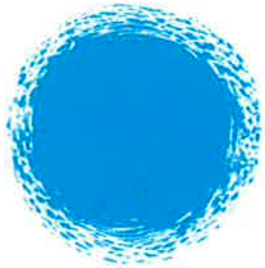

THE THEORY OF RELATIVITY:

A Key to the Universe

by Elma Ehrlich Levinger

1 The clerk from the Swiss Patent Office drew a package from the pocket of his shabby coat. The editor ran a practiced eye over the closely written sheets of manuscript, remarking thoughtfully, "H'm, thirty pages."

2 "It will be much shorter in print," the clerk assured him.

3 "But the issue I'm preparing for the press is already rather crowded."

4 Albert Einstein flushed a little and said, "I should like to see it printed if you can find room for it; I think your readers may find it interesting."

5 The man behind the desk, thinking, perhaps, about the enthusiastic response Einstein's four previous papers had drawn, murmured, "Let's see." He read the title, "Toward the Electrodynamics of Moving Bodies," and, frowning in concentration, glanced over the initial pages. "Now what's all this about relativity?"

6 Others all over the world were to ask the same question; countless studies, many of them profound and perceptive, and even more of them foolish, were to be written about it. Within a short time after the publication of his paper, Einstein was to be acclaimed by many as the greatest scientist who ever lived.

7 Curiously enough, it was a seeming failure that had given him a clue to his revolutionary theory. In 1887, while Einstein was a schoolboy in Munich, two American professors, Albert Abraham Michelson and Edward William Morley, were working on a fascinating problem. Knowing, as did all scientists, the speed at which the earth revolves round the sun, these two men tried to find out how fast the earth travels on its own path through space. To determine this, they designed an experiment that would measure with absolute exactness the speed of light going "with" the motion of the earth and "against" it. They constructed an ingenious apparatus consisting of two pipes placed at right angles to each other so that if light passing through one followed the direction of the earth's motion, light going through the other would have to "cross the current," like a swimmer crossing a river, and would be measurably slower. A mirror was placed at the end of each pipe, and a beam of light was shot into each pipe at exactly the same moment.

8 The experiment, however, did not produce the anticipated result; although the men moved the pipes in every direction, there was never any appreciable difference in the speed with which the two beams of light were reflected—they always came back together at the identical fraction of a second. After trying repeatedly, the experimenters became discouraged; it was an irrefutable fact that the earth moved, but their work indicated that it was standing still—a startling and terribly baffling development.

9 In the paper that he published eighteen years later, Einstein answered the question that had long puzzled not only Michelson and Morley, but all the eminent physicists of the day. The two Americans had not failed; on the contrary, their measurements had been accurate. Einstein's theory explained

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that light always travels at the same speed; moreover, the speed of light is the only fixed quantity that is always the same regardless of the conditions under which it is measured. Albert Einstein reasoned that the light beams had not encountered any obstacles as they sped through space because it is impossible to detect absolute motion in the universe by any experiment, no matter how carefully contrived. He declared that there was nothing absolutely at rest on earth or anywhere else in the universe; everything is continually in motion—from atoms too infinitesimal to be seen through the most sensitive microscope, to stars too distant to be perceived through the most powerful telescope. In such a universe, where all is motion and nothing is fixed, everything is relative to the circumstances under which it is observed.

10 The concept of relativity was by no means a novelty, but scientists had always believed that certain facts of the physical world were *absolute* and would not change under any circumstances; in measuring length, weight, and speed, a physicist assumed that the yardstick, the scales, and the clock gave correct answers. Einstein's theory became an international sensation because it applied the concept of relativity to the exact science of physics. He became known as the man who had slowed down the clocks, shrunk the yardsticks, and changed the scales. His reputation grew as, one after another, his theories were proved in the laboratories of other scientists.

11 One of the most familiar examples of relativity is that of moving objects: to a passenger on a moving train, the seats and other furnishings in the interior of the railroad car appear stationary, while the landscapes outside seem to whiz past; but to a farmer plowing a field near the tracks, it is the train that hurtles by, and the trees that stand still. As the train speeds on at sixty miles per hour, the earth is circling the sun; simultaneously the entire solar system is moving in the direction of a remote star. A person standing on the sun and looking through a giant telescope would observe the earth and the train moving below; another observer on the nearest fixed star, four light-years away, would four years later see the sun, the earth, and the moving train traveling together through space, all these motions being relative to the position of the observer.

12 If motion through space is relative, what about relativity of time? Every physical object has three dimensions, but inasmuch as everything actually moves and changes, the world actually exists in three dimensions of space plus a fourth dimension—the fourth dimension being, according to Einstein's theory, time. In the universe he has hypothesized, neither time nor space continues indefinitely; both change relative to the position and traveling rate of the observer.

13 We compute days by the earth's revolution on its axis, and years by the earth's annual journey round the sun; because Jupiter, for example, takes longer to circle the sun, a year on Jupiter is longer than a year on earth. In frontier days, it took a covered wagon a year to complete the three-thousand-mile journey from San Francisco to New York City; today a jet plane crosses the continent in less than five hours. If we could accomplish the impossible and travel with the speed of light, there would be no time—everything would happen at once. As we approached the incredible speed of light, not only our watches but our pulses would slow down; even the whirling electrons inside the atom would move increasingly slower. If we could travel faster than light we could actually move backward in time like the heroine of the popular limerick:

There was a young lady named Bright
Whose speed was faster than light;
She set out one day
In a relative way
And returned home the previous night!

