Reflections on the Mind of Nikola Tesla

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This "blog" was originally an academic paper that was submitted for publication in the prestigious journal *Proceedings of the IEEE* in 2006, the year of Tesla's 150th birth anniversary. Although well-received by some, it was, alas, rejected. That same manuscript has been augmented, updated, and reformatted here, to be shared with the wider world. Hyperlinks have been added for the convenience of the reader. I apologize if this blog reads like a *slog*. ☺

Introduction

Nikola Tesla was a prodigious genius who benefited mankind immensely. He embodied a strange combination of fiery imagination, more suited to the poet or artist, tempered by the discipline of the engineer, grounded in mathematics and experimental science. The fact that he worked mostly alone and produced baffling inventions has led to his being labelled as both sorcerer and genius. He was superhuman in his will power and in his appetite for work. Yet he was also a frail human being who suffered a nervous breakdown, who had a fixation on the number three, and who, in later life, made bizarre claims which alienated him from mainstream science. Although he was well recognized by his scientific peers and the media in the late nineteenth and early twentieth century, Tesla today remains a largely unknown and unsung hero, who has not been accorded his rightful place in history.[1] It is also ironic that, although others profited immensely from his inventions, Tesla himself did not enjoy a prosperity commensurate with his abilities or contributions, and died alone and in penury.

It is impossible to review the visionary contributions of Tesla within the compass of one paper, let alone do justice to analyzing his unique mind. Only certain aspects of Tesla's mind will concern us here; the interested reader is referred to brief synopses and fuller accounts of his life and writings elsewhere [1]–[8]. In this paper, we focus on only four of his documented mental characteristics:

1. An extremely acute sense of hearing and sight;
2. A power of visualization so vivid as to mimic reality;
3. Eccentricities of habit and behaviour; and
4. Making grandiose claims, some of which remain open until today.

[1] This was written *before* the electric vehicle brand Tesla gained global prominence.
[2] The uncoloured image is available at Wikipedia and is in the public domain in the US and certain other countries.

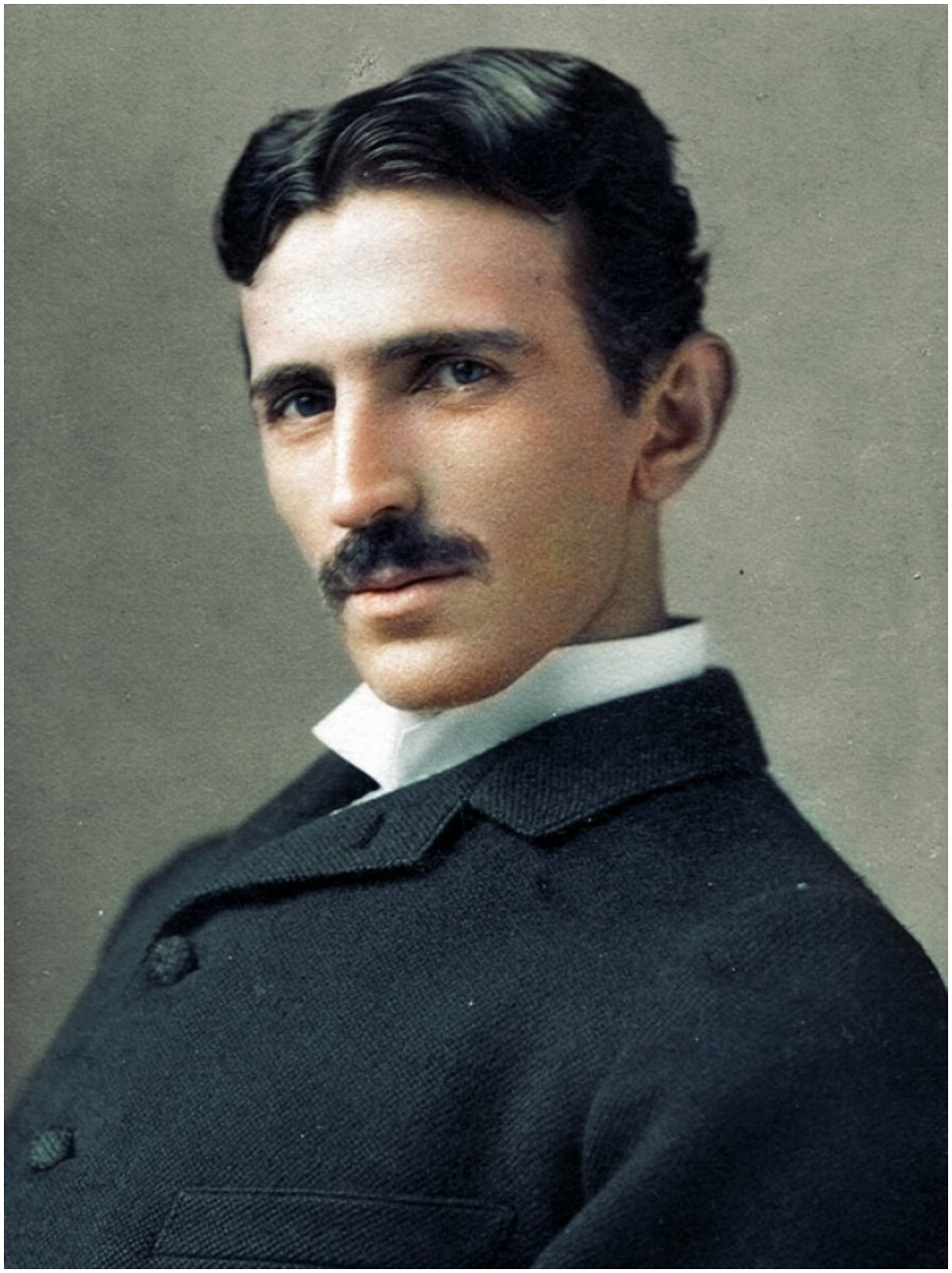

Figure 1: Nikola Tesla at age 34; photograph by Napoleon Sarony; colorized by Dana Keller.[2]

In each case, evidence is furnished from Tesla's own writings, his biographies, or from the other available literature. Each of these traits is examined in some detail, especially with respect to his creativity. Comparisons are made with other well known scientists with similar characteristics, and speculative comments are made, along with a list of questions worthy of further investigation. Finally, a hypothesis is put forward—based on the idea of mental evolution, as proposed by R M Bucke [9]—as one possible explanation for Tesla's prodigious and rare mind.

Tesla's hypersensitive hearing and sight

From a young age, Tesla had hypersensitive hearing and sight. For example, he recounted [3] that in his boyhood, he saved his neighbours' lives when he heard the crackling of flames consuming their homes at night. At the age of 25, he suffered what was termed by his doctors a "nervous breakdown" for want of a better term. While he was ill, Tesla's pulse varied from a few beats to two hundred and sixty beats per minute and all the tissues of his body quivered and twitched [1]. During the period he was ill, Tesla had the following extraordinary aural experiences[1], [3]:

1. He could hear the sound of a watch ticking three rooms away;
2. A fly landing on a table in his room caused a dull thud in his ear;
3. A carriage passing several kilometres distant caused his whole body to shake;
4. He could not endure the vibration in his chair caused by a train whistle thirty-two kilometres away;
5. Rubber cushions had to be placed under his bed so that he could rest undisturbed by the vibrations of sounds around him; and
6. In the dark, like a bat, he could sense an object at a distance of about four metres by a peculiar creepy sensation on the forehead.

