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Scientists as People

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SCIENTISTS AS PEOPLE

by James Brennan

What kind of people are scientists and how do they think?

From our first course in science, we begin to learn about the "scientific method" as if it were some sort of magical technique. We are told that a scientist must first make observations, then formulate an hypothesis, design and conduct experiments to test the hypothesis (to test it, not to prove it), construct a theory supported by adequate experimental or observational proof, and finally, if there is adequate support from many sources of evidence, add another principle to the discipline. Yet there are few, if any, scientists in my experience who think much about such a structured procedure in their work. The so-called scientific method is more often found in general textbooks than as a consciously utilized technique.

Certainly scientists observe natural phenomena around them, and anyone who is curious about natural phenomena is almost bound to begin to speculate about the underlying causes. It is usually wise for a person formulating hypotheses about observed phenomena to preface such guesses with, "Intuitively, it looks to me like . . . ," for intuition is a significant and valuable part of the process. The scientist with a good mind and good background can run the new observations through a vast mental array of similar and dissimilar related events and make well-educated guesses about the mechanisms involved.

Scientists then are analytical in their manner of thinking. Probably without realizing it, they observe the nature of things in a new situation, hypothesize intuitively, and begin to devise experiments to test their ideas.

Obviously, to use this method of analysis, a scientist must have a large amount of current information available for comparison with each new idea. Scientists must relate, interrelate, index, cross-index, and file away in the brain the multitude of abstractions that are the tools of the trade. If such people seem preoccupied or distant from everyday matters, there may be a reason.

Only an immature or non-practicing scientist, or maybe even a pseudoscientist views a scientific discipline as immutable. The inherent tentative nature of science requires an unusual state of mind. The so-called "facts" of science are really only temporary points of reference: viewed from another angle or under different conditions, they may prove to be something much different than originally thought. Scientists, alert to this situation, know that they must occasionally reject basic tenets in their knowledge and replace them with new ones.

In writing style, scientists may even be more distinctive than in the other characteristics we have come to associate with them. Sentences are short, clipped, and to the point; every word is precise and meaningful. In non-scientific literature, English is often redundant and somewhat wasteful. A missed word here or there or the wrong letter in a word seldom causes any misreading or misunderstanding. However, the labels, terms, and statements of the scientist can assume exactly opposite meanings with misplaced or substituted symbols.

Scientific publications follow a strict pattern of arrangement into categories. Sometimes the traditions of past work are the only significant reason for the organization of a research report. Scientists are extremely careful to avoid any hypothesizing or interpreting in sections that report their results. Methods and materials are always listed in enough detail to permit reproduction in another lab. Precedence of publication date means everything in assigning credit for discovery, and young scientists are usually in a hurry, to prevent being "scooped."

A dual categorization of scientists according to their roles might reveal two groups that could be labeled "fact gatherers" and "synthesizers." The overwhelming number of scientists are fact gatherers -- the real laborers of the trade. The synthesizers are widely recognized as especially skilled, with an ability to view a broad perspective, tying together the tiny bits and pieces contributed by hundreds of workers. It is the synthesizers who are able to see major threads and then formulate the broad principles of a science. They are a rare breed and only a handful can be listed as active in a field at any given time. Two of history's most eminent biologists, Mendel and Darwin, may serve as examples of the "fact gatherer" and the "synthesizer."

The overwhelming number of scientists are fact gatherers . . .

Synthesizers formulate the broad principles of a science.

The theories of heredity and evolution were proposed to the scientific world in the mid-1800s in Europe. While these theories were tentatively based on small amounts of evidence at the time, they have both been well supported by a great many observations since then. Data supporting the theories of heredity and evolution would have been mutually supportive at the time, but their discoverers were apparently unaware of, or uninterested in, one another's work.

Charles Darwin

The backgrounds and training of Darwin and Mendel were very different, and, partly as a result, the circumstances surrounding their discoveries were quite different.

