the individual human mind's design which permits an individual human being, but no animal, to make such a type of valid discovery of the necessary change in principled modes for shaping of the future?

Third, how does the individual human mind manifest such a unique power, with no precursor for this in the Biosphere as such?

Is it some principle of "tuning?" Has the development of the human mental-biological apparatus taken the human species to a point at which it is "tuned into" a higher power in the universe, a higher power which is not only expressed as truly anti-entropy, as defined by the great Eighteenth Century mathematician Abraham Kästner, but a supreme universal physical principle of anti-entropy? So, Philo of Alexandria condemned the Aristotlean's theological insistence on the self-inflicted, permanent impotence of the Creator, and did so on the basis of the strongest quality of argument in evidence against such an absurd theology, and, implicitly, against an absurd, Aristotelean, Claudius Ptolemy-like misconception of science.

There are two cases of such crucially significant behavior. In one case, there is the universe in the large, as governed by an anti-entropic principle driving the universe into successively higher qualitative states of organization as a universe. In the other case, as posed in ***Genesis*** 1, mankind acts upon its place in the universe to similarly anti-entropic effect. In the other aspect of the matter, we have the evidence that the human mind has a potential quality which, by sheer weight of definition, is not a product of its biology as we define biology today, but the "tuning" of the human form of thinking to agreement with cognitive powers which have never been shown to exist in lower forms of life. Yet, as is shown by the growth of the Noösphere, relative to the Biosphere, this power of the human mind is fully efficient within our universe.

As Nicholas of Cusa presented the case, as our Creator of the universe is to man, so man mimics that Creator in man's spiritual power over, and obligation to caring for dogs.

The more modest point to be proffered in this context, is the evidence that the universe is intrinsically anti-entropic, and that the obligation which mankind must meet if mankind is to survive, is to act in the way the Creator of our universe has governed. We are properly "tuned" to be creatures devoted to the service of anti-entropy, such that those who express a contrary view, such as the Malthusians and former U.S. Vice-President Al Gore today, are therefore evil in what they do in service of entropy.

With respect to the great question which has been the subject of my report here, we are in a predicament with practical implications like those confronted by Louis Pasteur on the matter of life. We do not have the true solution; but, we must not avoid the implications for the present practice of science, of the unanswered, stubbornly persisting question which it would be incompetence to avoid. In science, until we pose the question, as I have proposed we do here, we will never begin to discover the answer.

Fermat and Least-Time

Descartes Did Not See the Light

by Jason Ross,
LaRouche Youth Movement

In early 1637, René Descartes submitted a copy of his *Dioptrique* for publication. In it, Descartes (1596-1650) announced his formulation of the laws of reflection and refraction, using analogies of moving balls, the walking stick of a blind man, and wine grapes being trampled in a vat, to make his meaning clear. (He mentioned no actual experiments with light, however.) With ballistic analogies, he made the case for the equality of angles in reflection. The case of refraction was more difficult, requiring the motion of a ball to make one part of his demonstration, and the blind man's walking-stick, to solidly prove that light moves more forcefully in water than in air, and then using the example of wine dripping out of a vat, to sketch out the instantaneous motion of light, notwithstanding the different vigors of motion that it had in different media. He even refers in one diagram (by means of analogy, perhaps) to a tennis racket appearing from nowhere to hit the ball downwards as it reaches the surface of water, to explain its increased vigor in the water after moving through air. From these bizarre reasonings come the law of refraction: The sines of the angles of incidence and refraction are proportional to the different ease of light's passage through the two media.

A copy of this masterpiece was given to M. Beaugrand, the King's Secretary, who was in charge of approving all books for publication. Sometime in the Spring, Beaugrand "borrowed" Descartes' writing, and passed it around. Fermat (1601-65) was one of the beneficiaries (if you can call it that) of Beaugrand's kindness, and in September, shortly after receiving the *Dioptrique*, Fermat wrote a letter to Mersenne to tell him what he thought about the work. (If you read it, you may wonder if Fermat is being coy by expressing reservations about Descartes without expounding his own idea of light taking the least time. The simple explanation is that Fermat was not born with that discovery, and would not make it for another two decades.) Descartes responded to Fermat via Mersenne. Fermat wrote one more letter to Descartes, which was the last letter between the two of them dealing primarily with light, although a major dispute over Fermat's *Method of Maxima and Minima* was about to begin. Three letters of this time

Pierre de Fermat's (right) "new idea"—that shortest time, rather than shortest distance—was the principle at work in the refraction of light, overturned Decartes' (left) "ballistic" explanation.

period offer short remarks between the two men on the subject of refraction.

