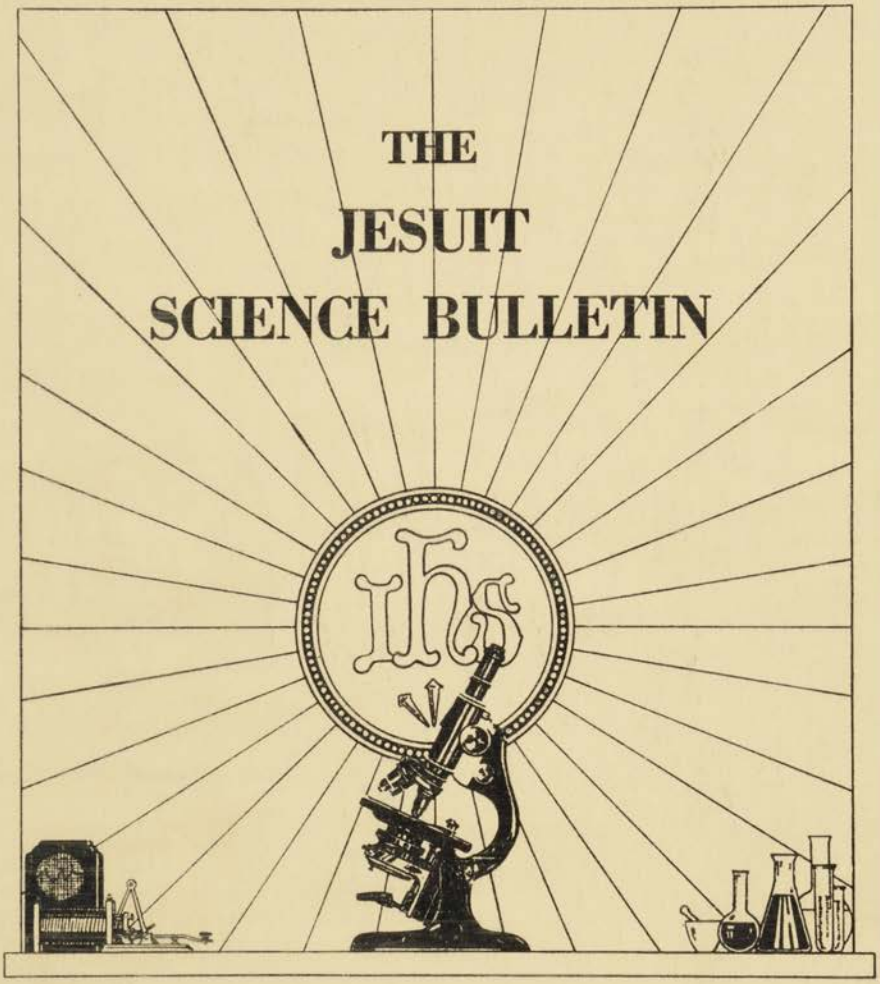

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NOTICE TO AUTHORS

Manuscripts are to be submitted to associate editors of the appropriate section and *may* be submitted directly to the editor in chief. Clear manuscript, preferably typed, with wide margin to the left, with double spacing between lines, is desirable. Please try to follow the typographical style of the most recent issue of the BULLETIN. Line drawings should be submitted on Bristol board, or similar material, and done in India ink. Figure number should be written on this in pencil. Titles for drawings, with figure numbers, should be typed on a separate sheet. Please try to minimize footnotes. Appended references and bibliographies, clearly so marked, should be done in the style of the A.A.A.S. publication, *Science*.

Manuscripts of NEWS ITEMS should be sent to the NEWS EDITOR: Rev. Bernard M. Scully, S.J., Cranwell Preparatory School, Lenox, Mass.

CURRENT TRENDS IN EDUCATIONAL BIOLOGY

Joseph A. Panuska, S.J.

Every American scientist has the natural desire to see his discipline develop and to see the United States grow in scientific strength. This latter factor especially has effected a rapidly expanding effort to improve the education of scientists. In 1954 the Division of Biology and Agriculture of the National Academy of Sciences—National Research Council set up a *Commitee on Educational Policies*. With the aid of national conferences this committee has considered problems pertinent to educational biology, such as, means of finding and stimulating talented students, preparation for college teaching, the continuing education of biologists, reappraisal of undergraduate curricula, and the promotion of experimentation in teaching. The committee published the results of a survey of 314 teachers in a brochure on improving college biology teaching.[1] A second booklet summarizes the conclusions of a conference on undergraduate curricula.[2]

Advanced placement in the biological sciences was also recently the subject of a conference held at Goucher College under the sponsorship of the College Entrance Examination Board.[3]

Changes taking place in the teaching of mathematics and physics have sometimes been termed revolutionary. In the biological fields, appropriately enough, there is more a question of adaptation than revolution. It cannot be said that biology has reached its limits as a descriptive science because there is still significant descriptive work to be done.[4] Today, however, morphological description is not the dominant activity. There is a strong trend in another direction which perhaps could be summarily described as dynamic, physiological, experimental, and principle-centered. As is apparent, all of these characteristics do not necessarily conflict with morphological description.

