FACT AND FANCY

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DOUBLEDAY & COMPANY, INC.
GARDEN CITY, NEW YORK

LIBRARY OF CONGRESS CATALOG CARD NUMBER 62-7598

PRINTED IN THE UNITED STATES OF AMERICA

15 *Those Crazy Ideas*

Time and time again I have been asked (and I'm sure others who have, in their time, written science fiction have been asked too): "Where do you get your crazy ideas?"

Over the years, my answers have sunk from flattered confusion to a shrug and a feeble smile. Actually, I don't really know, and the lack of knowledge doesn't really worry me, either, as long as the ideas keep coming.

But then some time ago, a consultant firm in Boston, engaged in a sophisticated space-age project for the government, got in touch with me.

What they needed, it seemed, to bring their project to a successful conclusion were novel suggestions, startling new principles, conceptual breakthroughs. To put it into the nutshell of a well-turned phrase, they needed "crazy ideas."

Unfortunately, they didn't know how to go about getting crazy ideas, but some among them had read my science fiction, so they looked me up in the phone book and called me to ask (in essence), "Dr. Asimov, where do you get your crazy ideas?"

Alas, I still didn't know, but as speculation is my profession, I am perfectly willing to think about the matter and share my thoughts with you.

The question before the house, then, is: How does one go about creating or inventing or dreaming up or stumbling over a new and revolutionary scientific principle?

For instance—to take a deliberately chosen example—how did Darwin come to think of evolution?

To begin with, in 1831, when Charles Darwin was twenty-two, he joined the crew of a ship called the *Beagle*. This ship was making a five-year voyage about the world to explore various coast lines and to increase man's geographical knowledge. Darwin went along as ship's naturalist, to study the forms of life in far-off places.

This he did extensively and well, and upon the return of the *Beagle* Darwin wrote a book about his experiences (published in 1840) which made him famous. In the course of this voyage, numerous observations led him to the conclusion that species of living creatures changed and developed slowly with time; that new species descended from old. This, in itself was not a new idea. Ancient Greeks had had glimmerings of evolutionary notions. Many scientists before Darwin, including Darwin's own grandfather, had theories of evolution.

The trouble, however, was that no scientist could evolve an explanation for the *why* of evolution. A French naturalist, Jean Baptiste de Lamarck, had suggested in the early 1800s that it came about by a kind of conscious effort or inner drive. A tree-grazing animal, attempting to reach leaves, stretched its neck over the years and transmitted a longer neck to its descendants. The process was repeated with each generation until a giraffe in full glory was formed.

The only trouble was that acquired characteristics are not inherited and this was easily proved. The Lamarckian explanation did not carry conviction.

Charles Darwin, however, had nothing better to suggest after several years of thinking about the problem.

But in 1798, eleven years before Darwin's birth, an English clergyman named Thomas Robert Malthus, had written a book entitled *An Essay on the Principle of Population.* In this book Malthus suggested that the human population always increased faster than the food supply and that the population had to be cut down by either starvation, disease, or war; that these evils were therefore unavoidable.

In 1838 Darwin, still puzzling over the problem of the development of species, read Malthus's book. It is hackneyed to say "in a flash" but that, apparently, is how it happened. In a flash, it was clear to Darwin. Not only human beings increased faster than the food supply; all species of living things did. In every case, the surplus population had to be cut down by starvation, by predators, or by disease. Now no two members of any species are exactly alike; each has slight individual variations from the norm. Accepting this fact, which part of the population was cut down?

Why—and this was Darwin's breakthrough—those members of the species who were less efficient in the race for food, less adept at fighting off or escaping from predators, less equipped to resist disease, went down.

The survivors, generation after generation, were better adapted, on the average, to their environment. The slow changes toward a better fit with the environment accumulated until a new (and more adapted) species had replaced the old. Darwin thus postulated the reason for evolution as being the action of *natural selection.* In fact, the full title of his book is *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.* We just call it *The Origin of Species* and miss the full flavor of what it was he did.

It was in 1838 that Darwin received this flash and in 1844 that he began writing his book, but he worked on for fourteen years gathering evidence to back up his thesis. He was a methodical perfectionist and no amount of evidence seemed to satisfy him. He always wanted more. His friends read his preliminary manuscripts and urged him to publish. In particular, Charles Lyell (whose book *Principles of Geology*, published in 1830–1833, first convinced scientists of the great age of the earth and thus first showed there was *time* for the slow progress of evolution to take place) warned Darwin that someone would beat him to the punch.

While Darwin was working, another and younger English naturalist, Alfred Russel Wallace, was traveling in distant lands. He too found copious evidence to show that evolution took place and he too wanted to find a reason. He did not know that Darwin had already solved the problem.

