; the energy content of fuels and foods are well known since years ago by calorimeter measurements (using a bomb calorimeter, Ref. [9]). Measuring the combustion heat is equivalent to know the energy content of any biological substance. Experimental values do not differ much from one to another food. Mean values are:

Carbohydrates ~ 17kJ/g,
Proteins ~ 17.5kJ/g,
Fats ~ 39kJ/g.

At present the subject of bioenergy is of utmost importance, and there are several science journals exclusively dedicated to it (Fig. 5).

FIGURE 5. Bioenergy science journals.

FIGURE 6. Bioenergetics journals.

On the other hand, bioenergetics is the study of the chemical reactions that provide mechanical energy and heat at cellular level. The energy interchange is measured from the oxygen consumption in cells, a complex biochemical subject.

In spite of the former, pseudoscientists distort the reality in many ways, attributing to bioenergy the meaning of some kind of energy associated exclusively to living things; for them, bioenergetics is the science studying bioenergy.

Some psychologists use the concept 'bioenergetics analysis' to design something:

- Not clearly defined.
- Supposedly associated only to life.
- Without numbers, non measurable, therefore,
- There is no way to check the conservation principle
- Hence, it is not an energy and, in the end,
- There is not even proof that this 'something' –whatever it is - exists.

However, they talk about this unknown 'something' as if it were able to influence the human behaviour and, even more; they claim to have the ability to control it to heal its patients.

There are also science journals exclusively devoted to bioenergetics (Fig. 6). Notice that bioenergetics in NOT the science studying the bioenergy; they are two completely different subjects.

The introduction of the false bioenergetics is attributed to the psychotherapist Alexander Lowen (1910-2008) who wrote several books on the subject, ignoring the already well established universal consensus about energy existing in Science. For about 20 years Lowen has been a pupil of Wilhem Reich, who had proposed the also non existing 'Orgone' energy. Reich died in prison, in 1957, convicted by fraud. His state of mind was diagnosed as 'Paranoia, becoming apparent as delusions of grandeur and persecution…' (*sic*) [15]. However, in some circles both psychologists are considered as prophets, their groundless criteria being accepted without questioning.

***Chakras and bioenergy*.** But this is not the only distortion about bioenergy that can be found. In the medical journal MEDISAN (2004; 8(4):78-83), under the title '*Bioenergía aplicada en rehabilitación y ginecoobstetricia…*' the following definition can be found: '*Bioenergy is the energy of living beings, conforming the structure of cells, organs and systems, as well as allowing their internal functions and interchange with the surrounding world'*.

In another article (MEDISAN 2005; 9(2)), the same authors classify the energy as mechanics, quantum and atomic –without references- and afterwards they add that '*quantum physics verify the reality of the energy centres or chakras, which take up vital energy from the breathing process and, through the nadis or meridians, transmit it in a way similar as the lymphatic or arterial-vein system do'*.

This is a remarkable paragraph because of the gathering of many absurd statements in so short a space. There is no 'energy net' in the human body similar to the blood or the lymphatic ones; it was already pointed out that vital energy is a religious concept, divorced from breathing and vital capacity and, of course, quantum physics has nothing to do with the chakras, also a religious concept.

According to Hinduism, the chakras are seven magic points 'invisible and immensurable', each with its own name, placed in several parts of the body. They control the energy of different organs and are associated to different gods and colours. The orange suadhistana is linked to *Vishnu* and sexuality, the yellow manipura to *Rudra* and digestion; the remainders to other gods, colours and functions. The seventh floats invisible on the head and is associated to *Shiva* (Fig. 7).

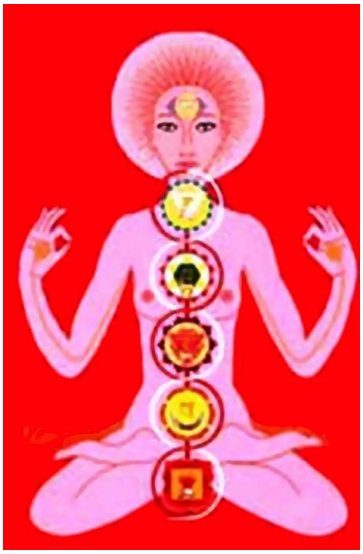

FIGURE 7. The chakras in Hinduism

In spite of being 'immensurable' some people have managed to measure the false bioenergy associated to the diverse organs (an illusion inside another one), as it is shown in the equipment in Fig. 8, commercialized in the WEB.

