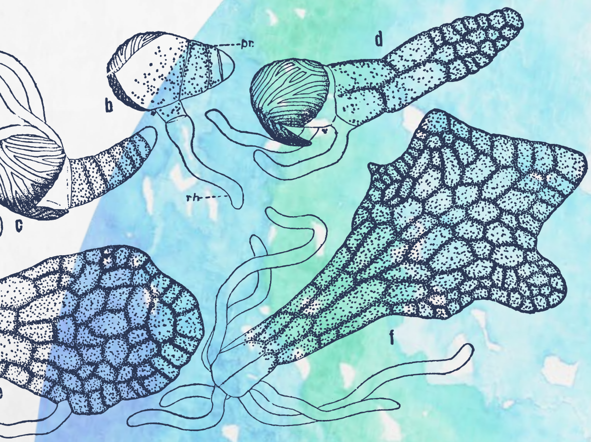
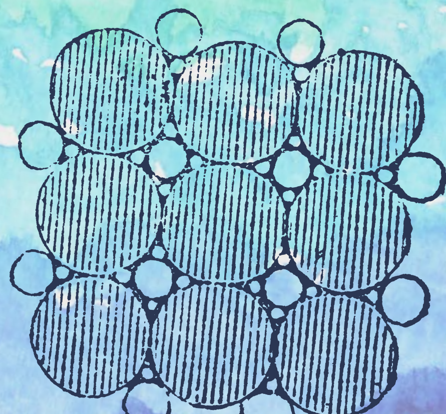
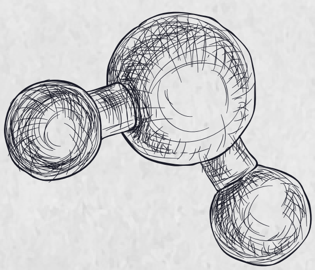


Intuition And Its Application In Natural Science





By Sara Ortiz Rous

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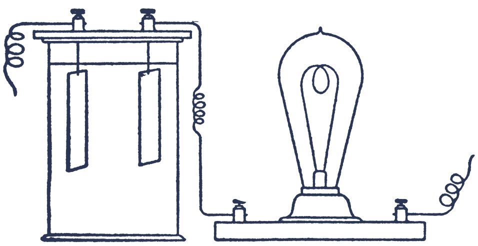
Our duty is to keep alive in the human being his spiritual intuitions.
H.P.Blavatsky

The only really valuable thing is intuition.
A.Einstein

Introduction

One of the main characteristics of the human mind is its ability to form concepts, principles and theories for the purpose of understanding the world around us. Einstein used to say in wonder that the most surprising thing about the universe is that it seemed intelligible. It might well not be, but it is. What we do not understand seems messy to us, and stimulates us to discover it. In the search for knowledge, human beings have not settled for beliefs, conjectures and hypotheses, we have the palpable desire to achieve certainty as a psychological experience and truth as a transcendent experience.

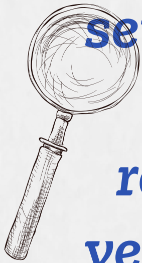
Thus, depending on the field in which we are working – psychological or metalogical – we like evidence and axioms. This work explores one of the characteristics we have to achieve this experience: intuition. Intuition is certainly a very controversial concept in science and philosophy.



Accepted by some as the basic source of all true knowledge, rejected by others as potentially misleading, intuition is revived again and again in philosophical disputes, in the foundations of the formal and natural sciences, in mystical considerations, in ethics and aesthetics, in pedagogy...(1)

1 (2) p. 10

Definitions and scope of the term "intuition"



It is not always that sensory observations bring us closer to reality. Hundreds of years ago if we asked people does the earth move? They would have told us no...

Intuition is a term that designates the faculty to understand things immediately, without specific reasoning. It is also defined as the direct and immediate perception of an object and its relationships, by the knowing subject. The qualities that characterize it are sudden, total, and exact apprehension, and a radical opposition to rational processes. Intuition is related either to the senses, or to the capture of knowledge or to the vision of essences; in this way we have sensory, intellectual and suprarational intuition.