He spent three years puzzling, and then in 1858, he too came across Malthus's book and read it. I am embarrassed to have to become hackneyed again, but in a flash he saw the answer. Unlike Darwin, however, he did not settle down to fourteen years of gathering and arranging evidence.

Instead, he grabbed pen and paper and at once wrote up his theory. He finished this in two days.

Naturally, he didn't want to rush into print without having his notions checked by competent colleagues, so he decided to send it to some well-known naturalist. To whom? Why, to Charles Darwin. To whom else?

I have often tried to picture Darwin's feeling as he read Wallace's essay which, he afterward stated, expressed matters in almost his own words. He wrote to Lyell that he had been forestalled "with a vengeance."

Darwin might easily have retained full credit. He was well-known and there were many witnesses to the fact that he had been working on his project for a decade and a half. Darwin, however, was a man of the highest integrity. He made no attempt to suppress Wallace. On the contrary, he passed on the essay to others and arranged to have it published along with a similar essay of his own. The year after, Darwin published his book.

Now the reason I chose this case was that here we have two men making one of the greatest discoveries in the history of science independently and simultaneously and under precisely the same stimulus. Does that mean *anyone* could have worked out the theory of natural selection if they had but made a sea voyage and combined that with reading Malthus?

Well, let's see. Here's where the speculation starts.

To begin with, both Darwin and Wallace were thoroughly grounded in natural history. Each had accumulated a vast collection of facts in the field in which they were to make their breakthrough. Surely this is significant.

Now every man in his lifetime collects facts, individual pieces of data, items of information. Let's call these "bits" (as they do, I think, in information theory). The "bits" can be of all varieties: personal memories, girls' phone numbers, baseball players' batting averages, yesterday's weather, the atomic weights of the chemical elements.

Naturally, different men gather different numbers of different varieties of "bits." A person who has collected a larger number than usual of those varieties that are held to be particularly difficult to obtain—say, those involving the sciences and the liberal arts—is considered "educated."

There are two broad ways in which the "bits" can be accumulated. The more common way, nowadays, is to find people who already possess many "bits" and have them transfer those "bits" to your mind in good order and in predigested fashion. Our schools specialize in this transfer of "bits" and those of us who take advantage of them receive a "formal education."

The less common way is to collect "bits" with a minimum amount of live help. They can be obtained from books or out of personal experience. In that case you are "self-educated." (It often happens that "self-educated" is confused with "uneducated." This is an error to be avoided.)

In actual practice, scientific breakthroughs have been initiated by those who were formally educated, as for instance by Nicolaus Copernicus, and by those who were self-educated, as for instance by Michael Faraday.

To be sure, the structure of science has grown more complex over the years and the absorption of the necessary number of "bits" has become more and more difficult without the guidance of someone who has already absorbed them. The self-educated genius is therefore becoming rarer, though he has still not vanished.

However, without drawing any distinction according to the manner in which "bits" have been accumulated, let's set up the first criterion for scientific creativity:

1) The creative person must possess as many "bits" of information as possible; i.e. he must be educated.

Of course, the accumulation of "bits" is not enough in itself. We have probably all met people who are intensely educated, but who manage to be abysmally stupid, nevertheless. They have the "bits", but the "bits" just lie there.

But what is there one can do with "bits"?

Well, one can combine them into groups of two or more. Everyone does that; it is the principle of the string on the finger. You tell yourself to remember *a* (to buy bread) when you observe *b* (the string). You enforce a combination that will not let you forget *a* because *b* is so noticeable.

That, of course, is a conscious and artificial combination of "bits." It is my feeling that every mind is, more or less unconsciously, continually making all sorts of combinations and permutations of "bits," probably at random.

Some minds do this with greater facility than others; some minds have greater capacity for dredging the combinations out of the unconscious and becoming consciously aware of them. This results in "new ideas", in "novel outlooks."

The ability to combine "bits" with facility and to grow consciously aware of the new combinations is, I would like to suggest, the measure of what we call "intelligence." In this view, it is quite possible to be educated and yet not intelligent.

Obviously, the creative scientist must not only have his "bits" on hand but he must be able to combine them readily and more or less consciously. Darwin not only observed data, he also made deductions—clever and far-reaching deductions —from what he observed. That is, he combined the "bits" in interesting ways and drew important conclusions.

So the second criterion of creativity is:

2) The creative person must be able to combine "bits" with facility and recognize the combinations he has formed; i.e. he must be *intelligent.*

Even forming and recognizing new combinations is insufficient in itself. Some combinations are important and some are trivial. How do you tell which are which? There is no question but that a person who cannot tell them apart must labor under a terrible disadvantage. As he plods after each possible new idea, he loses time and his life passes uselessly.