Even when Tesla was past forty, and conducting research into lightning in the Colorado mountains, in the USA, he could hear thunderclaps 880 kilometres away, whereas his assistants, at half his age, could only hear them up to 240 kilometres away [1], [3].

Not only was his hearing acute, Tesla's sense of sight was incredible. It enabled him to perform what may be termed *peregrinations of the mind*. Let us hear it in his own words:

> In my boyhood I suffered from a peculiar affliction due to the appearance of images, often accompanied by strong flashes of light, which marred the sight of real objects and interfered with my thought and action. They were pictures of things and scenes which I had really seen, *never of those I imagined*. When a word was spoken to me the image of the object it designated would present itself vividly to my vision and sometimes I was quite unable to distinguish whether what I saw was tangible or not. This caused me great discomfort and anxiety...
>
> Then I instinctively commenced to make excursions beyond the limits of the small world of which I had knowledge, and I saw new scenes. These were at first very blurred and indistinct, and would flit away when I tried to concentrate my attention upon them, but by and by I succeeded in fixing them; they gained in strength and distinctness and *finally assumed the concreteness of real things*. I soon discovered that my best comfort was attained if I simply went on in my vision farther and farther, getting new impressions all the time, and so I began to

> travel—of course, in my mind. Every night (and sometimes during the day), when alone, I would start on my journeys—see new places, cities and countries—live there, meet people and make friendships and acquaintances and, however unbelievable, it is a fact that they were just as clear to me as those in actual life and not a bit less intense in their manifestations. [1] (*emphasis* is mine)

Here we see that it was not a hypersensitivity to an actual stimulus, but the sensation of vision that had verisimilitude, without the need for any external stimulus, which is singular.

Questions and conjectures: hearing and sight

The following questions and conjectures arise regarding Tesla's unusual hearing and sight:

1. Was Tesla's mind influenced in any way by his heightened and unusual sensory awareness?
2. If so, what was the cause-effect relationship?
    a. Were his hyper-acute senses responsible for his mental powers?
    b. Or did his sensory acuity arise from his amazing mental faculties?
3. Were his sightseeing journeys a form of vivid daydreaming, or were they hallucinations, or were they some other as yet unlabelled phenomenon?
4. Did his "nervous breakdown" influence his inventive abilities?
5. Were his eccentric habits and behaviour in later life the sequelae of his "nervous breakdown"?

It is believed that these and other questions posed here are worthy of further investigation by specialist researchers; the answers to them are likely to shed light on many aspects of the creative scientific process.

Tesla's vivid visualization and mental experiments

If Tesla's hyper-acute senses marked him out as unusual, his vivid visualization and extremely efficient method for realizing his inventions are unique in the annals of the history of science. Tesla not only discovered hidden forces and sources of energy, but he also designed machines that made practical use of his discoveries for the benefit of humanity. Thus, not only was he an applied mathematician and experimental scientist, he was also a highly accomplished engineer, but one whose methods were atypical. We will first examine in some detail the genesis of the invention of the induction motor that came about from his grasping the idea of rotating magnetic fields. This is followed by a brief recountal and analysis of the discovery of the benzene ring by the chemist Friedrich August Kekulé. Then we will explore and discuss Telsa's vivid faculty of visualization, and compare it with similar instances from other well known scientists. We conclude this section with a discussion of the process of scientific discovery and creativity.

The AC induction motor

In 1875, at the age of 19, Tesla enrolled at the Polytechnic Institute at Graz in Austria to study electrical engineering. In his second year there, his professor demonstrated a direct current (DC) motor for the first time. Tesla was impressed but objected to the sparking that he saw taking place at the commutator. His professor replied that the sparking was inevitable, being inherent

in the design of the machine. Tesla was unconvinced and felt that there must be some way to circumvent the use of commutators. He felt inwardly assured that there was a solution to this problem, although his instructors did not share this view [2]. He later used these words to describe this inner certitude:

> In attacking the problem again I almost regretted that the struggle was soon to end. I had so much energy to spare. When I undertook the task it was not with a resolve such as men often make. With me it was a sacred vow, a question of life and death. I knew that I would perish if I failed. Now I felt that the battle was won. Back in the deep recesses of the brain was the solution, but I could not yet give it outward expression. [1]

Paradoxically, the demonstration of the DC motor had convinced him that by using alternating current (AC) with its changing direction of current flow, the commutator could be eliminated altogether. While he felt an inner assurance that it could be done, what he did not know was how to accomplish it [2]. The answer came to him, not by logical reasoning, but by a flash of insight that he later described in these words:

> I could not demonstrate my belief at that time, but it came to me through what I might call instinct, for lack of a better name. But instinct is something which transcends knowledge. We undoubtedly have in our brains some finer fibres which enable us to perceive truths which we could not attain through logical deduction, and which it would be futile to attempt to achieve through any wilful effort of thinking. [2] (p 49).

After six years of intensive thought, Tesla did finally get the revelation that revolutionized our world: the AC induction motor and, concomitantly, the AC generator. It occurred in Budapest during a walk in the late afternoon that he took with a friend in February 1882. The full flavour of the revelation that dawned on him is best conveyed by his own words:

> One afternoon, which is ever present in my recollection, I was enjoying a walk with my friend in the City Park and reciting poetry. At that age I knew entire books by heart, word for word. One of these was Goethe's *Faust*. The sun was just setting and reminded me of the glorious passage:
> Sie rückt und weicht, der Tag ist überlebt,
> Dort eilt sie hin und fördert neues Leben.
> O, daß kein Flügel mich vom Boden hebt,
> Ihr nach und immer nach zu streben!
> ...
> Ein schöner Traum, indessen sie entweicht,
> Ach, zu des Geistes Flügeln wird so leicht
> Kein körperlicher Flügel sich gesellen!
>
> The glow retreats, done is the day of toil;
> It yonder hastes, new fields of life exploring;
> Ah, that no wing can lift me from the soil
> Upon its track to follow, follow soaring!
> ...
> A glorious dream! though now the glories fade.
> Alas! the wings that lift the mind no aid
> Of wings to lift the body can bequeath me.

> As I uttered these inspiring words the idea came like a flash of lightning and in an instant the truth was revealed. I drew with a stick on the sand the diagrams shown six years later in my address before the American Institute of Electrical Engineers, and my companion understood them perfectly. The images I saw were wonderfully sharp and clear and had the solidity of metal and stone, so much so that I told him: "See my motor here; watch me reverse it." I cannot begin to describe my emotions. Pygmalion seeing his statue come to life could not have been more deeply moved. A thousand secrets of nature which I might have stumbled upon accidentally I would have given for that one which I had wrested from her against all odds and at the peril of my existence. [1]

Writing in the *Scientific American*, Tesla explains this revelation further:

> It is extremely difficult for me to put this experience before the reader in its true light and significance for it is so altogether extraordinary. When an idea presents itself it is, as a rule, crude and imperfect. Birth, growth and development are phases normal and natural. It was different with my invention. In the very moment I became conscious of it, I saw it fully developed and perfected. [10]