Charles Darwin was born into an aristocratic English family. Both his father and grandfather were respected physicians, while his mother was a member of the Wedgewood family (of pottery fame). He was groomed to be a medical doctor also, but was notably uninterested in the profession. Furthermore, in his first year at Edinburgh, he ran from a surgical demonstration, appalled at the sight. His university education was subsequently completed at Cambridge in studies for the ministry. While at Cambridge he developed an interest in nature studies under the influence of Professor John Henslow. As a result of this interest and the connections of Henslow, he was steered away from a career as a small country church parson.

Shortly after graduation from Cambridge, he accepted a non-paying position as naturalist aboard the H.M.S. Beagle on a five-year trip around the world. He left England as a novice, but returned an accomplished naturalist. Somewhere along the way he also made the subtle change from naturalist to scientist. For several years after his return, he continued to catalog and identify his specimens in the style of a naturalist, but fermenting in his mind was the momentous theory of evolution.

Gregor Mendel, in contrast, was born into the family of a peasant farmer in what is now Czechoslovakia. There were no great expectations for a professional career in his case, but he did show exceptional aptitude in his early schooling and thus went on to further education along the only route open to him -- the priesthood. Where Darwin failed to become a minister, Mendel succeeded, but his intellectual attributes led him to a life of teaching, rather than the pastoral duties of most priests. In a fashion reminiscent of Darwin's revulsion at surgery, Mendel was repelled by the sickroom and deathbed duties common to clerics.

Both Darwin and Mendel showed great curiosity about natural phenomena; in fact, their curiosity was clearly the driving force in their selection of careers. In specific aptitudes, they were quite different, but in a general way they both showed the mental ability we might expect of scientists capable of understanding significant theories. Their minds filled with well-organized information, they were capable of analyzing carefully, using their intuition to establish important facts, while providing a well-thought-out explanation.

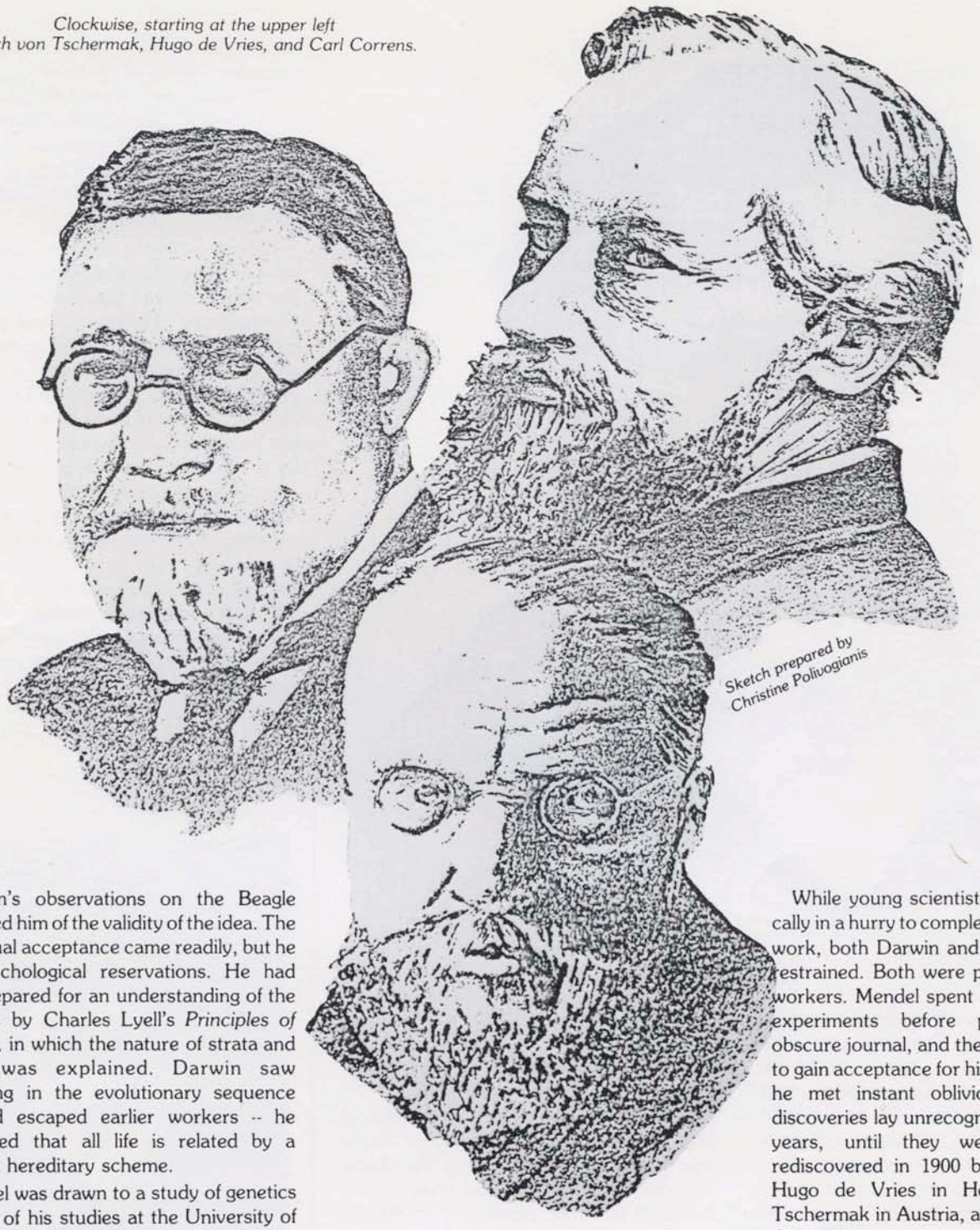
Darwin's interest and aptitude were specifically in the area of biological observations. As a naturalist, he was a collector of immense numbers of specimens of different kinds of organisms. Astute at identifying slight differences and subtle relationships, he was able to see the significance of changing forms through time. Mendel, on the other hand, had a bent for mathematics and physics, in spite of his extensive background in practical biology on the farm. He was able to apply numerical analysis to living things in an unusual fashion.