There is also no question but that there are people who somehow have the gift of seeing the consequences "in a flash" as Darwin and Wallace did; of feeling what the end must be without consciously going through every step of the reasoning. This, I suggest, is the measure of what we call "intuition."

Intuition plays more of a role in some branches of scientific knowledge than others. Mathematics, for instance, is a deductive science in which, once certain basic principles are learned, a large number of items of information become "obvious" as merely consequences of those principles. Most of us, to be sure, lack the intuitive powers to see the "obvious."

To the truly intuitive mind, however, the combination of the few necessary "bits" is at once extraordinarily rich in consequences. Without too much trouble they see them all, including some that have not been seen by their predecessors.[1]

It is perhaps for this reason that mathematics and mathematical physics has seen repeated cases of first-rank break-

[1] The Swiss mathematician, Leonhard Euler, said that to the true mathematician, it is at once obvious that $e^{\pi i} = -1$.

throughs by youngsters. Evariste Galois evolved group theory at twenty-one. Isaac Newton worked out calculus at twenty-three. Albert Einstein presented the theory of relativity at twenty-six, and so on.

In those branches of science which are more inductive and require larger numbers of "bits" to begin with, the average age of the scientists at the time of the breakthrough is greater. Darwin was twenty-nine at the time of his flash, Wallace was thirty-five.

But in any science, however inductive, intuition is necessary for creativity. So:

3) The creative person must be able to see, with as little delay as possible, the consequences of the new combinations of "bits" which he has formed; i.e. he must be intuitive.

But now let's look at this business of combining "bits" in a little more detail. "Bits" are at varying distances from each other. The more closely related two "bits" are, the more apt one is to be reminded of one by the other and to make the combination. Consequently, a new idea that arises from such a combination is made quickly. It is a "natural consequence" of an older idea, a "corollary." It "obviously follows."

The combination of less related "bits" results in a more startling idea; if for no other reason than that it takes longer for such a combination to be made, so that the new idea is therefore less "obvious." For a scientific breakthrough of the first rank, there must be a combination of "bits" so widely spaced that the random chance of the combination being made is small indeed. (Otherwise, it will be made quickly and be considered but a corollary of some previous idea which will then be considered the "breakthrough.")

But then, it can easily happen that two "bits" sufficiently widely spaced to make a breakthrough by their combination are not present in the same mind. Neither Darwin nor Wallace, for all their education, intelligence, and intuition, possessed the key "bits" necessary to work out the theory of evolution by natural selection. Those "bits" were lying in Malthus's book, and both Darwin and Wallace had to find them there.

To do this, however, they had to read, understand, and appreciate the book. In short, they had to be ready to incorporate other people's "bits" and treat them with all the ease with which they treated their own.

It would hamper creativity in other words, to emphasize intensity of education at the expense of broadness. It is bad enough to limit the nature of the "bits" to the point where the necessary two would not be in the same mind. It would be fatal to mold a mind to the point where it was incapable of accepting "foreign bits."

I think we ought to revise the first criterion of creativity, then, to read:

1) The creative person must possess as many "bits" as possible, falling into as wide a variety of types as possible; i.e. he must be broadly educated.

As the total amount of "bits" to be accumulated increases with the advance of science, it is becoming more and more difficult to gather enough "bits" in a wide enough area. Therefore, the practice of "brain-busting" is coming into popularity; the notion of collecting thinkers into groups and hoping that they will cross-fertilize one another into startling new breakthroughs.

Under what circumstances could this conceivably work? (After all, anything that will stimulate creativity is of first importance to humanity.)

Well, to begin with, a group of people will have more "bits" on hand than any member of the group singly since each man is likely to have some "bits" the others do not possess.

However, the increase in "bits" is not in direct proportion to the number of men, because there is bound to be considerable overlapping. As the group increases, the smaller and smaller addition of completely new "bits" introduced by each additional member is quickly outweighed by the added tensions involved in greater numbers; the longer wait to speak, the greater likelihood of being interrupted, and so on. It is my (intuitive) guess that five is as large a number as one can stand in such a conference.

Now of the three criteria mentioned so far, I feel (intuitively) that intuition is the least common. It is more likely that none of the group will be intuitive than that none will be intelligent or none educated. If no individual in the group is intuitive, the group as a whole will not be intuitive. You cannot add non-intuition and form intuition.

If one of the group is intuitive, he is almost certain to be intelligent and educated as well, or he would not have been asked to join the group in the first place. In short, for a brainbusting group to be creative, it must be quite small and it must possess at least one creative individual. But in that case, does that one individual need the group? Well, I'll get back to that later.