A New Idea

In 1657, Marin Cureau de la Chambre wrote a book titled, simply, *Light*, which he sent to Fermat to read. In this book, de la Chambre states his disagreement with those who seek to explain the motion of light ballistically (as Descartes does), saying instead that in the case of reflection, equal angles are not made due to some principle that creates equal angles as such, but rather because nature does everything by the simplest means, and that the equality of angles in reflection was merely a necessary result of light taking the simplest (shortest) path. He gives a geometric proof, like that of Heron of Alexandria, that least-distance results in equal angles. He was stumped, however, on the question of refraction, which violated this law of shortest distance, a violation that de la Chambre attributed to all that pesky material in the medium, preventing light from having "liberty" to move in the shortest distance. Fermat soon wrote back to de la Chambre, telling him that he was in agreement that nature takes the simplest means to achieve its ends, but that distance should be considered only when time is not a consideration. But since light takes time to travel, the path of effort must include the amount of time required to traverse that path. Shortest time, rather than shortest distance, was the principle at work!

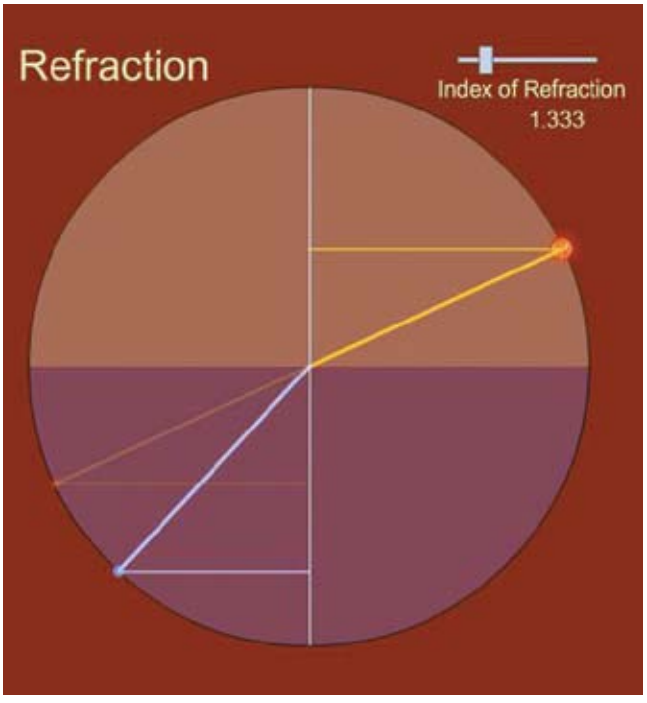
Now, although Fermat felt confident that his hypothesis was correct, he was troubled by the fact that experiments performed by one M. Petit, among others, had repeatedly confirmed the ratio of sines that Descartes had expounded as the law of refractions. Also, the calculations required to determine the actual angles that would result from his principle—calculations made according to his method of *Maxima and Minima*—would be rather involved. Amazingly, it took almost half a decade before he performed the necessary calculations!

In the meantime, he got into a protracted dispute with Claude Clerselier, the head Cartesian and publisher of the works of the then-deceased Descartes. Clerselier's initial letter to Fermat is, unfortunately, lost. Fermat's first two letters to Clerselier, written in 1658, go after the axioms underlying Descartes' demonstrations—the separation of what Descartes calls the "determination" to move from motion itself, and then the out-of-the-blue physical ideas that Descartes draws upon to make his conclusion work. Clerselier's response contains a defense of the skeptic that Fermat used in his last letter, a defense which rests on using the (actually non-existent) distinction between movement and the determination to move. Clerselier's friend, an M. Rohault, also responds to the letter Fermat wrote to Descartes in December 1637, in a remarkably condescending letter.