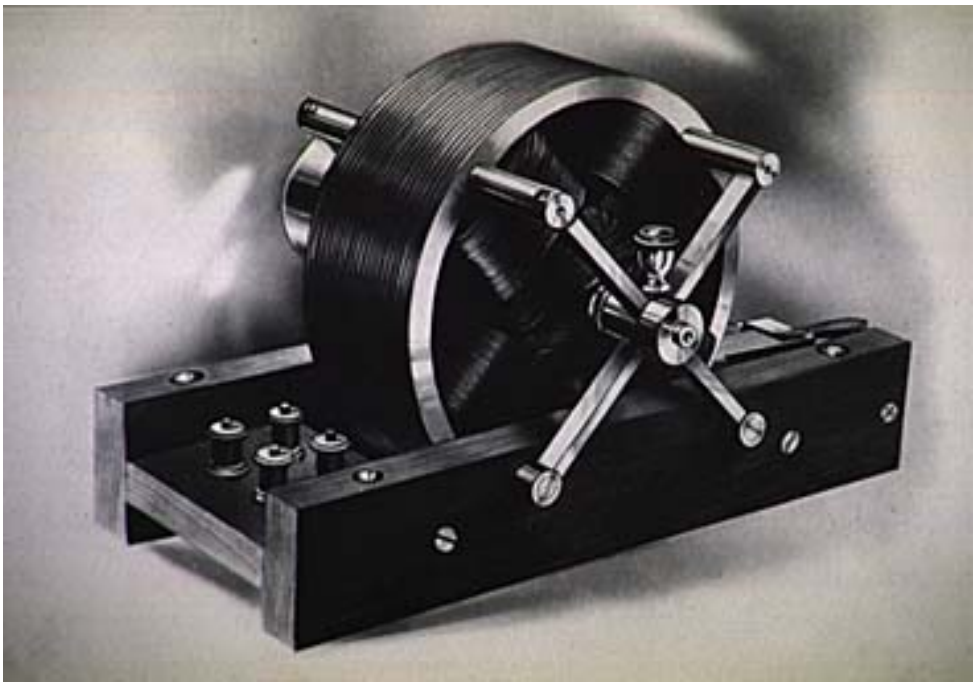

Figure 2: The AC induction motor.[3]

In his own mind, the idea of the rotating magnetic fields, one chasing the other, that formed the basis of the induction motor and the AC generator, was the greatest secret that he had plucked from Nature. Ever since he first saw the DC motor with its commutator and sparking, he had resolved to invent a motor that did away with those features. After six years of protracted thought and indefatigable effort, he had at last succeeded, but he paid a price by suffering from a "nervous breakdown" soon thereafter.

[3]This is one of the two two-phase induction motors demonstrated by Tesla in his historic lecture of 16 May 1888, before the American Institute of Electrical Engineers at Columbia University. The motor developed one-half horsepower and showed that brushes and commutators could be eliminated. This image and the information in this footnote are taken from the PBS (Public Broadcasting System) web site on Tesla [8].

Archimedes, the eureka moment, and incubation

There are two well-known instances of scientific discoveries that occurred as flashes of insight after protracted mental effort at problem solving, not unlike Tesla's vision of the rotating magnetic fields. The first is that of Archimedes of Syracuse as he was in his bath. When he saw the water overflow as he sank into the bath, he spontaneously saw the solution to his problem. Oblivious to his nakedness, he ran unclad along the streets of Syracuse, proclaiming "Eureka!" (I have found it!). Such nodal points of scientific discovery may be called *eureka moments*.

Tesla's eureka moment regarding the induction motor, and conversely AC power generation, occurred during an evening walk with his friend, as we have already seen. Such insights are often the result of sustained thinking on a topic, with a subsequent relaxation, as in Archimedes's bath or Tesla's walk, when unheralded, "the penny drops" and the solution is revealed, apparently without any immediate conscious effort on the part of the scientist. The mathematician Jules Henri Poincaré believed that after prolonged thinking on a problem, there is a period of *incubation* or unconscious thought, after which the solution would pop up spontaneously, and seemingly without conscious effort [11] (p 15).

Kekulé and the benzene ring

Another historically documented eureka moment that occurred after incubation was the elucidation of the structural formula of benzene, by the organic chemist, Frederich August Kekulé. It occurred in a now-famous series of dreams.

In Kekulé's time, all the known compounds of carbon and hydrogen were composed of chains of carbon atoms "connected" or bonded to each other and to hydrogen atoms, obeying the rule that each carbon atom must have four bonds. The molecule of benzene, C_6H_6, was however, composed of six carbon atoms and six hydrogen atoms. Try as he might, Kekulé could not reconcile this formula with any structural arrangement of the atoms that satisfied the requirement for four bonds per carbon atom. He mulled over the problem for some time before he got the solution which changed organic chemistry forever.

There are actually two episodes. The first was in London, when he saw the atoms dancing while he was travelling in a bus. Later, in 1865 while writing his textbook at Ghent in Belgium, Kekulé had the following experience:

> I turned my chair to the fire and dozed. Again the atoms were gambolling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of the kind, could now distinguish larger structures of manifold conformation; long rows, sometimes more closely fitted together; all twining and twisting in a snake-like motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I woke. [12] (p 43).

[4]The author of this image is Haltopub. The image has been copied from Wikipedia and it is subject to the Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) licence.

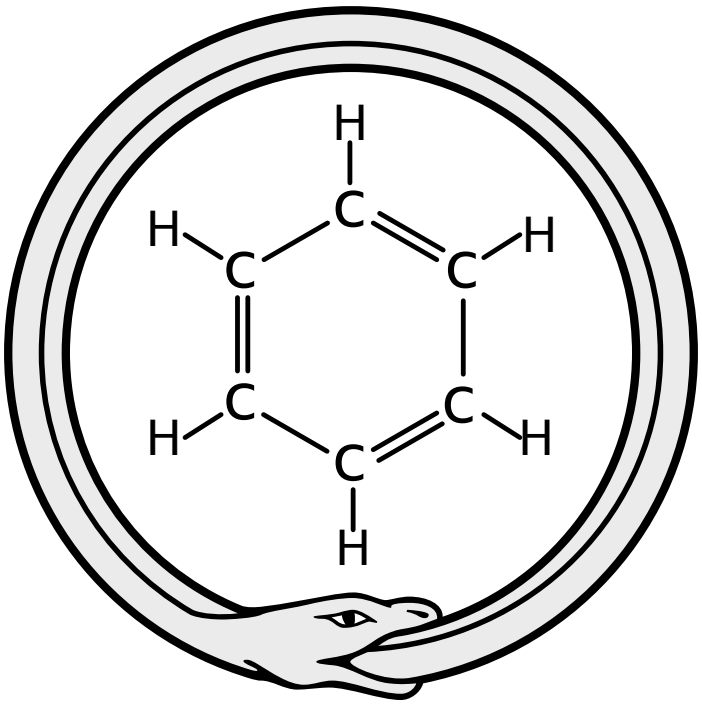

Figure 3: The benzene ring encircled by the snake eating its own tail, the ouroboros.[4]

A low resolution video dramatization of Kekulé's dream is available on YouTube [13]. It is interesting that, instead of "dozed", the original German word used by Kekulé in his description of the second dream was "Halbschlaf" which literally means "half-asleep" [11] (p 32). So, it is clear that the revelation came to him during a period in the hypnagogic, twilight state between wakefulness and sleep.