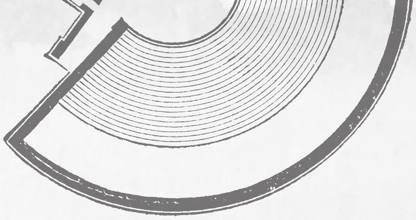
When related to sensory knowledge, intuitive knowledge is more or less equivalent to perception (i.e., concrete objects, images, diagrams). The term intellectual intuition can also be used to designate forms of immediate knowledge that is not sensory, that deals with concepts, formal relationships, theories. One can claim, for example, that the statement, "Every natural number has a successor" is intuitively acceptable, and in this case we have an intellectual intuition. In contrast, intuitive assessment of the weight of an object or the speed of a moving body would represent sensory intuitions.

The rapid identification of a thing, an event or a sign depends on the perceptual acuity of the subject, his memory, his intelligence, his experience and his information. In general, we do not perceive what we are not prepared to discover. We could say that before seeing we must believe, we must give ourselves the mental possibility that what we are going to perceive exists. I want to point out a reflection of Einstein: "A theory can be contrasted with experience, but there is no path from experience to the construction of a theory... Equations as complex as those of the gravitational field can only be found by finding a logically simple mathematical condition that determines the equations."(2)

We also say that something is intuitively clear when ideas are laid out in simple terms familiar to us. And that depends on our previous training in that area. The beginner intuits certain objects, but the initiate captures relationships and complexities that escape the novice.

There are those who have a capacity for interpretation and understand the physical meaning of equations; for example they see in the square of a magnitude, a form of

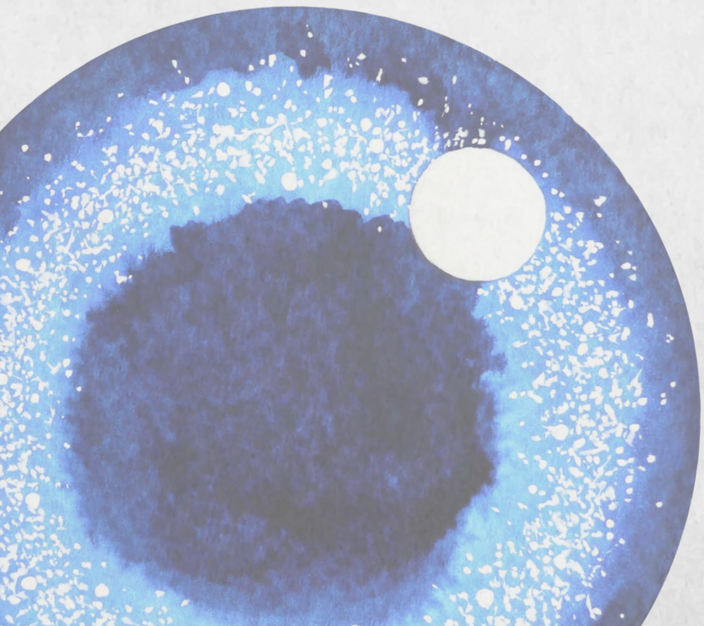
2 (1) p. 83



energy. And there are also others, who have an ease in transforming physical phenomena into equations or laws. In these cases we call perception, sensitive intuition.

Intellectual intuition also appears as the ability to correctly judge the importance and merits of a theory. Phronesis or sanity allows us to deduce the most "reasonable" alternative. The scientist, the technician, the artist develop a sense of smell or penetration with respect to the lines of research. No concept in science is absolutely and inherently intuitive or counterintuitive, it is usually relative to cognitive baggage, common sense that is gradually enriched by knowledge.(3)

This intuition is the product of several factors among which we must highlight concentration and introspection. To reflect, we must close our minds to external stimuli. When we reflect we start from a specific knowledge of the problem that we have acquired plus all our baggage of information, experiences..., the ideas are somewhere in the mind and it is about silencing everything else to be able to listen to them. So intellectual vision or intuition appears with the process of focusing inward, inhibiting irrelevant thoughts, and preparing to switch to new styles of thinking; this makes us much more likely to experience sudden intuition.

