duction we may have the basis for the duplication and perpetuation of molecular patterns.

It may not be acceptable much longer to claim that reproduction is a unique biological property as contrasted with non-biological substances believed to be devoid of this property.

POST-WAR GEOLOGY

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IMMEDIATE PROSPECT

REDUCED civilian teaching schedules and smaller classes, even though partially supplemented by the introduction of ASTP, FAL, lately, ASTRP instruction, leave me time to ponder the status of post-war geology. Shall earth sciences flourish or languish, shall we have an influx of students for whom employment awaits only graduation, will the "G.I. Bill of Rights" return many of our students now in uniform? Personally, I think we shall have plenty of students. I believe curricula in geology and allied sciences will see, if not a boom, a considerable increase over pre-war registration. If so, must course content be revised? Will specialization be stressed? I believe changes must be made, particularly at graduate level because specialization will assuredly be stressed far more than in the past. Initial employment and subsequent advance in geology will go more and more to the man with the Ph.D. There may be so great an immediate demand that anybody who has rubbed elbows with geology in college can find employment, but I am looking beyond such a period to more settled conditions, steady employment. If this be so, what field or fields will have the accent; which may remain unaccented, what may drop from the picture? Where will curricular emphasis fall? What must we plan for undergraduate preparation and post-graduate specialization?

With such questions in mind, I commenced fact-gathering through correspondence and conferences with teachers of geology, geologists with the state and federal surveys, at museums, private consulting and industrial positions. In each case I tried to find out the individual's opinion on post-war geology and proper preparation of men for the work to be. Since some of the answers are confidential, I refrain from specific citations but shall summarize opinions and even have the temerity to introduce suggestions of my own.

EMPHASIS, WHERE?

Among those interrogated, optimism dominates. Geologists are generally hopeful that the science has an immediate, luminous if not scintillating future. Agreement is less general as to where greatest development will come. Nevertheless, two developments of earth science were most often mentioned: applied geology in engineering and economic geology, including mineral fuels.

Closer bonds between applied geology and certain types of engineering, particularly civil and mining, appeal to reason. How often has the civil engineer been accused of too little familiarity with the earth into which he digs, upon whose surface his structures rise? Conversely, many a geologist, called in on a construction job, has been baffled by ignorance of engineering terminology and practise. Though a man trained in neither field need master fully the other, he can have a basic knowledge thereof. A civil engineer or geologist with extra study can acquire enough knowledge to function intelligently in the complementary science. The super-highway, railroads, dams, water supply, flood control, foundations, harbor and shore installations are among civil engineering projects where geology must serve. To prepare for work on such projects, can we not, at the expense of one or two extra study years, create a civil-engineering geologist? I have had students who "split majors" in these fields even though their years in college were crowded to meet the added load. Their professional success fully justifies the preparation. While such a hybrid-trained student might split his major as suggested, he could achieve the objective if he took his bachelor's degree in geology, followed with a degree in civil engineering or *vice versa*.

There was a time a generation ago when mining engineers had a tolerable geologic training. To-day, the trend seems to be to prepare a man to lay track and string wires underground, to get out coal or ore regardless of its geologic nature and occurrence. I have no argument with this type of training, if it follows the trends of the time and fills a need of our civilization. Yet, if the old concept of the mining engineer is to be discarded, why not develop in his stead the newer concept of a mining geologist? If his education followed a program of the pattern suggested for the civil-engineering geologist, it would turn out a man capable of giving correct geologic interpretations to mining problems.

One could propose more applications of geology to engineering and allied fields. I have often felt that the metallurgist to-day is going the way of the mining

engineer, but in his case the drift is less serious since his actual contact with the raw materials is more remote. Pedology and all that it may imply in its especial dealings with the regolith embracing water supply, agricultural engineering practices, flood and erosion control, soil mechanics and allied problems are topics that must receive more geologic support.

Economic geology has been more or less arbitrarily trisected into metallic, non-metallic, mineral fuels. I believe that for economic geology, methods of study and their application rather than subject-matter will change. The war has emphasized two phases of economic geology, the strategic mineral and the depletion of mineral resources. There has been intensive search for strategic minerals or their substitutes, for low-grade deposits, for new reserves hitherto neglected, undervalued or unknown. If such exploration and exploitation are to continue, and surely they must as we more and more approach a mineral-poor civilization, old, supposedly exhausted workings may enjoy a face-lifting. We shall require new and special emphasis upon structural geology, stratigraphy, refined petrographic methods, applied paleontology (particularly micropaleontology), geochemistry and, perhaps above all, geophysical methods of prospecting. Incidentally, let it not be overlooked that, after all, civilized man's most important mineral asset is an abundant supply of fresh water. Water supply problems grow directly with population and the demand for bath tubs, even though such be ethical rather than physiologic.

Granting that engineering geology and economic geology are those fields with the most engaging future, they are not the whole picture. The emphasis which war has placed upon meteorology and climatology is alone enough to assure their future as their application to civilian needs develops. Some will say, "Oh, but meteorology and climatology are not geology!" Who said they were? They *are* earth science and they *are* consanguineous to orthodox geology. A geologist, *sensu stricto,* needs some meteorology; the converse is equally patent. So, too, with geophysics. I mentioned its application to economic geology; its bearing on engineering problems is axiomatic. Oceanography, structural and dynamical geology, seismology are likewise closely associated with earth-physics. As with meteorology, so with geophysics, the specialists in these fields and the geologist need to know something of each other's work. Their interfusion defies sharp separation.