Otto Loewi's dream

Another famous discovery inspired by dreams was that of the Nobel Prize-winning physiologist Otto Loewi, who showed conclusively that nerve impulses were chemically transmitted [14]. The quaint story behind this discovery is given by Otto Loewi himself so:

> The night before Easter Sunday of [1920] I awoke, turned on the light and jotted down a few notes on a tiny slip of thin paper. Then I fell asleep again. It occurred to me at 6.00 o'clock in the morning that during the night I had written down something important, but I was unable to decipher the scrawl. The next night, at 3.00 o'clock, the idea returned. It was the design of an experiment to determine whether or not the hypothesis of chemical transmission that I had uttered 17 years ago was correct. I got up immediately, went to the laboratory, and performed a simple experiment on a frog heart according to the nocturnal design. [15]

Vivid visualization and mental experiments

Tesla possessed unique powers of visualization. He could volitionally form in his mind pictures of objects that did not exist in the outside world, and that he did not see with his eyes, but which were just as clear to his visual sense as actual objects seen with the eyes. At the age of seventeen, he started seriously applying this unusual faculty toward his inventions. As he recounted it:

> ... Then I observed to my delight that I could visualize with the greatest facility. I needed no models, drawings or experiments. I could picture them all as real in my mind. Thus I have been led unconsciously to evolve what I consider a new method of materializing inventive concepts and ideas, which is radically opposite to the purely experimental and is in my opinion ever so much more expeditious and efficient. The moment one constructs a device to carry into practice a crude idea he finds himself unavoidably engrossed with the details and defects of the apparatus. As he goes on improving and reconstructing, his force of concentration diminishes and he loses sight of the great underlying principle. Results may be obtained but always at the sacrifice of quality.
>
> My method is different. I do not rush into actual work. When I get an idea I start at once building it up in my imagination. I change the construction, make improvements and operate the device in my mind. It is absolutely immaterial to me whether I run my turbine in thought or test it in my shop. I even note if it is out of balance. There is no difference whatever, the results are the same. In this way I am able to rapidly develop and perfect a conception without touching anything. When I have gone so far as to embody in the invention every possible improvement I can think of and see no fault anywhere, I put into concrete form this final product of my brain. Invariably my device works as I conceived that it should, and the experiment comes out exactly as I planned it. In twenty years there has not been a single exception. Why should it be otherwise? Engineering, electrical and mechanical, is positive in results. There is scarcely a subject that cannot be mathematically treated and the effects calculated or the results determined beforehand from the available theoretical and practical data. The carrying out into practice of a crude idea as is being generally done is, I hold, nothing but a waste of energy, money and time. [1]

Thus, Tesla produced his inventions without drawings or blueprints. He did not have computers like we do, to conduct inexpensive and complex simulations before building prototypes. Indeed he generally did not build physical prototypes for his inventions. Instead, he conducted all the preliminary work for the machines he built *entirely in his mind*. It is only after he had satisfactorily concluded those mental experiments that he proceeded with physical fabrication of the devices.

It is a curious fact that once Tesla started an experiment, say switching on a motor and keeping it running for several days, he could devote his mind to other tasks while the running motor experiment carried along on its own, without conscious intervention from him, until he decided to switch the motor off and examine the wear and tear. This is a form of *multitasking* which those who are familiar with computing will understand, as the ability of an operating system to process several computing tasks by attending to each of them sequentially in specific slices of time, giving rise to the illusion of simultaneity. But even this analogy is flawed because in a computer only one task is performed at any one time, whereas the experiment in Tesla's mind ran automatically without conscious intervention from him, while he attended to other tasks.

Moreover, Tesla asserts that his mental experiments never failed him even once in a long and fecund inventing career. Even more surprisingly, "his memory ever afterward retained all of the details, even to the finest dimensions," [2] of each of his mental experiments. Such a mind is a researcher's El Dorado, and it has the capability to revolutionize the way scientific research is conducted, and is itself worthy of further research.

Conjectures: vivid visualization and mental experiments

The fact that we have a brain that is split into two hemispheres with accompanying hemispherical asymmetry has been known since the nineteenth century [16]. Interestingly, though, it is researchers in education, working in the field of children with learning difficulties, who have come up with the classification that some people are predominantly visual thinkers and learners [17], [18]. The terms *visual thinker* or *visual-spatial learner* are used to describe individuals who think in visual rather than verbal mode. They predominantly use the right side of their brain, and may excel in art and music, but are not generally as adept as the general population in left-brain verbal-logical tasks.

Tesla and other visually gifted people

Tesla was a visual thinker par excellence. He possessed an ability to visualize that is unparalleled in the annals of science. There have been many eminent scientists, mathematicians, artists, and poets who have had unusual abilities to visualize [18]. Among them may be quoted the scientists Michael Faraday and Albert Einstein, the mathematicians Henri Poincaré and Srinivasa Ramanujan, and the mystic poet and painter William Blake. The visual mode of thinking was dominant in each of these people.

Einstein, for example, imagined a man riding on a wave of light, and developed his theory of special relativity based on the consequences of this visualization. Faraday was also a visual thinker who liberally illustrated his scientific diaries with diagrams but rarely, if ever, used algebraic equations [18] (p 29), [19]. Poincaré, one of the founding fathers of topology—the mathematical field that explores what happens to objects as they are deformed, twisted, or stretched, but not torn—was by his own admission a visual thinker. Ramanujan claimed that many of his results appeared in his dreams as ready-made theorems [20] (p 66). William Blake saw visions of realms finer and subtler than this world, while he was, it has been conjectured, in a hallucinatory state of consciousness [21].

What sets Tesla apart from even this distinguished company of gifted people, is that his visualization was conscious and volitional and had *verisimilitude*. This means that *what he visualized was indistinguishable from a real thing being perceived through his eyes, except that, in his case, there was nothing in front of his eyes resembling what he saw*. Tesla accepted this gift of his in a matter of fact fashion and even suggested an explanation for what he saw: it was simply the reverse phenomenon of normal vision, in that a mental image in his brain projected a corresponding image on his retina [1]. The current state of knowledge about human visual perception [22]–[24] is such that there is, at present, no definitive explanation for Tesla's experience.

Virtual laboratory

The term *gedankenexperiment* or "thought experiment" gained currency, especially after Einstein's traveller riding on a wave of light. However, Tesla's unique ability to use his mind as a fully equipped, albeit inexpensive laboratory, to conduct the entire design-prototype-test-repeat cycle iteratively, gives new meaning to what we *could* mean by thought experiment or mental experiment. Indeed, it is perhaps more accurate to coin the term *virtual laboratory* for describing

what Tesla accomplished with his mind and vivid visualization. That is the term we will use hereafter in this paper. The experiments in his virtual laboratory all obeyed the known properties of matter and energy as enshrined in the known laws of physics, and he did not need to tend them until he wished to examine the results.

The importance of imagination

From the foregoing, we know that Tesla had a vivid imagination—the making of images—harnessed by discipline. It is interesting that in his later years, he extolled the importance of a vivid imagination above that of reason in the following words:

> Our first endeavors are purely instinctive, promptings of an imagination vivid and undisciplined. As we grow older reason asserts itself and we become more and more systematic and designing. But those early impulses, though not immediately productive, are of the greatest moment and may shape our very destinies. Indeed, I feel now that had I understood and cultivated instead of suppressing them, I would have added substantial value to my bequest to the world. But not until I had attained manhood did I realize that I was an inventor. [1]

This resonates with Einstein's statement, "I am enough of an artist to draw freely upon my imagination. Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world." [25].