An interesting and often overlooked aspect of both men's careers is that the general source of their ideas is probably essentially the same. The facts which they revealed are credited to them, but the intellectual atmosphere of the time provided the material that influenced both of them.

The idea of changing life through vast expanses of time on the planet had been proposed by many before Darwin. In many ways it was unacceptable, contrary as it appeared to be to the Biblical story of creation. Even those scientists who could reject their prior teachings as weakly grounded, in fact, could find no sound scientific hypotheses about the mechanism to lend credence to the idea. Neither were experiments possible nor observations solid enough to support it.

Gregor Mendel

Clockwise, starting at the upper left
Erich von Tschermak, Hugo de Vries, and Carl Correns.



Sketch prepared by Christine Polivogianis

Darwin's observations on the Beagle convinced him of the validity of the idea. The intellectual acceptance came readily, but he had psychological reservations. He had been prepared for an understanding of the evidence by Charles Lyell's *Principles of Geology,* in which the nature of strata and fossils was explained. Darwin saw something in the evolutionary sequence that had escaped earlier workers -- he recognized that all life is related by a common hereditary scheme.

Mendel was drawn to a study of genetics because of his studies at the University of Vienna. There Franz Unger was teaching in the 1850s that plant species were not fixed, but had developed gradually, step by step; in other words, through evolution. The evidence suggests that Mendel was experimenting to test Unger's thesis that variants arise during hybridization. In the final analysis his studies led to an understanding of the basic mechanism of heredity in sexually reproducing organisms.

All of the characteristics of the successful scientist are present in Mendel and Darwin, but it is doubtful that anyone could have picked them from a group of people as scientists -- much less as contributors of immense stature in the history of biology.

Past Teaching and childhood beliefs are difficult to question . . .