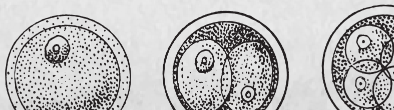


Very often intuition also means an elementary common sense, a primitive form of knowledge, as opposed to scientific conceptions and interpretations. Sometimes intuition is referred to as a global assumption for which an individual cannot offer a clear and complete justification. In contrast, according to some philosophers like Spinoza, intuition is the highest form of knowledge through which the very essence of things, and God Himself, is revealed.

The term intuition also has special connotations in particular domains. An example is moral intuition that would represent an a priori knowledge of the notions of "right" and "wrong." In Benedetto Croce's philosophy, intuition plays an essential role in aesthetic feelings. According to Croce, beauty is not the property of nature. It is rather the product of a specific type of selection and synthesis that is achieved by the human mind through intuition.(4)

3 (15) Paragraph III. 2.4

4 (6) Page 14.



Intuition in the natural sciences

The history of science is the biography of the successes and failures of empirical, rational, and intuitive cognitive activity(5). Scientists know that psychological evidence is no guarantee of truth, that it is highly personal and often plays tricks on us, but they appreciate intuition and creative imagination. The natural sciences are full of them. Heisenberg says he was on a Baltic island thinking about quantum mechanics when "I suddenly saw it clearly and I was happy".(6) Faraday, with very weak rational foundations, had for 23 years, the intuition that there was a connection between light and electricity and finally found it in the influence of magnetism on polarized light. In the twenties, Paul Dirac was motivated by purely formal and aesthetic considerations when he proposed an equation that accounted for both quantum physics and relativistic physics. His equation included four-by-four square matrices that had no physical interpretation. The equation he wrote was only the simplest mathematical equation that met certain requirements. But in imagining these matrices something new emerged: the prediction of the existence of antiparticles. Years later the positron would be discovered.(7) Russian scientist Dmitry Mendeleev discovered the pattern of sorting molecular elements. He wrote the items on cards according to their relative weight(8) and combined them on his worktable in a game of chemical patience, but there was no way to find the relationships. It was in a dream that he was assaulted by the conviction that he had to leave gaps, that is, some cards were missing.(9)

What is the process we can follow for the discovery of a new scientific idea? There are different paths. One of them may be (10) to set one of the working hypotheses, or to break some hidden or visible prejudice. There are examples as simple as solving the riddle "You have dropped the ring in a completely full cup of coffee.

5 (15) Section III.3.3

6 (2) p. 70

7 (2) p. 108

8 The key to the arrangement was called the atomic number, which depended on the number of protons in the nucleus and not on the combination of protons and neutrons that gave the full weight, although at that time no one knew about those smaller constituents.

9 (14) p. 115

10 (2) p. 11

Imagination and intuition are of great help to us in the limits of knowledge.

How to get it dry?", to (11) De Broglie's "absurd" idea of wave-corpuscle duality, or the Wright brothers' attempt to build an ingenuity to fly not "so stable" (but yes, stable to the right degree). Another path that has a lot to do with intuition, is to put the mind in a special state of consciousness where everyday experience disturbs less. Kekulé (1829-1896) says that fantasizing while dozing he conceived the hexagonal structure of benzene (C6H6). According to him, he was in Ghent writing a treatise of chemistry, but the work did not progress and he went back to the chimney to doze in the heat of the fire. As images of atoms danced before his eyes, his mental eye saw structures of various shapes in motion, writhing like snakes, and one of them clutched its own tail and moved mockingly. He woke up shaken by lightning and spent the rest of the night developing the consequences of this hypothesis. Let us not forget that his mind had been debating the subject for twelve years. The synthesis of his entire study was a vision like lightning, but then he proved it rationally and experimentally, because sometimes these conjectures are false. Warning: Dream, but then check! (12)

Newton, the giant hidden in the apple

Newton, in relating the movements of the following objects: a pendulum, an apple falling from the tree, the Moon and the movements of the sea, unified the celestial and the earthly, the big and the small. Kepler had conceived laws describing the motions of the planets, developed empirically on the basis of data. Galileo described the trajectory of a ball flying in the air. However, it was Newton who understood that they were all examples of the same phenomenon: gravity. There was no deductive or inductive reasoning, he simply tried to imagine something common in various phenomena. The most important aspect of the Law of Universal Gravitation is the statement that gravity acts universally: Any two bodies, anywhere in the universe, attract each other. And that law appeared in an imaginative intuition in a brilliant mind inclined to study, research, and experimentation.