Conjectures on the virtual laboratory

Tesla's intensity of visualization is denied most of us except when we dream. While we dream, we are cut off from sensory input from the outside world. The resulting concentration of mind allows us to visualize vividly in our dreams, but normally we do not have control over what we dream, or indeed even how. *Tesla was exceptional in being able to consciously and volitionally conduct what can only be called physically meaningful "dream experiments" in his virtual laboratory, while being fully awake!*

It is reasonable to speculate that the capacity of the right brain to imagine, or literally, make images, and the capacity of the left brain to sequence thoughts according to logic are *both* essential ingredients in the functioning of Tesla's virtual laboratory. One possible conjecture about Tesla's mental mode during his virtual laboratory experiments is given below.

Dreams, lucid dreams, and the virtual laboratory

It has generally been believed that wakefulness and sleep are mutually exclusive states of both body and mind. Apart from episodes of absent-mindedness that pass for day-dreaming and for abnormal mental states such as hallucinations, it was also the general consensus that dreaming occurred only during the state of sleep. A simplified pictorial relationship between these states is shown in the Venn diagram of Figure 4.

[5] A simplified picture of the relationship between the states of wakefulness, sleep, and dreaming. Wakefulness and sleep are mutually exclusive. Dreaming only occurs in the sleep state.

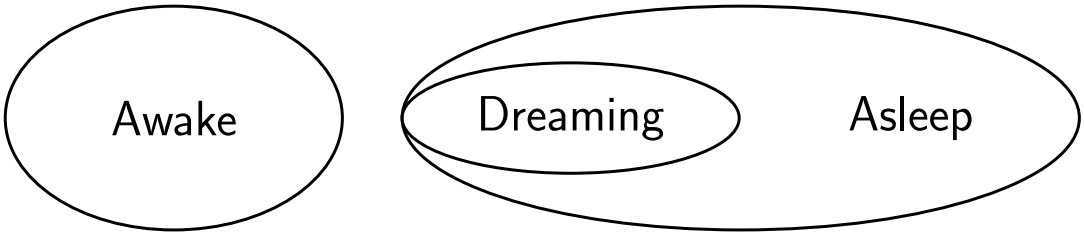

Figure 4: Relationship between wakefulness, dreaming and sleep.[5]

The phenomenon of lucid dreaming was scientifically established only in the 1980s. Psychophysiological research has since discovered that it occurs in Rapid Eye Movement (REM) sleep and is as vivid—if not more vivid than—a normal dream. Nevertheless, the subject who is dreaming is aware that he or she is dreaming and, moreover, can volitionally alter the dream, unlike the regular dreamer [26], [27]. This means that the lucid dreamer occupies a paradoxical state at the borderline between sleep and wakefulness in which the body is essentially in REM sleep, but the mind is aware that it is dreaming, and is capable of controlling the dream. Both the dream experience, and the fact that it was a conscious dream, can be recalled during the wakeful state. After the recognition and acceptance of lucid dreaming as a legitimate mental state, we may represent the relationship between wakefulness, sleep, and dreaming by the modified Venn diagram shown in Figure 5.

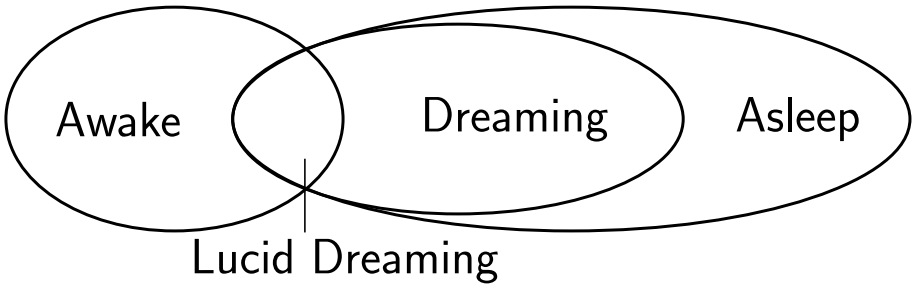

Figure 5: Modified relationship between wakefulness, dreaming and sleep.[6]

It is tempting to conjecture that Tesla, working in his virtual laboratory, functioned one level above the lucid dream, in being both physically and mentally awake while inwardly running his mental simulations with all the concentrated power, vividness, automaticity, and verisimilitude of the dreaming mind.

[6]Modified, simplified relationship between wakefulness, dreaming, and sleep after the recognition and acceptance of lucid dreaming as a legitimate mental state. Lucid dreamers are mentally aware that they are dreaming and have conscious control over their dreams, while paradoxically, their bodies are asleep.

Questions: vivid visualization and virtual laboratory

Tesla's virtual laboratory is so unusual as to beggar belief. However, Tesla was a scientist and engineer, schooled in accurate observation and respect for objective truth. Moreover, his mode of working in his virtual laboratory, without blueprints and prototypes, confounded and frustrated his co-workers. So we may safely assume that Tesla indeed ran his motor, examined its wear and tear, and then machined it to compensate for that, all in his mind [2] (p 58). This leads to many tantalizing questions, including these:

1. Very simply, how did he do it?
2. What are the prerequisites for an imagination as vivid as Tesla's?
3. How does one achieve his intensity of visualization while wide awake?
4. What is the peculiar state in which Tesla's mind operated while he ran his virtual laboratory? Specifically, was Tesla's mind in a state of daydreaming, hallucination, lucid dreaming, visual thinking, or some as yet unknown mode, during his experiments?
5. Did Tesla simply visualize only the motion, or did he visualize the electricity too?
6. How does one visualize electricity?
7. Is precise scientific knowledge a pre-requisite for visualization as in the case of the virtual laboratory? In other words, does a person with such faculties need to know, in addition, the laws of physics and material properties in order to conduct experiments like Tesla?
8. Can the ordinary person acquire the skills needed for a virtual laboratory by suitable training and practice as is done in sport or dance?

These fascinating questions are worthy of exploration, especially since we are so familiar with *virtual reality* in computer games and simulations nowadays. Using this language, it is clear that Tesla had replicated reality in his mind and was running a virtual laboratory there.

Eccentricities of habit and behaviour

Apart from his senses and vivid visualization, Tesla's body, habits, will power, and social interactions all exhibited anomalies that merit mention and reflection. Although he suffered a mental breakdown at 25, and was prone to nervous exhaustion after long periods without rest, his body exhibited remarkable features. Tesla had a superhuman appetite for work. He was "able to work thirty-eight years almost without a day's interruption, and [could] find himself still strong and fresh in body and mind" [1]. He also had enormous will power that could not only sustain a punishing schedule but could also permanently banish undesirable habits that he had formed, once he was so convinced. Some of his more notable traits are enumerated below:

1. During his first year at the Polytechnic at Graz, he "regularly started [his] work at three o'clock in the morning and continued until eleven at night, no Sundays or holidays excepted" [1].
2. Tesla excelled at languages and knew English, French, German, Italian and the Slavic dialects [3] (p 14).
3. He had a prodigious memory and could store entire logarithmic tables in his mind [3] (p 14).
4. He was left-handed but later became ambidextrous [2].
5. He was not good at drawing [1].

