some benefit from the very outset will progressively add to the enjoyment of his research.

5. Today I do not subscribe unreservedly to this mechanistic concept, nor do I adhere strictly to the physicochemical interpretation of life. The origin and morphology of cells and organs, heredity, evolution, and so on include phenomena that depend on incomprehensible absolute causes, notwithstanding the vaunted promise of Darwinism and the postulates of Loeb's school of biochemistry.

5 Diseases of the Will

Contemplators. Bibliophiles and polyglots. Megalomaniacs. Instrument addicts. Misfits. Theorists

We have all seen teachers who are wonderfully talented and full of energy and initiative—with ample facilities at their disposal—who never produce any original work and almost never write anything. Their students and admirers wait anxiously for the masterpiece worthy of the lofty opinion they have formed of the teacher. But the great work is never written, and the teacher remains silent.

Let us not be deceived by optimism and good intentions. Despite their exceptional merit, and the zeal and energy they display in the classroom, such teachers suffer from a disease of the will—although psychologists may not see it this way. Their sluggishness and neglect may not justify a diagnosis of abulia or loss of will power, but their students and friends may nevertheless consider them abnormal and suggest some adequate form of spiritual therapy, with all due respect to their fine intellectual abilities.

These illustrious failures may be classified in the following way: *the dilettantes or contemplators; the erudite or bibliophiles; the instrument addicts; the megalomaniacs; the misfits;* and *the theory builders.*

Contemplators

In this particularly morbid variety we may find astronomers, naturalists, chemists, biologists, and physicians who can be recognized by the following symptom: they love the study of nature but only for its aesthetic qualities—the sublime spectacles, the beautiful forms, the splendid colors, and the graceful structures. If the dilettante is a botanist, he will be anchored forever in the wonder of algae, and especially the diatoms, whose elegant shells capture his admiration. In his fetishistic worship, days pass examining and photographing these interesting creatures in a thousand different ways, arranging them into symbols, fretwork, escutcheons, and other ornamental designs. However, he will never add a new variety to the overflowing catalog of known species, or contribute in the slightest way to our knowledge of the structure, development, and function of these microorganisms.

If the sybarite researcher is a histologist, he will dedicate himself with zeal to the art of producing flashy staining patterns for cells and organic tissues. He will handle the microinjection syringe with ease, and in his naive admiration for the picturesque he will pass his evenings tracing the elegant little networks that carmine and Prussian blue embroider into the capillaries of the intestines, muscles, and glands. He will have mastered completely the most artistic histological staining techniques without ever feeling the slightest temptation to apply them to a new problem, or to the solution of a hotly contested issue.

If he is a geologist, he will be completely engrossed in observing the vivid colors produced in sections of rock by polarized light; if a bacteriologist, he will develop a delight in collecting and cultivating the various chromogenic and

phosphorescent microbes; and if an astronomer, he will devote his leisure moments to photographing the mountains on the moon or the spots on the sun.

Why go on? Everyone reading this will recall interesting varieties of this type. They are as likable for their juvenile enthusiasm and piquant and winning speech as they are ineffective in making any real scientific progress.

Bibliophiles and Polyglots

Just as the expert in photomicrography amuses himself with diatoms, or the zoologist with insects, shells, and birds of gorgeous plumage, the bibliophile takes pleasure in reading the newest book or monograph that is "highly important and thought-provoking" but that no one else can seem to find a copy of. Our model of erudition uses this strategy in a marvelous way to amaze his friends.

The symptoms of this disease include encyclopedic tendencies; the mastery of numerous languages, some totally useless; exclusive subscription to highly specialized journals; the acquisition of all the latest books to appear in the bookseller's showcases; assiduous reading of everything that is important to know, especially when it interests very few; unconquerable laziness where writing is concerned; and an aversion to the seminar and laboratory.

Naturally, our bookworm lives in and for his library, which is monumental and overflowing. There he receives his following, charming them with pleasant, sparkling, and varied conversation—usually begun with a question something like: "Have you read So-and-so's book? (An American, German, Russian, or Scandinavian name is inserted here.) Are you acquainted with Such-and such's surprising theory?" And without listening to the reply, the erudite one

expounds with warm eloquence some wild and audacious proposal with no basis in reality and endurable only in the context of a chat about spiritual matters.

Discussing everything—squandering and misusing their keen intellects—these indolent men of science ignore a very simple and very human fact. They are censured by their own friends, who feel more pity than respect. They seem only vaguely aware at best of the well-known platitude that erudition has very little value when it does not reflect the preparation and results of sustained personal achievement. All of the bibliophile's fondest hopes are concentrated on projecting an image of genius infused with culture. He never stops to think that only the most inspired effort can liberate the scholar from oblivion and injustice.