11 Maybe the coffee is in the form of a bean in the cup

12 (15) Section III.1.3

Intuition is a term that designates the faculty to understand things immediately, without specifying reasoning.

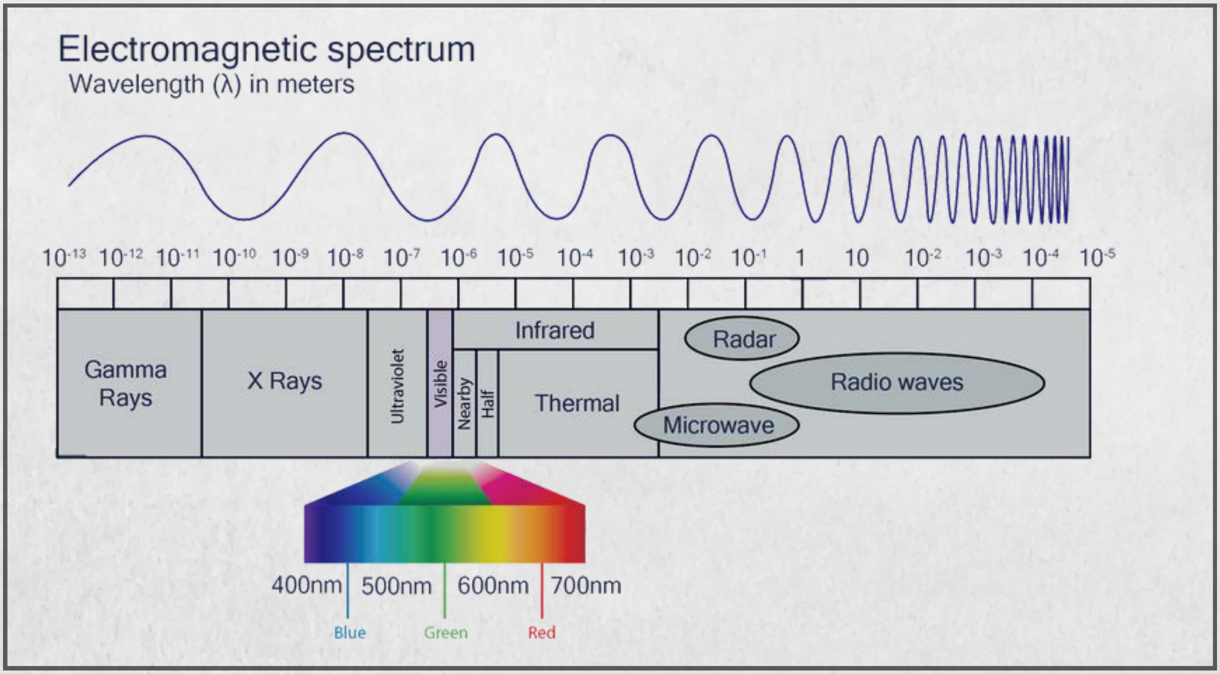
Maxwell's Equations: The Revolution of Contemporary Civilization (13)

At the beginning of the nineteenth century most people lit their houses with candles. Gas lighting, which dates back to 1790, was occasionally used in business, and the standard way to send messages was to write a letter and send it in a horse carriage. After a hundred years, houses and streets had electric lighting, the telegraph was in ordinary use and people could talk to each other on the phone. Two scientists made the main discovery that triggered this social and technological revolution. One was the Englishman Michael Faraday, who established the basic physics of electromagnetism. The other was the Scotsman James Clerk Maxwell who turned Faraday's mechanical theories into mathematical equations and used them to predict the existence of radio frequencies moving at the speed of light.