6. At the age of fifty-nine, when he slipped on icy ground, he righted himself like a cat while in the air and landed on his feet [1].
7. At sixty-three his body shape and weight had remained unchanged for thirty-five years [1].
8. He was attracted to gambling but gave it up when admonished by his parents. He not only "conquered [his] passion then and there ... [but also] ... tore it from [his] heart so as not to leave even a trace of desire [1].
9. He took up smoking, but on realizing that it would ruin his health, gave it up permanently [1].
10. When Tesla discovered that the innocent cup of coffee he consumed every morning could precipitate heart trouble, he discontinued it by strenuous will [1].

He saw his conquest of bad habits in a different light from most people. He said:

> In this way I checked and bridled other habits and passions and have not only preserved my life but derived an immense amount of satisfaction from what most men would consider privation and sacrifice. [1]

One interesting question that arises is whether Tesla's extraordinary visualization was in any way related to his tremendous will power.

Integrity and moral sense

Tesla was a humanist who desired to use his mind for the freedom of all mankind from the thralldom of matter. He wanted to liberate mankind from drudgery using his magical inventions. While this idealistic vision never left until the end, Tesla was singularly inept in his business dealings. Indeed, one academic who teaches engineering management, and is a lifelong Tesla enthusiast and biographer, has written that he uses Tesla to teach his students how *not* to run their business affairs [5]. Two incidents that well illustrate not only Tesla's integrity and moral sense but also his business naïveté are noted below.

Thomas Edison once offered Tesla the then staggering sum of USD 50,000 for improving motor and generator designs. Tesla assiduously applied himself to the changes and gave the Edison company several very profitable patents in the process. When Tesla asked for the USD 50,000, Edison is reported to have replied, "Tesla, you don't understand our American humor," and reneged on his promise [6]. Tesla promptly resigned.

The "War of the Currents" [3] (chapter 5) between DC and AC, waged between Thomas Edison and George Westinghouse, left both almost bankrupt. Tesla, feeling loyalty and generosity toward his new backer, Westinghouse, did not re-negotiate his patent royalties but rather released Westinghouse altogether. In the process, he lost what would have amounted to almost USD 12,000,000 in royalties [3] (p 48–49). Tragically, toward the end of his life, he was plagued by a chronic shortage of funds.

Tesla as a humanist

Tesla was unambiguous about the place of the inventor in society and of his own role in life. The opening paragraph of his autobiography, which may be called his *mission statement*, begins thus:

> The progressive development of man is vitally dependent on invention. It is the most important product of his creative brain. Its ultimate purpose is the complete mastery of mind over the material world, the harnessing of the forces of nature to human needs. This is the difficult task of the inventor who is often misunderstood and unrewarded. But he finds ample compensation in the pleasing exercises of his powers and in the knowledge of being one of that exceptionally privileged class without whom the race would have long ago perished in the bitter struggle against pitiless elements. [1]

Besides his innumerable inventions, he had also discovered the following, each of which was later "re-discovered" by others who won Nobel Prizes [2] (p 166):

1. Cosmic rays;
2. Artificial radioactivity;
3. Disintegrating beam of electrified particles or atom smasher;
4. Electron microscope; and
5. Very special radiation or X-rays.

Tesla was also the rightful inventor of radio, as established by the US Patent and Trademark Office after his death, although Guglielmo Marconi won the Nobel Prize for it [7]. It is regrettable that Tesla was not only a man ahead of his time, but also one whom society failed to recognize and reward, and whom time has literally forgotten.

Falling asleep

Tesla, being an experimental scientist, was an extremely keen observer. The merit in studying his mind is that he brought his powers of scientific observation to bear on his own mental processes and inner experiences. We therefore have a window into the subjective mind of an extraordinary person, impartially and accurately documented by himself. Tesla fell asleep in a different way than most of us do, and he described it thus:

> When I close my eyes I invariably observe first, a background of very dark and uniform blue, not unlike the sky on a clear but starless night. In a few seconds this field becomes animated with innumerable scintillating flakes of green, arranged in several layers and advancing towards me. Then there appears, to the right, a beautiful pattern of two systems of parallel and closely spaced lines, at right angles to one another, in all sorts of colors with yellow-green and gold predominating. Immediately thereafter the lines grow brighter and the whole is thickly sprinkled with dots of twinkling light. This picture moves slowly across the field of vision and in about ten seconds vanishes to the left, leaving behind a ground of rather unpleasant and inert grey which quickly gives way to a billowy sea of clouds, seemingly trying to mould themselves in living shapes. It is curious that I cannot project a form into this grey until the second phase is reached. Every time, before falling asleep, images of persons or objects flit before my view. When I see them I know that I am about to lose consciousness. If they are absent and refuse to come it means a sleepless night. [1]

Idiosyncrasies

Undoubted genius that he was, Tesla also exhibited traits that most of us would consider anomalous, if not downright abnormal. He had an abnormal fear of germs [3] (p 263–264) causing him to wash his hands several (but always a multiple of three) times. While dining, he needed eighteen clean linen napkins at the dining table [3] (p 1). He was also extremely fond of pigeons and used to nurse and feed any sick pigeons he found [3]. In his early life, Tesla developed a number of what he called "strange likes, dislikes and habits" [1]. His own account of them is as follows:

> During that period I contracted many strange likes, dislikes and habits, some of which I can trace to external impressions while others are unaccountable. I had a violent aversion against the earrings of women but other ornaments, as bracelets, pleased me more or less according to design. The sight of a pearl would almost give me a fit but I was fascinated with the glitter of crystals or objects with sharp edges and plane surfaces. I would not touch the hair of other people except, perhaps, at the point of a revolver. I would get a fever by looking at a peach and if a piece of camphor was anywhere in the house it caused me the keenest discomfort. Even now I am not insensible to some of these upsetting impulses. When I drop little squares of paper in a dish filled with liquid, I always sense a peculiar and awful taste in my mouth. I counted the steps in my walks and calculated the cubical contents of soup plates, coffee cups and pieces of food—otherwise my meal was unenjoyable. All repeated acts or operations I performed had to be divisible by three and if I missed I felt impelled to do it all over again, even if it took hours. [1]

The above quirks of mind and habit suggest that Tesla experienced the following anomalies of mind:

1. obsessive-compulsive disorder;
2. synaesthesia; and
3. high-functioning autism.

His fixation on the number three and having to wash his hands three times, have eighteen napkins on the table during meals, walking around a building thrice before entering it, etc., are all symptomatic of obsessive-compulsive disorder [6]. So, too, his counting the number of steps in his walks, and the cubic capacity of his soup plates and items of food and drink. Tesla's compulsion with germs and cleanliness may be traced back to periods in his life when he made a trans-Atlantic voyage without his luggage, and when he spent a year digging ditches in the United States to make ends meet. He vowed after these experiences that he would never use a towel twice [5] (pp 167–168). One is reminded in this context of how a deeply-felt regret can lead to an obsession, as in the case of Lady Macbeth who famously said, "Here's the smell of the blood still: all the perfumes of Arabia will not sweeten this little hand," [Shakespeare, *Macbeth*, act 5, scene, 1, lines 50–1].

Synaesthesia is a condition in which stimulation of one sensory modality gives rise to a response in another modality [28], [29]. A synaesthete may "taste" a shape for example. It is tempting to speculate that Tesla's awful taste when dropping paper squares into a liquid may be symptomatic of synaesthesia. It would also be interesting to explore whether his hyper-acute senses and cross-modal sensory responses influenced each other.