While young scientists are characteristically in a hurry to complete and publish their work, both Darwin and Mendel were very restrained. Both were painstaking, careful workers. Mendel spent seven years on his experiments before publishing in an obscure journal, and then he never pushed to gain acceptance for his ideas. As a result, he met instant oblivion and his great discoveries lay unrecognized for thirty-four years, until they were independently rediscovered in 1900 by three biologists: Hugo de Vries in Holland, Erich von Tschermak in Austria, and Carl Correns in Germany.

Could his failure to impress the world have been due to his mathematical orientation? Was his work too abstract for a biological audience? Darwin's work was more concrete -- it implied that humans were related to monkeys and it caused quite a splash.

Darwin was even more reserved in his approach to publishing his ideas. By 1838, just three years after the Beagle trip, he had established the rudiments of the theory of natural selection in his mind and could cite convincing evidence in its support. However, he did not commit it to writing for

Sketch prepared by Christine Poliyogianis

Alfred Wallace

at least two years and then he set down only a sketchy outline. Over the years, he continued to add a huge amount of supporting evidence and expanded the draft of his treatise. He wrote the first draft of somewhat more than two hundred pages in 1842. Fearful of the consequences of its publication, he deposited a sum of money with his wife for its posthumous publication. Darwin's study might not have been published at all if it had not been for one of those unusual coincidences of intellectual activity. In 1858, twenty years after the idea first came to Darwin, Alfred Wallace, another widely travelled naturalist, sent a brief paper to Darwin for review. In it he outlined exactly the same theory of natural selection as a mechanism for evolution as Darwin was proposing. This prompted immediate joint publication by Darwin and Wallace. As was the case with Mendel's work, the joint paper caused very little stir. In the following year, after intensive work to shorten and finish the writing he had started in 1842, Darwin published *The Origin of Species by Means of Natural Selection*. Immediate and widespread controversy was the result, and the debate continues today in many quarters.

In the final analysis, Darwin and Mendel may exemplify that rebellious trait that is one of the last to develop in the young scientist. In truth, some never cross this last hurdle. It is usually possible to accept the uncomfortable view that all scientific facts and principles are mutable, even though such acceptance often arrives late in a career. Past teaching and childhood beliefs are difficult to question, however, and it may be impossible to recognize their source as superstitions. Darwin and Mendel did not make the turn totally gracefully nor without creating concerns among those around them. Mendel's work was essentially noncontroversial, although there is some feeling that the hierarchy in the Augustinian order were concerned about his research topics. Had the significance of his work been more widely recognized, trouble might have developed. Mendel hid himself among his administrative duties as Abbot of the Monastery at Brno. Upon his death, his successor burned all his research records. Likewise, Darwin remained almost a recluse in his home in Kent in a state of ill health that very possibly was hypochondria. Just as he had no stomach for surgery, he never became comfortable with his role in the creation controversy.

Contemporary scientists have been known to complain that all of the easy work has been done and that there is little hope for significant discoveries. And yet great advances and astounding phenomena are announced regularly. There is no less curiosity than in the time of Darwin and Mendel. Neither of these great thinkers set out to make a revolutionary study. Both were careful, deliberate masters of observation and analysis. Both wanted to be correct. Clearly both thought it was more important to be knowledgeable than it was to be thought of as knowledgeable. Among the legions of people contributing ideas and information to scientific studies today, there are surely unrecognized persons whose work will stand out for its great significance in the future.

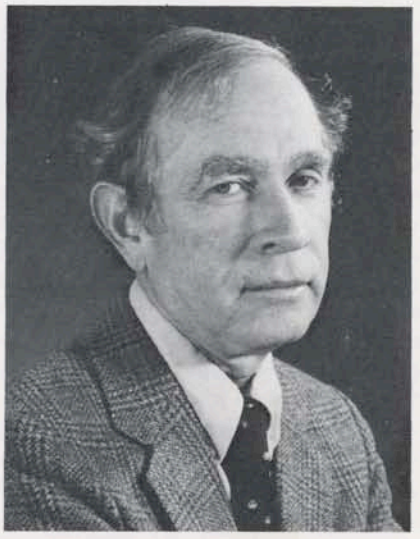


Photo by Robert Ward

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