14 It was once believed that matter and energy were completely different, that matter was something solid, like rock, whereas energy measured how rapidly an object moved or what it could do. Einstein demonstrated that actually there is an exceedingly close relation between matter and energy; the electron that moves with half the speed of light has terrific energy because it moves so rapidly, and this motion increases its weight, for the energy has been converted into matter.

15 Of enormous consequence is the fact that matter can also be converted into energy. Einstein was actually able to give a measurement for the amount of energy that is contained in any particle of matter; his famous formula is $E = mc^2$, E referring to energy, m standing for mass (or the weight of the matter), and c^2 referring to the speed of light multiplied by itself. Thus Einstein's formula signifies that the energy in every piece of matter equals the mass or weight of the

matter multiplied by the speed of light times the speed of light.

16 The speed of light is 186,300 miles per second; multiply this figure by itself and you will have some conception of what a prodigious amount of energy can be extracted from a minute piece of matter.

17 One striking application of Einstein's astounding formula is in explaining the mystery of how the sun has been able to distribute light and heat to the solar system for billions of years without burning itself out: some of the sun's atoms are constantly being transformed into energy. Another application is the atomic bomb, which by releasing the energy contained in matter ushered in the nuclear age.

HOW WELL DID YOU READ?

Did you see the reasons?

1. **Michelson and Morley were baffled because their measurements**
   A varied from one experiment to another
   B contradicted an accepted fact
   C indicated that light did not move
   D disagreed with those obtained by others

2. **Einstein demonstrated that the Americans had difficulty because they**
   A did not have a precise enough apparatus
   B tried to measure something that cannot be measured in experiments
   C did not make enough measurements
   D used a wrong figure in their calculations

Did you understand the important facts?

3. **According to Einstein's theory, everything in the universe is**
   A constantly in motion
   B absolutely fixed
   C motionless under some conditions
   D moving at the speed of light

4. **Einstein's theory startled physicists because**
   A they had not known the concept of relativity
   B they had never thought of physics as an exact science
   C their yardsticks and scales became useless
   D they learned that measurements could not be absolute

5. **If one could travel at the speed of light, time would**
   A be the only fixed quantity
   B repeat itself
   C pass very rapidly
   D cease to exist

Did you understand what you read?

6. **The four dimensions Einstein hypothesized are**
   A length, width, depth, time
   B space, speed, light, depth
   C energy, matter, mass, speed
   D time, space, energy, matter

7. **The limerick in paragraph 13 is intended to**
   A describe an event that might well happen
   B point up a basic flaw in Einstein's theory
   C present a ludicrous distortion of the theory of relativity
   D clarify a single part of Einstein's theory

Can you draw the right conclusions?

8. **According to Einstein's theory about matter and energy, a fast-moving baseball has**
   A more weight than a slow-moving one
   B less weight than an unmoving one
   C less energy than a slow-moving one
   D none of the above

9. **The fact that matter can be converted into energy explains**
   A how the atomic bomb releases energy
   B why the sun has not burned out
   C both **A** and **B**
   D neither **A** nor **B**

10. **The author probably believes that the average person**
   A has a duty to learn about scientific discoveries
   B should leave science to the scientists
   C has held back science through indifference
   D can contribute to scientific knowledge

LEARN ABOUT WORDS

A. Often you can tell the meaning of a word from its context—the words around it.

Directions: Find the word in the paragraph that means

1. discerning *(6)*
2. tending toward drastic change *(7)*
3. clever; original *(7)*
4. noticeable *(8)*
5. incapable of being disproved *(8)*
6. frustrating; puzzling *(8)*
7. exceedingly small *(9)*
8. at the same time *(11)*
9. theorized; supposed *(12)*
10. enormous *(16)*

B. A word may have more than one meaning. Its meaning depends on the way it is used.

Directions: Decide which meaning fits the word as it is used in the paragraph. Write the letter that stands before the meaning you choose.

11. issue *(3)*
    A question
    B publication
    C offspring

12. anticipated *(8)*
    A done in advance
    B expected
    C prevented

13. remote *(11)*
    A distant
    B slight
    C secluded

14. position *(11)*
    A posture
    B location
    C opinion

15. extracted *(16)*
    A selected
    B extorted
    C derived

C. *esce* (to become)
escent (beginning to be; in the process of)
escence (a becoming; state of becoming)

A knowledge of these **suffixes** will provide you with a key to the meaning of many unfamiliar words.

Directions: Use the suffix *-esce, -escent,* or *-escence* to complete each word so that it fits the definition. Write the word.

16. adol_____ (in the process of becoming an adult)
17. adol_____ (state of becoming an adult)
18. coal_____ (grow together)
19. lumin_____ (state of giving off light)
20. lumin_____ (in the process of giving off light)
21. conval_____ (in the process of recovering from an illness)
22. conval_____ (become well)
23. conval_____ (period of recovery from an illness)
24. obsol_____ (in the process of becoming out of date)
25. evan_____ (state of vanishing)

D. Figures of speech are used to make language richer and more vivid. Two devices that are often used to add color to language are **hyperbole** and **understatement.** Hyperbole is exaggeration for effect, not meant to be taken literally: "This rock is as old as time." Understatement is the opposite of hyperbole; it minimizes for effect: "This rock has been around for a few years."

Directions: These statements and quotations are either hyperbole or understatement. Write *hyperbole* or *understatement* for each.

26. It is not very courteous to poison a guest.
27. Every other building in New York City is a skyscraper.
28. "The English winter—ending in July,
    To recommence in August . . ."
29. "Boston State-House is the hub of the solar system."
30. "God made the wicked Grocer
    For a mystery and a sign
    That men might shun the awful shop
    And go to inns to dine."
31. London is a village of some size.
32. "A thousand apologies for the intrusion."
33. My sore throats are always worse than anyone's.