Tesla's abnormal sensitivity to sounds, his single-minded absorption in what fascinated him, his solitary work habits, his inability to see through the dishonesty of some of his work associates, etc., all suggest that he might have been autistic. However, he had no difficulties with language and, in fact knew Göthe's *Faust* by heart, along with several Serbian poems. This juxtaposition of some of the strengths found in the autistic with few of their deficiencies, has prompted some to suggest that Tesla probably suffered from high-functioning autism [30] or from Asperger's syndrome [31], which is a rare condition in which the autistic child is intelligent, highly verbal, and near normal [32]. This would explain both his extraordinary mental faculties and also a number of his mental quirks. The existence of "autistic idiot savants" [32] (pp 84–85), [33] who function with super-human excellence in some areas of human endeavour but who are lacking severely in others, suggests that some compensatory mechanism—a sort of zero sum for the total mental capacity—might explain the co-existence of both their "islets of abilities" and concomitant deficits.

Questions: idiosyncrasies

Given that Tesla was unusual in many ways, and could have had what are labelled today as "certain varieties of anomalous experience", the following questions suggest themselves:

1. Were his abnormalities like synaesthesia and obsessive-compulsive disorder the result of his mental precocity and extraordinary visual sense?
2. Are such conditions a "compensatory" accompaniment of genius?
3. Was Tesla indeed autistic?
4. Could it be that Tesla had both the left and right hemispheres of his brain functioning well above the capacity of normal human beings? (Recall that when the word for an object was spoken he "saw" the object referred to as if it were right in front of his eyes.)
5. Could this have led to some "cross-wiring" of his senses?
6. Could it also have led to the mélange of genius and eccentricity seen in him?

Tesla's grandiose claims

Tesla's plans were always grand. Typical of the visionary, he saw the fruition of his discoveries in his mind and spoke of them even before they had been realized. When commercial or financial imperatives obstructed their realization, he was often sidelined or ridiculed by the scientific establishment. Yet, the very things he envisioned then are realities in our present age of semi-conductors, computers, and the Internet. To appreciate just how prophetic his vision was, let us look at just one example: his "World-System". In the vocabulary of Tesla's day, this system would be capable of:

1. The inter-connection of the existing telegraph exchanges or offices all over the world;
2. The establishment of a secret and non-interferable government telegraph service;
3. The inter-connection of all the present telephone exchanges or offices on the Globe;
4. The universal distribution of general news, by telegraph or telephone, in connection with the Press;
5. The establishment of such a 'World-System' of intelligence transmission for exclusive private use;
6. The inter-connection and operation of all stock tickers of the world;

7. The establishment of a 'World-System' of musical distribution, etc.;
8. The universal registration of time by cheap clocks indicating the hour with astronomical precision and requiring no attention whatever;
9. The world transmission of typed or handwritten characters, letters, checks, etc.;
10. The establishment of a universal marine service enabling the navigators of all ships to steer perfectly without compass, to determine the exact location, hour and speed, to prevent collisions and disasters, etc.;
11. The inauguration of a system of world-printing on land and sea; and
12. The world reproduction of photographic pictures and all kinds of drawings or records. [1]

Grandiose claims they may have been in his time. Today, the world-mind has enlarged beyond measure compared to the pre-transistor days in which Tesla lived. It is to his great credit that in a world of condensers and coils, he could visualize what electricity was capable of, in the service of mankind.

In his later years, he formulated grand plans to use lightning to generate artificial rain to turn deserts into gardens [1]. Another of Tesla's pet projects was the wireless transmission of free electrical energy from which all mankind could benefit [34]. This was in keeping with his mission statement. It was also consistent with the fact the earth receives its sum total of energy from the sun in precisely the same fashion. Yet, such grandiose projects and claims led to the marginalization of Tesla as a force in science. Are his claims of tapping an infinite energy source all around us worth re-investigation in these times when global warming and the finitude of fossil fuels is forcing a re-examination of all energy options?

Tesla and Swami Vivekananda

Ideas about unlimited, free energy might have found resonance with Tesla after his meeting with the famous Hindu monk, Swami Vivekananda, who visited the United States in the 1890s [7], [35], [36]. It is held that Tesla met the Swami in 1895–6 and that he was receptive to the ideas expressed in the Sanskrit language of Hindu cosmology about a universal energy, called *prāṇa*, and the vehicle for it, called *ākāśa*, literally the medium for radiance. The exposure to the idea that everything is floating in a sea of universal *prāṇa* must have taken hold in his fertile imagination and given rise to claims about the possibility of free energy from the capture of solar "cosmic rays" that could be used to drive machines. His biographer O'Neill states that—in an unpublished article entitled "Man's Greatest Achievement"—Tesla speaks of mankind in general, saying [2] (p 270):

> There manifests itself in the fully developed being, Man, a desire mysterious, inscrutable and irresistible: to imitate nature, to create, to work himself the wonders he perceives ... Long ago, he recognized that all perceptible matter comes from a primary substance, or tenuity beyond conception, filling all space, the Akasa or luminiferous ether, which is acted upon by the life-giving Prana or creative force, calling into existence, in never ending cycles, all things and phenomena. The primary substance, thrown into infinitesimal whirls of prodigious velocity, becomes gross matter; the force subsiding, the motion ceases, and matter disappears, reverting to the primary substance.
>
> Can Man control this grandest, most awe-inspiring of all processes in nature? Can he harness her inexhaustible energies to perform all their functions to his bidding, more still to cause them to operate simply by the force of his will?

The fact that Tesla, who did not know Sanskrit, used the words prāṇa and ākāśa, lends support to the claim that he did indeed meet Swami Vivekananda. Tesla's expression "tenuity beyond conception" corresponds perfectly with the statement *"ta ākāśe na vidyante"* meaning "(this) ākāśa is imperceptible" [37] (p 92), showing Tesla's ability to grasp abstruse philosophical points. Indeed, he did expound on philosophy, and was in that sense a well-rounded scholar [38].

Post-Einsteinian physics has not found a need for *ākāśa* or the luminiferous ether, but there is a need for *something*, regardless of label. Indeed, in a recent article on the ether, it has been observed that "Physicists appear to need an ether on which to load all the properties of the physical world they cannot otherwise explain. Ether, alias the vacuum, exists. Void is anything but nothing" [39].

Tesla's pigeon

Although possessed of mental abilities that could almost be termed psychic, Tesla did not give vent to the expression of his spiritual side [2]. Indeed, when once approached by a team of engineers to join a psychological society for investigating psychic phenomena, Tesla almost threw them out [1].

With regard to his neglected spiritual side, Tesla's pigeon fixation affords an interesting story [3]. Tesla loved one particular female pigeon, almost as he would love a human being. He recalled that one night, as he was lying on his bed in the dark, this pigeon flew in through the open window, as if to deliver a message. He looked at her and realized that she had come to tell him she was dying. As he looked at her, Tesla said, "there came a light from her eyes—two powerful beams of light". He reaffirmed, "Yes, it was a real light, a powerful, dazzling, blinding light, a light more intense than I had ever produced by the most powerful lamps in my laboratory" [3] (p 229). When that pigeon died, Tesla "knew" that his life's work was finished.

