The Challenge of Biology

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THIS IS THE CENTURY of the biological sciences. The physical sciences have already achieved a high degree of consistency and conceptual maturity. In the life sciences, on the other hand, analytical understanding is still no more than rudimentary, unifying concepts are still scarce, and many fundamental principles remain to be discovered. The major job still lies ahead. At the same time, the urgency of the task grows, as mankind looks expectantly to new advances in agriculture, public health, and medicine, whose rational development depends on biological knowledge and understanding.

The biological sciences strive to measure up to the challenge. They are hitting an ever swifter stride and, being young, move on with optimism to a future full of opportunities and promise of fulfillment. Yes, biology is on the march. Its gathering momentum is gratifying; it also holds its dangers.

For in its fast advance, biology tends to break up into isolated columns, splintering into ever more subdivisions of specialization and particularization. Mastery requires concentration, and concentration is aided by seclusion. Thus, breaking up the larger tasks into narrower fragments is necessary for success. But unless the common goal—the understanding and control of life processes—is constantly kept in view as the beacon for the individual columns by which to chart their courses, they will lose contact, common purpose, and direction. *The unity of life* must find its true reflection in *unity among the biological sciences*. Beyond our preoccupation with our special interests, as anatomists, bacteriologists, cytologists, dendrologists, endocrinologists, geneticists, histologists, immunologists, limnologists, mammalogists, neurologists, oncologists, physiologists, radiologists, serologists, taxonomists, virologists, and zoologists, we must remain, above all, biologists, at least in spirit and allegiance, if not in performance.

Being a biologist is an attitude, not an occupation. Biology has grown in volume and diversity to the point where it would be far beyond the capacity of any one individual to acquire competence in more than a limited sector of the field. Biologists, in the sense of miniature incarnations of universal biological knowledge, no longer exist. Biological science has become a group enterprise with many servants in varied stations. The single-celled organism has evolved into a multicellular one, and its health, survival, and growth depend on the harmonious cooperation of its many specialized members. Anyone contributing to this collective task, constructively, competently, and conscientiously, thus becomes a biologist. Consequently, it takes all kinds of biologists to make the biological world, none of them able to carry on without the others. And biology needs their full diversity.

It needs the observer, the gatherer of facts, the experimenter, the statistician, the theorist, the classifier, the technical expert, the interpreter, the critic, the teacher, the writer. It needs the student of evolutionary history as much as it does the experimental physiologist; the precise recorder of morphological data as much as the analytical biophysicist and biochemist; the investigator of molecular interactions as much as the student of supramolecular organization, of the order of events in space and time. It needs the help of all hands at all stations, from the research man who conceives a new idea, to the assistants who prepare solutions or tend cultures or animals; from the mechanic who builds a new instrument, to the artist or photographer who prepares indelible records of microscopic specimens or physiological tracings; and last, not least, from the man who willingly gives of his time and effort in order to help obtain and distribute some of the most basic tools of science—fellowships, research grants, materials and jobs—to the one who willingly accepts them to good advantage. They all work for a common cause and should feel above the unjustified and undignified popularity contests that center on such monomaniac questions as who is "more important," the "fundamental" or the "applied" scientist; the explorer or the instructor; the technical expert or the philosopher. They are all needed—in their proper stations. And they should be rated not by *what* they are doing but by *how* they are doing it.

Competence, resourcefulness, scholarship, craftsmanship, imagination, self-criticism, discipline, honesty, responsibility, and logical clarity are the only valid criteria of merit; not whether one devotes himself to exploring the vegetation of the jungle or the permeability of a cell membrane. Good work in any line will bring success. Given some luck, discoveries will come abundantly, as Pasteur said, to the "prepared mind." Opportunities are the richer, the wider the field and the more there is yet to be discovered; chances the better, the more freely an individual of good sense can strike out for himself, free from the tyranny of fashion and the lure of popularity. In biology, in its campaign to conquer the unknown, the field is so broad, so much is yet to be discovered, ordered, and explained, and there is so much freedom yet for initiative and self-direction that rich yields await the curious, imaginative, resourceful, and courageous. Yet, as the freshly mined raw materials of

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new knowledge are fed in ever increasing volume into the processes of sorting, polishing, recording, distribution, storing, and application, even those who by inclination or talents have taken stations in this processing network behind the front lines of research will reap their share of credits and rewards, as they themselves take an essential share in the accomplished product: the advance of the biological sciences.