FIGURE 8. Equipment for chrometherapy… designed to treat the chakras with BIMET… is the only system in the market that measures and analyze the CHAKRAS… (Taken from http://www.aiabimet.com/equipos.asp 09/).

Bioenergy and acupuncture. Another masquerade involving the bioenergy concept is associated to acupuncture. In this case, the values of electric potential differences or electric resistance between different points in the skin –the acupuncture points- are arbitrarily associated to false bioenergy values. As stated for those who promote these procedures, their method allows the diagnostic as well as the treatment of several illnesses.

The electrodiagnostic equipment was introduced in the fifties of the past century by Reinhold Voll in East Germany. It was only a multimeter able to read potential differences or resistance when the probes were put in different points of the skin (Fig. 9).

FIGURE 9. The 1950's Dermatron of Reinhold Voll.

In principle any multimeter can be used with this purpose.

The procedure involves several pseudoscientific deceptions:

a) The mention of the distorted bioenergy.

b) It assumes the existence of the illusory 'bioenergy channels'.

c) Misinterprets the results of the measurements in the skin.

Additionally to the implicit falsehood of the matter, it is known that such measurements are very difficult to carry out and have a poor repeatability, since they depend on many factors very hard to control (which the pseudoscientists never fulfil) such as the humidity of the skin and surroundings, and the pressure exerted by the probe on the skin. Further, you never find reports of clinical tests, statistics, or science papers; only meaningless wordy claims full of ill-related scientific words and false promises addressed to the naïve patients.

Modern versions of this sham use a computer and a monitor instead of the original multimeter of Voll, with some software that supposedly measure the 'bioenergy', make the diagnostic and prescribe de adequate 'treatment' (completely divorced from medical science criteria). The potential danger for the patient when submitted to these procedures lead to its prohibition in the United States, where it is not considered pseudoscience, but a fraud [16].

VI. THE PLACEBO EFFECT

One unanswered question floats in the air; if all those energies are false, ¿How it is possible that these bogus therapies could flourish? Because it is known that many persons claim feel better when submitted to those 'treatments'.

However, things are that the practitioners of pseudosciences never take into account the placebo effect; they do not even mention it.

Discovered in the decade of 1950, the placebo effect consists in that some persons –not everyone- will claim to feel better after receiving some false medicine (the placebo). The effect is very well proved since many years ago. There are papers by hundreds or thousands on this matter in medical journals, and is a fact to be taken into account in clinical trials when studying the effect of drugs or therapies. Always will be a significant per cent of patients showing improvement in control groups receiving the placebo, devised to compare with the trial group the effects of the new drug or therapy.

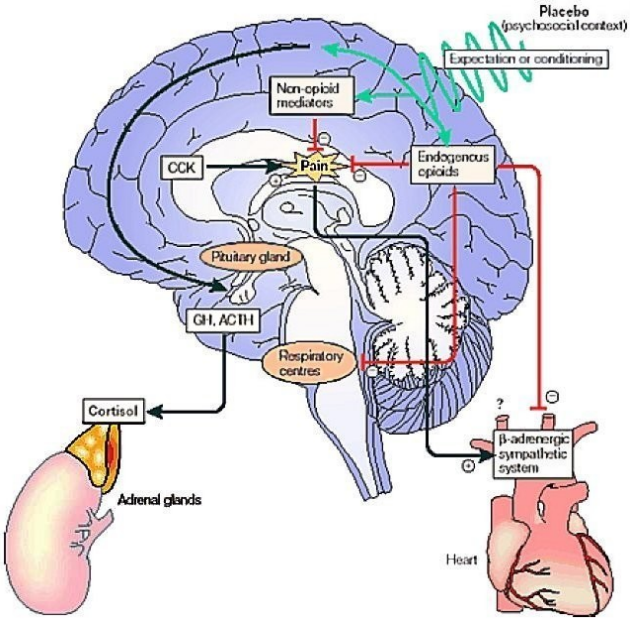

FIGURE 10. Taken from the Journal of Neuroscience, vol. 25(45) pp. 10390-10402, November 2005.