Fortunately, we needn't dwell at length on this point in order to correct mistaken social values. No one would deny the fact that he who knows and acts is the one who counts, not he who knows and falls asleep. We render a tribute of respect to those who add original work to a library, and withhold it from those who carry a library around in their head. If one is to become a mere phonograph, it is hardly worth the effort of complicating cerebral organization with study and reflection. Our neurons must be used for more substantial things. Not only to know but also to transform knowledge; not only to experience but also to construct—this is the standard for the genuine man of science to follow.

Thus, let us offer tribute and gratitude to those who leave a wake of brilliant observations, and let us forget those who wore themselves out with nothing to show for it but the transformation of their effusive, sonorous words into phonograph records. Like the popular tenor, the eloquent fount of erudition may undoubtedly receive enthusiastic plaudits

throughout life in the warm intimacy of social gatherings, but he waits in vain for acclamation from the great theater of the world. The wise man's public lives far away, or does not yet exist; it reads instead of listens; it is so austere and correct that recognition with gratitude and respect is only extended to new facts that are placed in circulation on the cultural market.

Megalomaniacs

People with this type of failure are characterized by noble and winning traits. They study a great deal, but love personal activities as well. They worship action and have mastered the techniques needed for their research. They are filled with sincere patriotism and long for the personal and national fame that comes with admirable conquests.

Yet their eagerness is rendered sterile by a fatal flaw. While they are confirmed gradualists in theory, they turn out to rely on luck in practice. As if believing in miracles, they want to start their careers with an extraordinary achievement. Perhaps they recall that Hertz, Mayer, Schwann, Roentgen, and Curie began their scientific careers with a great discovery, and aspire to jump from foot soldier to general in their first battle. They end up spending their lives planning and plotting, constructing and correcting, always submerged in feverish activity, always revising, hatching the great embryonic work—the outstanding, sweeping contribution. And, as the years go, by expectation fades, rivals whisper, and friends stretch their imaginations to justify the great man's silence. Meanwhile, important monographs are raining down abroad on the subjects they have so painstakingly explored, fondled, and worn to a thread. And alas, these monographs rob from our ambitious investigator the

cherished goal of priority, forcing him to change course. Without losing faith, the megalomaniac takes on another problem, and when he has just about finished the imposing new monument, rivals with scientific contributions extending to the finest detail elicit bitterness again. Finally, he reaches old age amid the indulgent silence of his pupils and ironic smiles of the wise.

All of this happens because when they started out these men did not follow with humility and modesty a law of nature that is the essence of good sense: Tackle small problems first, so that if success smiles and strength increases one may then undertake the great feats of investigation. This cautious approach may not always lead to fame, but at least it will earn for us the esteem of the learned and the respect and consideration of our colleagues.

The dreamers who are reminiscent of the conversationalists of old might be seen as a variety of megalomaniac. They are easily distinguished by their effervescence and by a profusion of ideas and plans of attack. Their optimistic eyes see everything through rose-colored glasses. They are confident that, once accepted, fruits of their initiative will open broad horizons in science, and yield invaluable practical results as well. There is only one minor drawback, which is deplorable—none of their undertakings are ever completed. All come to an untimely end, sometimes through lack of resources, and sometimes through lack of a proper environment, but usually because there were not enough able assistants to carry out the great work, or because certain organizations or governments were not sufficiently civilized and enlightened to encourage and fund it.

The truth is that dreamers do not work hard enough; they lack perseverance. As Gracián has so aptly pointed out in his *Oráculo Manual:* "Some people spend all at the start and

finish nothing; they invent but do not progress; everything stops short of completion...The discerning should kill the prey, not spend all of his energy provoking it."

Instrument Addicts

This rather unimportant variety of ineffectualist can be recognized immediately by a sort of fetishistic worship of research instruments. They are as fascinated by the gleam of metal as the lark is with its own reflection in a mirror. They lovingly care for the objects of their idolatry, which are kept as polished as mirrors and as beautifully displayed as images in a cathedral. Peace and monastic discipline reign in their laboratories, where not a spot is to be found and not the slightest noise is to be heard.

Keys jangle incessantly in the ample pockets of the instrument addict. When the professor is not around, it is impossible for assistants and students to access essential monographs and pieces of equipment. Microscopes, spectroscopes, analytical balances, reagents—everything is kept under lock and key. All an assistant would have to do to receive a sentence of doom from the chief would be to damage a Zeiss eyepiece, the refractometer, or the polarizing apparatus. It would be horrible! Furthermore, isn't the instrument addict usually given primary responsibility for laboratory supplies—the inviolable repository of the university? Will the time not come for a strict accounting to his superiors? Investigate? Prove? He will do it some day when he has the time—as soon as the latest monographs containing indispensable information arrive and are consulted! If the government should happen to increase his allotment of supplies, perhaps he could give up part of the hallowed trust for teaching purposes. But in the meantime?