After this initial bout, another round commenced, with Fermat writing two letters. In the first, a masterpiece of Socratic reasoning, Fermat combines the assumptions Descartes uses in reflection with the different assumptions he uses to explain refraction, to create two paradoxes: reflection occurring at unequal angles, and a case of refraction where light (or Descartes' ball) literally gets stuck when it encounters the new medium, requiring a "passport" to be given it by the friends of Descartes so that it may leave this "fatal point." He is quite blunt in the second letter, resolving the problems he had made for the ball in his previous letter by saying that a moving ball and the refraction of light "only resemble each other in the imaginary comparison of M. Descartes," and that the only geometric result of Descartes's composition of motions is a "dialectic circle."

Clerselier flips his wig when he receives these Fermat's letters, and makes an exhaustive response, in which he accuses Fermat of making ridiculous assumptions (Fermat had assumed that a ball could lose half its speed when it encounters a surface just as easily as, in Descartes's thinking,

FIGURE 1



Fermat concluded that for light to move in the least time, the sines of the angles of incidence and refraction must be in the same ratio as the speed of light in the two media!

its speed could be increased when it enters a new medium by an imaginary tennis racket hitting it!), and that he should not "marvel [that] from an assumed impossibility an absurdity follows." Further, whenever people doubt Descartes, they should assume that they are wrong and work harder to understand the meaning of the Master!

A Coincidence of Opposites

After prompting by others, and after considering that Descartes' formula could give results very near the true principle without actually coinciding with it, Fermat finally screws up his courage and delves into the equations. They really aren't all that bad, which he realizes when he gets into the work of calculating. He was shocked to find that his principle of shortest time resulted in exactly the formula that Descartes had published almost 25 years earlier: Fermat concluded that for light to move in the least time, the sines of the angles of incidence and refraction must be in the same ratio as the speed of light in the two media! He excitedly wrote to de la Chambre again, on New Year's Day, 1662, giving an account of his discovery. He likens Descartes' "discovery" to the surrender of a fortified location to an enemy, based solely on his reputation: Nature surrendered her principle to Descartes without ever being forced to by any demonstration on the part of Descartes: such is the power of the reputation of M. Descartes![1]

M. de la Chambre had not yet accepted that light could take time to travel, and Fermat makes another appeal to him at the end of the letter, including another way to think about the resistance light encounters in its travel, even if de la Chambre insists on thinking that it moves in an instant. The demonstration that Fermat attached to his letter to de la Chambre was printed in the *Works of Fermat*, as part of his writing on *Maxima and Minima*, as the penultimate section.

Clerselier throws a tantrum at this insult, writing a scathing letter in which he huffs that Fermat's principle "is merely moral, not physical," and cannot be the cause for anything. He blusters that Fermat's idea that light moves more quickly in air than in water is wrong, citing an experiment that Clerselier clearly never performed of throwing a rock into a pond. His roasting letter even insults Fermat in Latin, something for which he is forced to apologize in a later, somewhat conciliatory letter. Clerselier has lost, and he knows it. Fermat's last letter to Clerselier is quite short—and he says that he will give up the fight for physics, if he may only be left with his "pure and abstract" geometric proof. His last writings indicate that he is not really sincere about giving up.

Posterity

The last piece of Fermat's correspondence found in the *Works* was written in 1664 to an unknown person, for whom Fermat summarizes the entire history of his thoughts on refraction, and includes a demonstration of the truth of his principle. It is remarkable that two people setting out on completely opposite paths should arrive at the same truth: Descartes had assumed light to move more easily in water, while Fermat believed it to have greater facility of motion in air. The Cartesians should be content with splitting the victory: Descartes discovered the formula, and Fermat proved that it is actually true! He writes that although "the opinion of M. Descartes on the proportion of refractions is quite true.... His demonstration is quite false, and full of paralogisms!" Parodying a criticism Clerselier had made of him: that Nature could not take the time to think about and decide between two easy paths—one of shortest distance and one of shortest time—Fermat writes to future generations that it will be up to posterity to judge between Descartes' path to knowledge and his own.

Translations of all the sources referenced in this article, as well as more about Fermat, are available at: www.wlym.com.

1. In section 22 of his *Discourse on Metaphysics*, G.W. Leibniz considers whether Descartes ever could have gotten the law of refraction from his way of thinking, and asks whether Descartes learned the ratio from Snel in Holland.