The advance of biology has been much dependent on advance in instrumentation, perhaps excessively so. Unlike theoretical physicists, we have not liberated ourselves from the limits of measuring and viewing devices—at least not to any great extent. Theoretical biology is so rare that it is seldom mentioned. While biology is growing by the use of recent discoveries of the physical sciences, the remarkable depth of biological problems demands more than chemistry and physics can offer. George Wald, Harvard's authority on the chemistry of vision, recently wrote: ". . . I am sure that no amount of waiting will *reduce* the most characteristic problem of biology to present-day chemistry and physics. If biology ever is *reduced* to chemistry and physics, it will only be because the latter have grown up to biology. At that point it will be hard to tell which is which."[5] We have not yet reached *that point*, but the influence of the physical sciences on biology has become increasingly great. These fields have allowed the biologist to make his approach vital and dynamic in a practical way. Such approaches, of course, must be reflected in the classroom.

We cannot hope adequately to record the fruits of recent conferences in this article. The reader must refer to the proceedings themselves. It can be said, however, that there is a growing tendency to center instruction on science as a process rather than as an accumulation of fact, principle, and practical application. It is "an adventure of action and ideas—a complex process of wonder, imagination, trial, and verification."[6] Such a principle will lead to increased attention being paid to the classical investigations through which biology has developed. This altered emphasis, in turn, must inevitably decrease the time available for the amassing of informational data. In the survey mentioned earlier many teachers suggested that there be a new orientation to the structuring of courses. The old aim of a comprehensive survey, which made sense at the turn of the century, is no longer realistic. It has been suggested that one criterion for the inclusion of any particular topic in the program should be the degree to which it will portray biological science as "an open and growing field, full of challenging problems still seeking a solution."[7] The importance of information as an essential foundation of all good teaching is not belittled by such a proposal, but rather it suggests one criterion by which such information should be selected.

These conference reports also stress the importance of having students engage in such scientific activities as unprejudiced observation, hypothesis formation, and the design and implementation of experimental procedures suited to their ability. It is thus believed that the student who looks like a potential biologist should have an opportunity to act like one, that is, he should be trained in a research environment. Anne Roe's study of eminent biologists is the basis of much of this reasoning.[8]

A description of the introductory program (a one year course) was agreed upon by the N.A.S. conference: "This program should provide the understanding of biology essential for every college student, irrespective of his ultimate goal. The program should convey the nature of scientific processes and investigative methods, including some history of biology; develop an understanding of and interest in living organisms through a comprehension of important biological concepts, as shown by a careful selection of factual detail; present biology as a growing field which uses techniques and ideas from many sources; provide substantial field and laboratory experience; and relate the biological sciences to man's other intellectual, cultural and practical

activities. In addition, the program should encourage independent use of biological literature, foster skill in oral and written communication, and provide special opportunities for superior students. Intensive, searching study of a few judicially selected topics is preferable to superficial study of many. Examples should be selected from all major groups—micro-organisms, plants, animals—and should show their respective roles in the biological scheme. Essential topics include: structure, function and development at molecular, organelle, and organismal levels; reproduction; modern genetics; evolutionary mechanisms; organism-environment relationships and behavior; philosophy and history of biology; and an at most brief survey of the diversity of organisms. This kind of introductory program demands gifted instructors, opportunities for student-teacher interchange through small discussion and laboratory sections, and freedom for those who teach it to capitalize upon their special competences and enthusiasms within the boundaries of recommended objectives and content."[9] Other recommendations are given concerning more advanced work, physical science prerequisites, and the total college program.
Other recommendations are given concerning more advanced work, physical science prerequisites, and the total college program.

This report has been centered mainly on the colleges because it is on this level that biology is most universally taught in our Jesuit schools. Many Jesuit high schools give biology a very low priority in their programming. According to statistics available at the last J.E.A. Principals' Institute only the Maryland Province offers formal biology programs in all of its high schools. Other provinces reported little or none. In some cases, Cheverus (Portland, Maine) and McQuade (Rochester, N.Y.) for example, biology is essentially available only to terminal students. This is not true in the public school system.