Is the cultural side of geology defunct? Is pure science now really to become nonsense? I doubt it. I doubt if we have so far degenerated that only "practical" science can be tolerated, only the strictly utilitarian, *i.e.,* money-making, courses are worthwhile. Who expects us to give up most of astronomy or archeology, much of that part of biology we used to call "natural history"? Perhaps the days of the great fossil-hunts are gone, but speculation on organic evolution, the excavation of its fossilized, documentary evidence, description of new species, paleogeography, earth history, the very age of the earth itself are topics which surely will receive a fair share of attention among thinking men and women to be. Support of such work will continue just as long as philanthropy and curiosity retain residence in the human race. The immediate, post-war scramble for recovery and return to the ways of peace, the replacement of losses of material needs and comforts may for a few years shunt pure science on a siding, but eventually I look for its return to a clear right-of-way. From pure science have come so many great discoveries of applied science—geology is no exception.

CURRICULA

If the post-war geologist is to be a greater specialist than his *ante bellum* predecessor, thorough scrutiny of the curriculum by which he is educated professionally is imperative. Inevitable specialization in graduate studies means more years in college and university. The basis of this work is the undergraduate period. Suppose you were asked to set up an undergraduate course for the would-be geologist, what might be your reaction? Would you not take as your first or major premise that, because of specialization, our new crop of geologists must do post-graduate work? Second, whatever the post-graduate specialty, the undergraduate training must be basic and can vary little. Assuming that your geology major is committed to graduate work and that he has been "caught" early enough in his undergraduate career for fairly thorough preparation, what subjects shall he study?

It sounds paradoxical, if not downright suicidal, if I say that the fewer courses in geology an undergraduate geology major takes the better. Truly, that is overemphasis. Suppose we insist upon four basic semesters as a minimum coverage, these to be distributed among general geology, historical geology, mineralogy, including crystallography and blowpipe analysis, petrology. To these could be added a semester course each in paleontology, structural geology, field methods, map reading including photogrammetry. Beyond these I am convinced no undergraduate must travel, always provided he is destined to become a graduate student. I do not say that he shall take no more; I cite the *must* and *near-must* subjects only. If this is all the geology he is to take, what is our undergraduate to do with his time? This: distribute it broadly among as many fields as he can from the

sum total of those that are useful or essential to the geologist.

Give the undergraduate language, above all four years of English. Let him know and appreciate good literature and learn to write the language clearly, directly and yet *interestingly*. There is too much scientific writing that like some minerals is clear but colorless. Let him have a working knowledge of two modern languages, French and German. There is little advantage for him to spend years reading foreign classics. His working knowledge must be a thorough basis of grammar. This acquired, give the student a German or French geologic text, dictionary and plenty of room to flounder till he acquires a vocabulary. I disagree with those who cry out for Spanish. A speaking knowledge of that language is no doubt an asset to any who may go to South or Central America, but there is so relatively little in the literature in Spanish that its neglect will not prove fatal. Whatever the future status of European culture and languages may be, the vast geologic bibliographies printed of French and in German articles warrant the study of these languages first and always.

In engineering fields a geologist needs several courses. He must have mechanical drawing and plane surveying. With these I would somehow try to squeeze in descriptive geometry for its value in training a man to think in three dimensions. To these courses may be added one each in general metallurgy and the principles and practice of mining.

Courses in most of the major, non-geologic sciences are necessary parts of a geologist's training. He must have mathematics at least through plane trigonometry. That will take care of anything, including his surveying, he may encounter during undergraduate days, if not throughout his professional career. If he should become an engineering geologist or a geophysicist or a meteorologist, he must have more mathematics. Keep this in mind as his interests and learning progress. A year of chemistry, that is through qualitative analysis, is none too much. I should prefer to add a semester of quantitative analysis, but am not adamant on this point. Your economic geologist will need it, but he might take it in graduate school where physical chemistry may also be inserted. A year of physics is unavoidable. Should our man lean toward geophysics or meteorology, a minor in physics is advised. General biology he must have, for who dare speak in terms of bare fosil bones and empty shells but know nothing of their flesh and blood descendants? The amount of course dosage must be more or less controlled by individual interests and intentions. For a would-be paleontologist, general biology must be followed by courses in botany, ecology and perhaps embryology and comparative anatomy, especially if comparative anatomy of invertebrates is available.

I realize that I have set up an ideal, an educational vehicle with stellar attachments. That a set-up such as outlined may seldom be attained is true. Few students decide upon their major soon enough in their careers to complete such a major. They must postpone a varying percentage of the courses to graduate years. Too few curricula are liberal enough or flexible enough to permit insertion of all my suggestions. Nevertheless, here is the mark at which I aim.

Summation

Believing as I do that geology in the immediate future will have a greater application, that with that application we shall see its expansion, I present the suggestions in this paper. They are based upon careful consideration, analyses, deductions from assembled views and opinions. Specialization will mean more and better geologists but also a greater graduate school population which must be fed from the undergraduate curriculum. There, and there particularly, is the basement complex on which to build. The greatest immediate need in geology is a broad, adequate undergraduate preparation, not so much in geology itself, but in a slightly appalling list of collateral "must" subjects. Once this foundation is attained, graduate work in its several fields will care for itself.

OBITUARY

RECENT DEATHS

Professor James Alexander Shohat, of the department of mathematics of the University of Pennsylvania, died on October 8 in his fifty-eighth year.

Howard Chapin Ives, consulting civil and construction engineer, retired, formerly professor of railway engineering at the Worcester Polytechnic Institute, died on October 6, aged sixty-six years.

Dr. Earl C. Sherrard, since 1917 chemist with the U. S. Forest Products Laboratory at Madison, Wis., died on October 5 at the age of fifty-eight years.

Dr. Edward William Berger, who retired in 1943 as entomologist of the Florida State Plant Board, died on August 23. He was seventy-four years old.

Dr. William H. Schacht, mining engineer, since