In recent years the effect has been studied intensively by means of techniques such as the Magnetic Resonance Imaging and the Positron Emission Tomography [17]. Fig. 10 shows a review of some results found when checking the *physical changes* in the brain after the patient receives a placebo. In a 2010 review article with 107 references, Finnis *et al.,* reach the conclusion that there are several placebo mechanisms, and that the controlled use of the effect could have significant therapeutic effects. Besides, they point that, even there have been advances in the

knowledge of the placebo mechanism, much research still remain to be done [18].

VII. CONCLUSIONS

There are three different meanings for the word energy which are easily mixed up:

1. A rigorously defined energy (kinetic, potential) in physics and other natural sciences.

2. To specify where are kept or stored some of the energies described in (1), without these concepts being themselves additional energies (eolic energy, nuclear energy).

3. The third meaning describes a particular volitive attitude or state of mind. Is used freely by common people and psychologists but, obviously, it has no relation at all with physics.

These facts should always be taken into account when mentioning the concept 'energy', recalling that any energy in physics must be measurable and have associated numerical values. The use of the wrong meaning in science will lead by force to pseudoscience.

REFERENCES

[1] Hewitt, P. G., *Conceptual Physics*, 3rd Ed. (Addison Wesley Publishing Company, New York, 1997), pp. 1-7.

[2] Bunge, M., *Las pseudociencias, ¡vaya timo!*, (Editorial Laeotli, España, 2010).

[3] Guethón, A. J. y González, F. P., *Salud Ecológica, (Editorial de Ciencias Médicas*, La Habana, 2004). <http://bvs.sld.cu/salud_ecologica/indice_p.html>; ver también las críticas en http://bvs.sld.cu/salud_ecologica/nota_editorial.htm

[4] Figueroa, E., de Lewin, A. M., de Lomáscolo, M. T., *Enseñando la mecánica a partir del concepto de energía*, VIII Conferencia Interamericana sobre Educación en Física, CIAEF-IACPE, A-15, La Habana, Cuba (2003).

[5] González, A. A., *Calor y trabajo en la Enseñanza de la Termodinámica*, Rev. Cub. de Física **20**, 2, 129-134 (2003).

[6] González, A. A., *Falsas Energías, Pseudociencia y Medios de Comunicación Masiva*, Revista Cubana de Física **19**, 68-75 (2002).

[7] González, A. A., *El Concepto Energía en la Enseñanza de las Ciencias*, (a) Revista Iberoamericana de Física 1, 56-59 (2006), (b) Revista Iberoamericana de Educación, ISSN: 1681-565, número 38/2 (2006).

[8] González, A. A*., ¿Cómo definir la energía en los cursos básicos?*, Lat. Am. J. Phys. Educ. **2**, 275-276 (2008).

[9] González, A. A., *Y Ud... ¿Cómo mide la bioenergía?*, Lat. Am. J. Phys. Educ. **2**, 137-140 (2008).

[10] González, A. A., *Ciencia, pseudociencia y bioenergía*, Rev. Cub. Física **25**, 17-21 (2008).

[11] Rebollido, P. D., Silva, L. C. y Rodríguez, M. B., *Valoración experimental del efecto de la energía piramidal sobre el agua*, Medisur **4**, 44-47 (2006).

[12] Hernández, P. L., Perera, A. y Ulloa, A., *Una valoración experimental de la energía piramidal*, *Implicaciones para la práctica médica*, Revista de Medicina General Integral **23**, 1-9 (2007).

[13] Álvarez, J., *Experimentando con pirámides*, Revista Cubana de Física **25**, 22-27 (2008).

[14] Álvarez, G. J., Álvarez, C. J., Souto, R., Santos, Y., Galán, L., Díaz, C., *Ausencia de "efecto piramidal" sobre cardiomiocitos aislados de rata*, Rev. Cub. Inv. Biomédicas **26**, 1-6 (2007).

[15] García, V. M., González, S. D. y González, A. A., *Einstein y la 'energía psíquica'*, Rev. Cub. Física **25**, 53-58 (2008).

[16]http://www.quackwatch.com/01QuackeryRelatedTopics/electro.html.

[17] Zubieta, Jon-Kar, *et al*., *Placebo Effects Mediated by Endogenous Opioid Activity on μ-Opioid Receptors*, The Journal of Neuroscience **25**, 7754–7762 (2005).

[18] Damien, G., Finniss, T., Kaptchuk, J., Miller, F., Benedetti, F., *Biological, clinical, and ethical advances of placebo effects*, Lancet **375**, 686–95 (2010).