At the time, most physicists working on electricity and magnetism were looking for analogies with gravity. It seemed sensible: opposite electric charges attract each other with a force that is proportional to the square of the distance separating them. The standard way of thinking was that gravity was a force through which one body mysteriously acted on another distant body without anything happening between them: it was assumed that electricity and magnetism acted in the same way. Faraday had a different idea: both are "fields," phenomena that fill space and can be detected by the forces they produce.

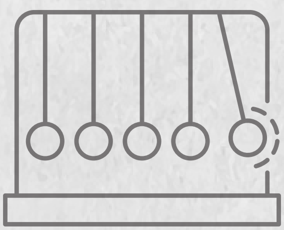
Faraday, who lacked mathematical training, had laid out his theories in terms of geometric structures, such as "lines of

13 (9) pp. 225-235



force" through which fields pull and push. Maxwell reformulated these ideas by analogy with fluid mathematics. For magnetic fields, Maxwell used the mental image of tiny vortices spinning in space. Electric fields were tiny charged spheres, and following this analogy Maxwell began to understand how a change in the electric force could create a magnetic field. As the electric spheres move, they cause the magnetic vortices to rotate, like a football fan passing through a tourniquet; the man moves through without turning, the tourniquet rotates without moving. The equations were published in 1864 in his famous article "A dynamical theory of the electromagnetic field". Maxwell's equations predicted that there must be electromagnetic waves of all kinds of lengths.

Heinrich Hertz, in 1886 built an apparatus that could generate, and another that could receive, radio frequencies. When asked about the implications of its discovery, he replied: "It has no use ... it only proves that Master Maxwell was right." Here imagination was lacking, Hertz's so-called useless experiment would lead to the invention of radio. Engineer Nikola Tesla invented and built all the main gadgets needed for radio transmission. The engineer Marconi in 1895 with the support of the British Post Office sent signals across distances of 1.5 km, 16 km... The entire collection of modern communications, radio, television, radar, mobile microwaves,



and even X-rays and T-rays, have been possible because two geniuses, Faraday and Maxwell realized that electricity and magnetism, joined forces to create a wave(14).

Thermodynamics (15)

The first references to the power of steam came from the Roman architect and engineer Vitruvius who in 15 BC.C. described a machine called an aeolipile built by Heron of Alexandria years later. The discovery in modern times is attributed to James Watt (1736-1819). The anecdote recounts that, as a child, sitting in his mother's kitchen, watching as the steam raised the lid of a kettle, he had an inspiration: heat can do work.

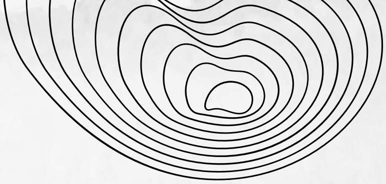
Watt's contribution was to introduce a separate condenser for the steam, reducing heat loss and thus giving it an industrial use. And from there the basic question was born: How efficient could a steam engine be? The answer did more than describe the limits of steam engines; it created a new branch of physics, with applications that had almost no limits, explaining the complex processes of life itself. It was called thermodynamics: the movement of heat.

Relativity

Maxwell's equations showed that light was a wave, like sea waves that are waves in water, sound that are waves in the air, and

14 (9) Page 238-242

15 (9) Page 246- 268



earthquakes that are waves on Earth. So the waves of light were waves in... what? By analogy physicists became convinced that there was a medium they called ether that held electromagnetic waves. Vibrations move faster the stiffer the medium and the light was very fast, so ether had to be extremely rigid. Although the planets could move through it without resistance. As it had not been detected, ether should have no mass, no viscosity, be incompressible and transparent to all forms of radiation. A combination of overwhelming attributes, but these were assumed because something had to carry the light wave. In 1887, Albert Michelson and Edward Morley carried out one of the most famous physical experiments despite its rebuttal character: they ruled out the existence of ether. And threatened to dismiss the theory of electromagnetism.(16)

At this point Einstein appeared, who not only solved the problem, but changed the concepts of space, time, mass, and ceased to be the sensory intuitive concepts of Newtonian mechanics.(17) Einstein says in his autobiographical notes(18): "If I run behind a ray of light at the speed of light, I should perceive the luminous ray as a stationary electromagnetic field, albeit spatially oscillating." But the stationary field existed neither in experience nor in Maxwell's equations, because in truth what was wrong was the axiom of the absolute character of time that was inadvertently anchored in the unconscious.