Of course, reward is counted not only in economic terms, but more in terms of intellectual and emotional satisfaction—the thrill of discovery, the pride of achievement, the sense of service to man and his welfare. Being young and in the ascendancy, biology can promise the members of its family more of these rewards than most other fields of science. What is more, being highly diverse and relatively undeveloped, it offers the *individual* more latitude of personal choice and broader opportunity for the expression of his personal talents than older, more standardized and grooved endeavors.

Therefore, biology has room for a very wide range of personalities and trainings; while for its frontline advances it needs the best of brains and eyes, and hands, it is no less dependent on the large corps of comrades in arms who support, consolidate, exploit, and enlarge those advances. All it takes to join these forces is: some aspirations, to point the goal; some inspiration, to point the way; and perspiration, to get you there. What can you get out of it?—a happy and a useful life.

Observations on the Formation and Behavior of "Conjugation" Cells and Large Bodies in *Azotobacter agile*[1]

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DURING SINGLE-CELL STUDIES on *Azotobacter agile,* strain M.B. 4.4,[2] the development of two unusual cell types—"conjugation" cells and large bodies—was observed. Löhnis and Smith (*1*) reported cellular fusion in Azotobacter, but this was considered by Lewis (*2*) to be incomplete division. The formation of large bodies in *A. agile* M.B. 4.4 was believed by Eisenstark *et al.* (*3*) to be caused by the stimulus of substances in the culture medium. The formation of large bodies was followed by time-lapse, phase-contrast, photomicrography in a *Bacillus* by Schaechter (*4*) to the point of formation of apparently motile granules, and small, nonmotile, occasionally budding elements.

So far as the authors are aware, this is the first report of observations of these forms at close intervals under conditions such that some previously advanced interpretations of the causes could be ruled out. These observations are reported because they offer support to the contention of Lewis and a possible alternative to the interpretation of Eisenstark *et al.*

The strain was routinely carried in stock on slants of modified Karlsson and Barker (*5*) selective medium in which 1 per cent glucose was substituted for 1 per cent ethyl alcohol. The medium was nitrogen free except for that contained in 0.02 per cent yeast extract. An inoculum was transferred in water of syneresis from the base of a slant, by means of a micropipet and micromanipulator (*6*), to the surface of a film of the same medium on a coverslip inverted on a moist chamber, where it could be watched with the microscope. For the initial experiments the moist chamber slides were incubated at 30° C in closed cans containing wet filter paper. For observation, the chambers were removed from the tins and placed on the microscope, which rested on a bench at room temperature. There was considerable loss of water during observation, to the extent that it became difficult to express moisture from the agar with the microneedle. Under these conditions, the viability of the microcultures was, in general, rather low. Many cells either failed to grow and divide, or divided once or twice in the usual manner and then became vacuolated and nonviable on transfer to fresh medium shortly after removal from the tin. It was noticed, in more than six separate instances, that a cell would start to divide in an unusual manner, the first sign of which appeared as a refractile granule near the center of a swollen cell. The granule elongated to become a line across the cell, and shortly after, a cleft appeared in the center of the line and proceeded along it so that the cell divided as in Fig. 1, a–d. Uneven division resulted in earlier separation at one end, thus leaving the two sections at the incompletely divided end attached by a narrow strip and giving the impression of two cells joined by

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[2] Obtained from A. E. Eisenstark, Oklahoma A. and M. College, Stillwater.