Why did Darwin work fourteen years gathering evidence for a theory he himself must have been convinced was correct from the beginning? Why did Wallace send his manuscript to Darwin first instead of offering it for publication at once?

To me it seems that they must have realized that any new idea is met by resistance from the general population who, after all, are not creative. The more radical the new idea, the greater the dislike and distrust it arouses. The dislike and distrust aroused by a first-class breakthrough are so great that the author must be prepared for unpleasant consequences (sometimes for expulsion from the respect of the scientific community; sometimes, in some societies, for death).

Darwin was trying to gather enough evidence to protect himself by convincing others through a sheer flood of reasoning. Wallace wanted to have Darwin on his side before proceeding.

It takes courage to announce the results of your creativity.

The greater the creativity, the greater the necessary courage in much more than direct proportion. After all, consider that the more profound the breakthrough, the more solidified the previous opinions; the more "against reason" the new discovery seems; the more against cherished authority.

Usually a man who possesses enough courage to be a scientific genius seems odd. After all, a man who has sufficient courage or irreverence to fly in the face of reason or authority *must* be odd, if you define "odd" as "being not like most people." And if he is courageous and irreverent in such a colossally big thing, he will certainly be courageous and irreverent in many small things so that being odd in one way, he is apt to be odd in others. In short, he will seem to the non-creative, conforming people about him to be a "crackpot."

So we have the fourth criterion:

4) The creative person must possess courage (and to the general public may, in consequence, seem a crackpot).

As it happens, it is the crackpottery that is most often most noticeable about the creative individual. The eccentric and absent-minded professor is a stock character in fiction; and the phrase "mad scientist" is almost a cliché.

(And be it noted that I am never asked where I get my interesting or effective or clever or fascinating ideas. I am invariably asked where I get my *crazy* ideas.)

Of course, it does not follow that because the creative individual is usually a crackpot, that any crackpot is automatically an unrecognized genius. The chances are low indeed, and failure to recognize that the proposition cannot be so reversed is the cause of a great deal of trouble.

Then, since I believe that combinations of "bits" take place quite at random in the unconscious mind, it follows that it is quite possible that a person may possess all four of the criteria I have mentioned in superabundance and yet may never happen to make the necessary combination. After all, suppose Darwin had never read Malthus. Would he ever have thought of natural selection? What made him pick up the copy? What if someone had come in at the crucial time and interrupted him?

So there is a fifth criterion which I am at a loss to phrase in any other way than this:

5) A creative person must be lucky.

To summarize:

A creative person must be 1) broadly educated, 2) intelligent, 3) intuitive, 4) courageous, and 5) lucky.

How, then, does one go about encouraging scientific creativity? For now, more than ever before in man's history, we must; and the need will grow constantly in the future.

Only, it seems to me, by increasing the incidence of the various criteria among the general population.

Of the five criteria, number 5 (luck) is out of our hands. We can only hope; although we must also remember Louis Pasteur's famous statement that "Luck favors the prepared mind." Presumably, if we have enough of the four other criteria, we shall find enough of number five as well.

Criterion 1 (broad education) is in the hands of our school system. Many educators are working hard to find ways of increasing the quality of education among the public. They should be encouraged to continue doing so.

Criterion 2 (intelligence) and 3 (intuition) are inborn and their incidence cannot be increased in the ordinary way. However, they can be more efficiently recognized and utilized. I would like to see methods devised for spotting the intelligent and intuitive (particularly the latter) early in life and treating them with special care. This, too, educators are concerned with.

To me, though, it seems that it is criterion 4 (courage) that receives the least concern, and it is just the one we may most easily be able to handle. Perhaps it is difficult to make a person more courageous than he is, but that is not necessary. It would be equally effective to make it sufficient to be less courageous; to adopt an attitude that creativity is a permissible activity.

Does this mean changing society or changing human nature? I don't think so. I think there are ways of achieving the end that do not involve massive change of anything, and it is here that brain-busting has its greatest chance of significance.

Suppose we have a group of five that includes one creative individual. Let's ask again what that individual can receive from the non-creative four?

The answer to me, seems to be just this: Permission!

They must permit him to create. They must tell him to go ahead and be a crackpot.[2]

How is this permission to be granted? Can four essentially non-creative people find it within themselves to grant such permission? Can the one creative person find it within himself to accept it?

I don't know. Here, it seems to me, is where we need experimentation and perhaps a kind of creative breakthrough about creativity. Once we learn enough about the whole matter, who knows—I may even find out where I get those crazy ideas.

[2] Always with the provision of course, that the crackpot creation that results survives the test of hard inspection. Though many of the products of genius seem crackpot at first, very few of the creations that seem crackpot turn out, after all, to be products of genius. I shall go into that aspect of the matter in the next chapter.