Einstein assumed the constancy of the speed of light as the revelation of a universal law. Apparently, there is nothing amazing about this statement. It simply reiterates the faith of scientists in the harmony of natural laws. But assuming the constant speed of light regardless of motion, philosophically implies ceasing to look for an absolute and stationary space in the universe, and also discarding the idea of absolute time. It is difficult to accept that the instant we call now cannot be applied to the entire universe. The star Arthur, which is 33 light-years away, is a ghost; it is actually an image of the light that moved away from there in 1987. Our today is Arthur's yesterday. When science fiction considers traveling at the speed of light, the Twin Paradox appears. Imagine an astronaut twin who at the age of 30, travels to space in a ship at 267,000 km/s, and his brother stays on this blue planet. He returns after 10 Earth years, for him only five would have passed, so one would be 35 years old and another 40. What a business for aesthetic clinics, age

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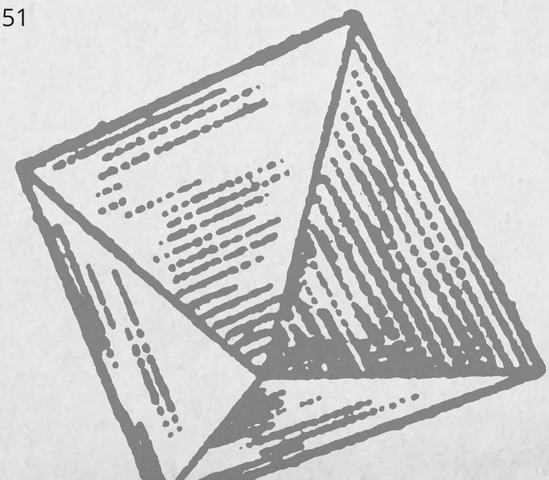
17 Newtonian Mechanics: An independent space and time and a mass and size of bodies that do not vary.

18 (1) p. 51

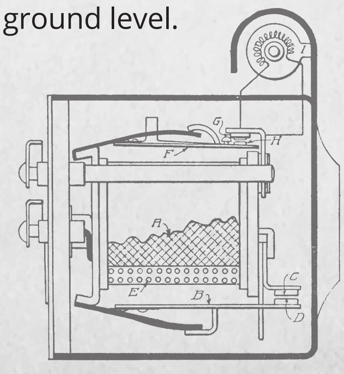


Newton, in relating the movements of the following objects: a pendulum, an apple falling from the tree, the Moon and the movements of the sea, unified the celestial and the earthly, the big and the small.

five years less than your friends! When these facts are first known to be difficult to digest, Einstein allowed his imagination to wonder: why is it stranger to think that clocks slow down and objects contract, than to think that they don't? My senses don't perceive it, but can we perceive everything?

It is not always that sensory observations bring us closer to reality. Hundreds of years ago if we would have asked people - does the earth move? They would have told us no, the leaves fall, the stars revolve around us, but the earth does not move, and yet... it moves.

Einstein later developed the general theory of relativity where he says he had the happiest occurrence of his life. He imagined an immensely tall building, inside which was an elevator with its cables gone loose. Inside, a group of physicists did experiments: the objects remain in the air because they are falling along with the elevator. In this situation, physicists might believe that they had been transported out of the earth's gravitational field. You cannot distinguish whether you are at rest in a free space or falling in a gravitational field. According to Newton's Law of Gravitation, the forces of gravity were mysterious forces acting in the distance. Einstein proposed that masses are not subjected to distant forces, but that masses change space, like the shape of a mattress when we put a heavy object on top of it. To understand this idea, Einstein gave another brilliant example: Imagine a child playing with marbles on an irregular terrain, full of elevations and depressions. A man located ten stories above the street would not notice these irregularities of the terrain, and observing that the marbles avoid certain sections of the ground and move towards others, might think that the marbles were attracted by a force. But for the child the trajectory of the marbles is governed by the curvature of the soil. Newton is the observer from the window, and Einstein the child who plays at ground level.