These teachers—and we all remember more than one example—have chosen the wrong profession.[1] They think of themselves as inspiring and zealous officials, when they are in fact simply good housekeepers. Don't they remind one of those excellent housewives who primly set their front rooms in order, keep the furniture scrupulously arranged, polish the floors daily, and receive their relatives and friends in the dining room to avoid dust and disorder?

Obviously, cold-hearted instrument addicts cannot make themselves useful. They suffer from an almost incurable disease, especially when it is associated (as it commonly is) with a distinctive moral condition that is rarely admitted—a selfish and disagreeable obsession with preventing others from working because they personally do not know how, or don't want, to work.

Misfits

There would be many fewer examples of a strange contradiction between genuine vocation and official business, between working for pay and scholarly activity, if a professorship were not so often used merely as a stepping-stone to politics, or as advertising to help build a lucrative medical practice. Instead, our professorial candidates should be required to present objective (and in a sense, predictive) evidence of aptitude and suitability through competitive examination.

"One reason for England's prosperity," a Cambridge professor once told me, "lies in the fact that each one of us fills our own post." With certain noble exceptions, the exact opposite occurs in Spain, where many people seem to occupy the same post—not to discharge the responsibilities it carries, but simply to collect the salary, and to enjoy the

incidental pleasure of excluding the competent. Who can't think of generals born to be ordinary government officials or justices of the peace, professors of medicine cultivating literature or archeology, engineers writing melodramas, pathologists dedicated to the science of ethics, and metaphysicians sworn to politics? The result of this situation is that instead of devoting all of our spiritual energy to our official duties, we devote only a small part—and that reluctantly, as if it were a painful duty.

However, we would certainly not recommend that the life of the professor, or the man of science in general, should be so austere and strict that his entire life is devoted to professional duties. Instead, we would only hope that whatever energy he has left is spent on light, agreeable pastimes—those perfectly legitimate wanderings of attention that are fueled by the intensity and monotony of daily work.

Some might think that instead of being abnormal, misfits are simply unfortunate individuals who have had work unsuited to their natural aptitudes imposed on them by adverse circumstances. When everything is said and done, however, these failures still fall in the category of abulics because they lack the energy to change their course, and in the end fail to reconcile calling and profession.

It appears to us that misfits are hopelessly ill. On the other hand, this certainly does not apply to the young men whose course has been swayed by family pressure or the tyrannies of their social environment, and who thus find themselves bound to a line of work by force. With their minds still flexible, they would do well to change course as soon as favorable winds blow. Even those toiling in a branch of science they do not enjoy—living as if banished from the beloved country of their ideals—can redeem themselves and work productively. They must generate the determination

to reach for lofty goals, to seek an agreeable line of work—which suits their talents—that they can do well and to which they can devote a great deal of energy. Is there any branch of science that lacks at least one delightful oasis where one's intellect can find useful employment and complete satisfaction?

Theorists

There are highly cultivated, wonderfully endowed minds whose wills suffer from a particular form of lethargy, which is all the more serious because it is not apparent to them and is usually not thought of as being particularly important. Its undeniable symptoms include a facility for exposition, a creative and restless imagination, an aversion to the laboratory, and an indomitable dislike for concrete science and seemingly unimportant data. They claim to view things on a grand scale; they live in the clouds. They prefer the book to the monograph, brilliant and audacious hypotheses to classic but sound concepts. When faced with a difficult problem, they feel an irresistible urge to formulate a theory rather than to question nature. As soon as they happen to notice a slight, half-hidden, analogy between two phenomena, or succeed in fitting some new data or other into the framework of a general theory—whether true or false—they dance for joy and genuinely believe that they are the most admirable of reformers. The method is legitimate in principle, but they abuse it by falling into the pit of viewing things from a single perspective. The essential thing for them is the beauty of the concept. It matters very little whether the concept itself is based on thin air, so long as it is beautiful and ingenious, well-thought-out and symmetrical.

As might be expected, disappointments plague the theorist. Current scientific methods are so inadequate for the generation of theories that even those with true genius need to devote themselves to years of struggle and incessant experimental work. So many apparently immutable doctrines have fallen!

Basically, the theorist is a lazy person masquerading as a diligent one. He unconsciously obeys the law of minimum effort because it is easier to fashion a theory than to discover a phenomenon.

Liebig was a good judge of these matters, and he penned some fatherly advice to young Gebhard, a promising chemist who was too inclined toward ambitious synthesis: "Don't make hypotheses. They will bring the enmity of the wise upon you. Be concerned with the discovery of new facts. They are the only things of merit that no one disregards. They speak highly in our favor, they can be proved by all intelligent men, and they create friends for us and command the attention and respect of our adversaries."