Although Tesla never publicly gave expression to his religious or spiritual beliefs, this pigeon episode inevitably calls for comparison with the Biblical account of the baptism of Jesus by John the Baptist: "... and he saw the Spirit of God descending like a dove, and lighting upon him ..." [Matthew~3:17].

Bucke's hypothesis on human mental evolution

The medical doctor, Richard Maurice Bucke,[7] writing at the beginning of the twentieth century, advanced the radical hypothesis that evolution also applied to the human mind [9]. Although he used the word "evolution", Bucke did not imply any particular engine, like Darwinian natural selection, for driving mental evolution, but rather asserted blandly "that growth, evolution, development, ... has ... always gone on, is going on now, and ... will always go on" [9] (p 61).

[7] Formerly Medical Superintendent of the Asylum for the Insane at London, Ontario, Canada

As a lead-in to his idea of mental evolution, Bucke proposed, among other things, that man's sense of colour, sense of fragrance, and musical sense had all developed over time to their present state. Accordingly, he proposed that human colour vision was a recent evolutionary development. He suggested that as sensory perception evolved, the vocabulary of languages kept pace to deal with this increasing sophistication. Tracking the gradual development of the words for different colours in ancient languages and literature, he suggested that the perception and recognition of colours kept pace with each other according to the tree illustrated in Figure 6. Bucke claimed that:

> When a new faculty appears in a race it will be found, in the very beginning, in one individual of that race; later it will be found in a few individuals; after a further time in a larger percentage of the members of that race; still later in half the members; and so on, until, after thousands of generations, an individual who misses having the faculty is regarded as a monstrosity. [9] (p 52)

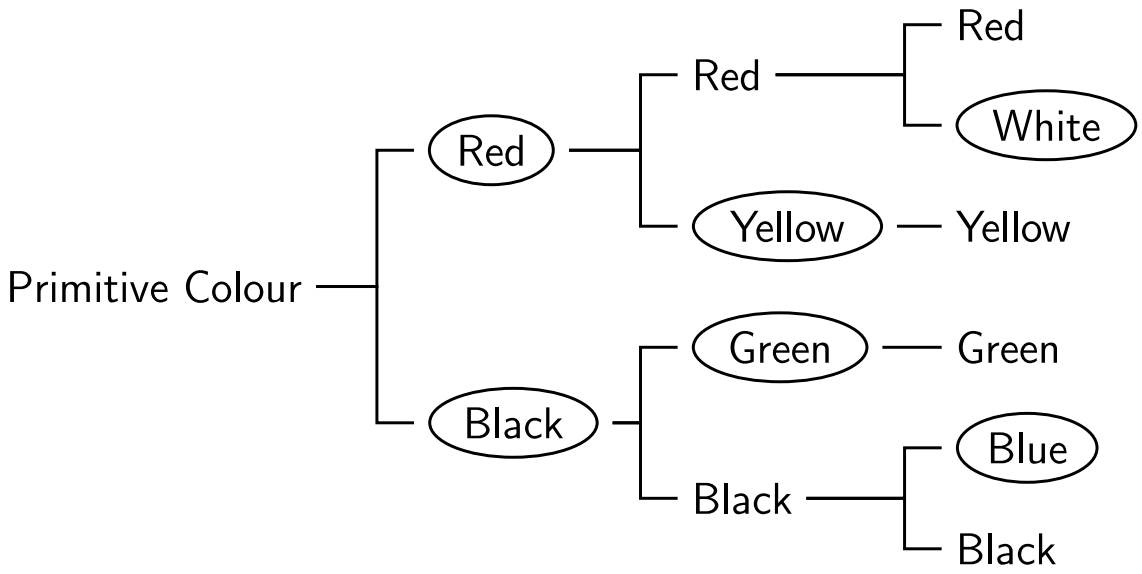

Figure 6: Evolution of colour perception in human beings.[8]

Extrapolating from his suggested hypothetical development of colour vision, etc., over time, Bucke postulated that the human mind also evolved with time. He distinguished three progressive states of consciousness so:

1. Simple consciousness that is possessed by the higher animals and man by which they are aware of their surroundings and also of their own bodies as integrated entities;
2. Self consciousness which is not present in animals, but only in man, whereby man becomes aware of himself as a distinct entity apart from the rest of the universe, and which allows him to treat his own mental states as objects of consciousness, and also allows communication by language; and

[8] Evolution of colour perception in human beings as conjectured by R M Bucke. This diagram is adapted from Bucke [9] (p 36). Time increases as one moves right. The circled colours were the ones newly recognized at any particular period. So, the progression of newly recognized colours was red/black, followed by yellow/green and later by white/blue. Bucke cites literary and scientific evidence in support of his conjecture. While his scientific arguments have now been supplanted, the literary arguments are still persuasive.

3. Cosmic consciousness which includes simple and self consciousness, but which in addition allows "a consciousness of the cosmos, that is, of the life and order of the universe" [9] (p 3) and "an intellectual enlightenment or illumination which alone would place the individual on a new plane of existence—would make him almost a member of a new species" [9] (p 3). Bucke stated that the burden of his book was to expound the nature of this exalted state and identify some of its exemplars.

While there have been many extraordinary spiritual leaders of humankind with superior mental attributes, Tesla's phenomenal mental abilities present one of the most prominent examples of such abilities in a man or woman of science. Whether or not Tesla possessed "cosmic consciousness" in accordance with Bucke's definition, we may justifiably ask whether Tesla possessed a more evolved mind than the ordinary human being. *Or more precisely, was Tesla a representative from our future, in which those possessing his faculties would be more numerous than today?* It is a tantalizing question that may have no clear cut answers for now.

Conclusions

Like Icarus, Tesla sought the freedom of flight. Like Prometheus, Tesla wrested the subtle fire of electricity from the realm of the invisible and brought it down into the world of mortals. Like Zeus, he wielded the thunderbolt by creating lightning artificially. Like Archimedes, his thoughts were always on a grand scale and he was not only the theoretical mathematical physicist but also the practical engineer-inventor.

Tesla was larger than life and greater than most of his fellow human beings. He excelled in his intellect, power of will and visualization, and his moral sense. He was unambiguous in his personal mission statement about the social responsibility of the inventor-scientist as one who ameliorates the life of his fellow human beings. He held that the pleasure of discovery and invention was its own reward. He embraced the insights that came to him through non-rational processes of thought. Perhaps, he exercised, more symmetrically and to a greater degree than most people, both the right and left hemispheres of his brain.

One rather sad, recurring theme in the biographies of Tesla is that he was somehow a misfit either in the society in which he lived and worked, or the times in which his life was enacted. Margaret Cheney's biography, *Tesla: Man Out of Time*, clearly shows this in its very title. As does also the subtitle of Lomas's book [5], *Nikola Tesla, Forgotten Genius of Electricity*. Do these titles hold the key to Tesla's mystery? *Was Tesla from our future?*

The most important contribution of Tesla may not be the alternating current grid, or the induction motor, or any of his other electrical inventions. It may simply be the fact that he was a very unusual human being with remarkable mental powers that most of us can only call incredible or legendary. How did he come by them? Were his abilities the result of some form of compensation, as in the autistic idiot savant, *or was it simply that Tesla was a man from our future who had torn the veil of time to visit us and give us a glimpse of the future capabilities of humankind?*

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Feedback

Please email me your comments and corrections.

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