The solutions of his equation had a surprising implication: the universe was not stationary, it moved. For once Einstein's imagination failed, he did not conceive of the motion of the Universe and introduced into the equations the cosmological constant to park it. In 1929, American astronomer Edwin Hubble found evidence of the expanding universe.

Quantum theory(19)

The intuition of the great physicist Lord Kelvin in 1900 was accurate when he said that the theory about heat and light, which was considered an almost complete description of nature, was "obscured by two clouds". The first had to do with the question, how could the Earth move in an elastic solid like the ether? The second with the partition of energy. The first gave rise to relativity and the second to quantum theory. The quantum world is different, strange and if someone doesn't appreciate how weird it is, they may not be grasping the implications of the theory. Here the deduction by processes of analogy or previous experience totally loses its meaning. In 1894 Max Planck tried to design the most efficient bulb possible and through experimental observations adapted a mathematical formula between frequency and energy. The later interpretation he made was that the energy levels of a body's vibration modes could not form a continuum, but had to be discrete, and were multiples of a frequency we call Planck's constant, h= 6.62606937*10-34. We call the tiny packets of energy, quanta, from the Latin quantus. And that implied that nature at very small scales must be discreet, although it didn't initially occur to Planck.

Einstein, in 1905, his wonderful year, also investigated the photoelectric effect and realized that Planck's quanta of light explained why when light has a higher frequency, electrons have higher energies, and suggested that light, rather than being a wave, was composed of tiny particles called photons. A photon was a quantum of light. And so we came to wave-particle duality because there was abundant evidence that light was a wave, but the photoelectric effect showed that light was a particle.

As physicists understood nature at very small scales, they saw that it was not only light that had this duality, all matter had it. The first person to grasp this dual

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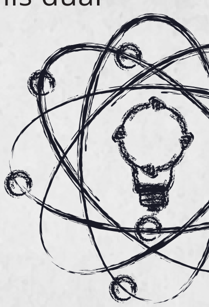
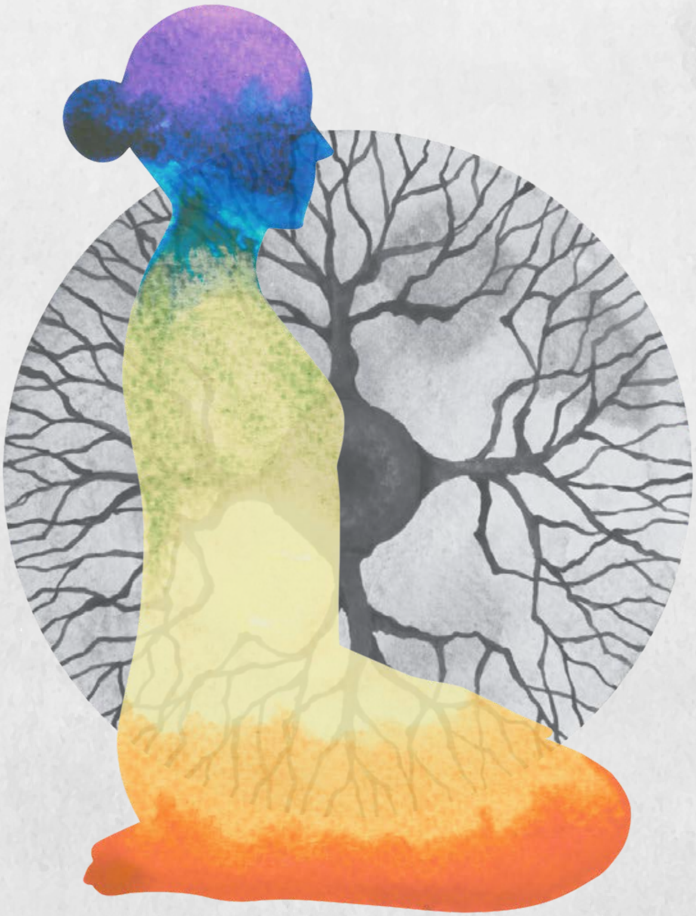