There is a great deal of truth in what Liebig wrote. Theories definitely present an exceptional danger to the beginner's future. To instruct carries with it a certain pedantic arrogance, a certain flaunting of intellectual superiority that is only pardoned in the savant renowned for a long series of true discoveries. Let us first become useful workmen; we shall see later if it is our fate to become architects.

The reader may be asking whether or not we are being inconsistent in view of what has already been said about the need for hypotheses. One must distinguish between working hypotheses (*Arbeitshypothesen* of Weismann) and scientific theories. The hypothesis is an interpretative questioning of nature. It is an integral part of the investigation because

it forms the initial phase, the virtually required antecedent. But to speculate continuously—to theorize just for its own sake, without arriving at an objective analysis of phenomena—is to lose oneself in a kind of philosophical idealism without a solid foundation, to turn one's back on reality.

Let us emphasize again this obvious conclusion: a scholar's positive contribution is measured by the sum of the original data that he contributes. Hypotheses come and go but data remain. Theories desert us, while data defend us. They are our true resources, our real estate, and our best pedigree. In the eternal shifting of things, only they will save us from the ravages of time and from the forgetfulness or injustice of men. To risk everything on the success of one idea is to forget that every fifteen or twenty years theories are replaced or revised. So many apparently conclusive theories in physics, chemistry, geology, and biology have collapsed in the last few decades! On the other hand, the well-established facts of anatomy and physiology and of chemistry and geology, and the laws and equations of astronomy and physics remain—immutable and defying criticism. "Give me a fact," said Carlyle, "and I will prostrate myself before it."

In short, the beginner should devote maximal effort to discovering original facts by making precise observations, carrying out useful experiments, and providing accurate descriptions. He will use hypotheses as inspiration during the planning stage of an investigation, and for stimulating new fields of investigation. If, in spite of everything, he feels compelled to create vast scientific generalizations, let him do so later on when the abundant observations he has reaped have earned for him a solid reputation. Then and only then will he be listened to with respect and discussed

without ridicule. And if fortune smiles, he will someday wear the double crown of investigator and philosopher.

We have now described the major types of failures, highlighting their ethical weaknesses and intellectual poverty in rather bold colors perhaps. We have done this to put them in front of a mirror where they, along with their students and admirers, can observe their defects. We do realize, though, that our diagnoses will do little if any good for the adult and the callous. Instead, our advice is directed to the young who openly crave prestige, even when based on questionable foundations. But even more so, it is directed to those cultured professors who are capable of producing worthwhile results but, with the discouragements accompanying their work, begin to feel the unhealthy and unpatriotic desire to imitate our fruitless braggarts—whether they have been influenced by poor example or lack inner discipline.

If none of the advice in this chapter seems to help those for whom it is intended, they should examine their conscience and decide whether or not they would benefit from undergoing a spiritual cure abroad. The laboratory of a scholar is an ideal sanatorium for wandering attention and a faltering will. Here, old prejudices vanish and new contagions that are both enlightening and sublime are contracted. Working beside an industrious and gifted scholar, he who is lacking in will power can receive the baptism of fire in research. In such a laboratory he will observe with commendable envy the fervent ambition to wrest secrets from the unknown; he will absorb the unrelenting scorn toward vain theories and rhetorical discourse; and finally, on foreign soil, he will experience the rebirth of a growing patriotism. And once started down the road of his own work, he now has a store of respectable discoveries to his credit. Back in

his native country, he will have learned how to focus his interests, and will now look with disdain—if not pity—on his old idols.

Note

1. We know some who are not content with locking the cabinets in their laboratories; they padlock and seal them before leaving.

6 Social Factors Beneficial to Scientific Work

Material support. Having a profession and doing research work are compatible. The investigator and his family

Like all mental activities, the accomplishments of the scientist are heavily influenced by the physical and moral environments around him. It has been said, with good reason, that the man of learning is like a delicate plant that only thrives in a special medium—soil deposited by the culture of centuries and tilled by society's care and esteem. In favorable surroundings, even the backward type has a feeling of accomplishment, whereas in a hostile or indifferent environment even the sharpest mind is discouraged. How can we go on when no one is interested in our work? Only the stern and heroic have the strength to overcome adverse environmental conditions and wait in obscure resignation for the approval of posterity. But society must not count on heroes because there may be no opportunity for them to appear. Instead, we must rely on people with average skills and ordinary talents who are inspired with a noble patriotism and clear ambition. Governments and educational institutions must contribute to the formation and cultivation of these laboratory patriots by creating a nurturing social