...the rigorous study of the impossible, of what is proposed by human imagination and intuition, has opened up new domains of science that are totally unexpected.

nature of matter was Louis-Victor de Broglie in 1924. It provoked a radical overhaul of the physics of the world at very small scales, in which each object has a wave function that describes a cloud of probability of possible states. The Copenhagen interpretation says that until someone observes the atom, it is a superposition of two states. In Schrödinger's famous thought experiment, the cat in the box is dead and alive at the same time. But But beware, quantum superposition cannot be extended to the macroscopic world!

Conclusions

Michio Kaku in his book *Physics of the Impossible* raises as possible many proposals that have arisen from human intuition and imagination, although he classifies them into three types. Those of class I, impossible with the technology today, but that do not violate the laws of physics, include teleportation, telepathy, invisibility and psychokinesis. Those of class II, that are at the limit of our understanding of our physical world, but perhaps in thousands or millions of years can be reached: time travel, travel in hyperspace, in wormholes. And there are the class III ones, that violate the laws of physics. But he very strongly affirms that the rigorous study of the impossible, of what is proposed by human imagination and intuition, has opened up new domains of science that are totally unexpected.(20) Imagination and intuition are of great help to us in the limits of knowledge. The questions are: why is there something instead of nothing? Why does this cosmos exist, with these laws? The answers need science and much more.



The boundaries between the psychic phenomena that we call sensory intuition, intellectual intuition, reason, and spiritual intuition are blurred, but exist. Intuition, hunch, are present in the human mind and are fertile. They acquire clarity and scope as they are refined and developed by reason. Uneducated intuition blocks access to reality, but it also happens that wrong reasoning spoils intuition.(21) One of the most interesting aspects that has emerged in almost all examples is the possibility of educating intuition and imagination, and would encompass aspects as interesting as,

20 (16) Page 19

21 (15) Paragraph III. 3.1.

avoiding being influenced by social pressure, daring to look for evidence that can disconfirm our intuitions, and learning to differentiate true intuitions from those that are not.

What are the virtues of the scientist who senses, imagines and creates? He must have a lot of curiosity, patience in observation, a broad culture to combine, choose and extrapolate different information, using it in a new way. In order not to drown in the enormous amount of information that exists, he must have discernment and capacity for analysis and synthesis. As for character, he needs empathy towards divergent ideas, and a lot of independence and autonomy, that is, to be freed from the opinion of others, from conventional restrictions and inhibitions, and finally a temperament with capacity for play and fun. Michelson was once asked why he kept trying to test with complicated and repeated experiments the relative motion of the Earth with respect to the presumed ether, when the theory of relativity had already been formulated and long accepted. "It's that it amuses me a lot", he replied.(22) As Marcus du Sautoy says,(23) Wittgenstein's *Tractatus Logico-Philosophicus* can be given an even better ending than: "Whereof one cannot speak, thereof one must be silent". He proposes "From what cannot be known, our imagination draws material to play with." Fun is implicit in the minds of great scientists; imaginative and intuitive, they all have something of an artist and have fun with what they do.

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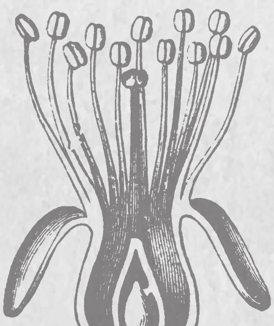
23 (14) Page 530



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2 (1) p. 83
3 (15) Paragraph III. 2.4
4 (6) Page 14.
5 (15) Section III.3.3
6 (2) p. 70
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8 The key to the arrangement was called the atomic number, which depended on the number of protons in the nucleus and not on the combination of protons and neutrons that gave the full weight, although at that time no one knew about those smaller constituents.
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11 Maybe the coffee is in the form of a bean in the cup
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16 (9) Page 269-301
17 Newtonian Mechanics: An independent space and time and a mass and size of bodies that do not vary.
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19 (9) pp. 303-340