High school trends are similar to those of the colleges. There is interest in more laboratory work, the use of live plants and animals rather than dead material, greater stress on basic principles and on evolution as a unifying principle. There are even certain *research* grants available to high school students.[10]

This brief summary has indicated new approaches to biology which should be reflected in the classroom. Conferences assist us in organizing programs, and general statements of aims and policy help us to clarify our thought, but these aids will not make us teachers of modern biology. To teach modern biology effectively we must be modern biologists. Concretely this means that we must not allow the field to move too far ahead of us. We must study with greater urgency than might have been necessary several decades ago, and this is true even for the experienced teacher. Unless we think currently, our students will be out of step with the times.

NOTES

1. *Improving College Biology Teaching.* National Academy of Sciences—National Research Council, Publication 505. June, 1957.
2. *Recommendations on Undergraduate Curricula in the Biological Sciences.* National Academy of Sciences—National Research Council, Publication 578. 1958.
3. College Entrance Examination Board Conference on Advanced Placement in the Biological Sciences. Held at Goucher College, Baltimore, Maryland in June, 1958.
4. Willis H. Johnson, who was chairman of one of the N.A.S. conferences on undergraduate curricula, emphasized at the Goucher meeting that "while the conference stressed the importance of the physiological and the biochemical, it did not advocate substituting *physiological dissection* for all anatomical dissection but rather held that the students must be concerned with all levels of biological problems from the biochemical to the behavior of whole organisms, both plant and animal."
5. George Wald. Innovation in Biology. Scientific American, **109**, 100-113 (1958).

   In the same issue of *Scientific American* J. Bronowski (The Creative Process, pp. 58-65) pertinently remarks: "There is, however, one striking division in these articles, between those which treat of the physical and those which treat the biological sciences. The physical scientists have more fun. Their theories are more eccentric; they live in a world in which the unexpected is everyday. This is a strange inversion of the way we usually picture the dead and the living, and it reflects the age of these sciences. The physical sciences are old, and in that time the distances betwen fact and explanation has lengthened; their very concepts are unrealistic. The biological sciences are young, so that fact and theory look alike; the new entities which have been created to underlie the facts are still representational rather than abstract. One of the pleasant thoughts that these articles prompt is: How much more extravagant the biological sciences will become when they are as old as the physical sciences." Perhaps the revolution in biology is yet to come?
6. *Improving College Biology Teaching, op. cit.,* p. 3.
7. *Recommendations . . ., op. cit.,* p. 17.
8. Anne Roe. A Psychological Study of Eminent Biologists. Psychological Monographs, **65**, 1-68 (1951).
9. *Recommendations . . ., op. cit.,* p. 85.
10. The Heart Association of Southeastern Pennsylvania offers such support. For this and certain other high school data I am endebted to Rev. John G. Fay, S.J. of St. Joseph's High School, Philadelphia.

THE JESUITS' CHALLENGE TO BETTER CORRELATION BETWEEN HIGH SCHOOL AND COLLEGE SCIENCE

GEORGE F. DRISCOLL, S.J.

One thing seems evident: there is a great need to give the talented student a challenging education; and our Jesuit schools must meet this need if they are to maintain their reputation. Better correlation will start, practically speaking, through the mutual efforts of individual schools, and individual teachers motivated by a desire to challenge these talented students. Secular institutes are ahead of us. If we work together we may match their progress.

THE HONORS LEVEL

Some Facts of Capability and Curriculum

All our high schools are homogeneously grouping their students and enriching the course given to the top students. For example, at the Brooklyn Preparatory School, where I spent the last three years, an Honors Program (beyond the traditional Greek program) was established for the top twenty-five boys. This past year about ninety per cent of the group were offered at least one scholarship. Colleges want these students.

Along with the upgraded literary program, some advances have been made in mathematics and science. For the pilot honors group at Brooklyn Preparatory School, four years of mathematics along with two laboratory sciences, physics and chemistry, were taken along with Greek. Mathematics was stepped up to include an introduction to the calculus. Sciencewise, standard curricula were followed in shorter time. Any strain came from the time element, not from course content. Qualitywise we found that students were capable of doing more if they had the foundation. For example, a course in the experimental introduction to modern physics was given. This was correlated from three familiar college texts: Richtmeyer and Kennard, Humphreys and Berringer, and Oldenberg. The thirty top junior and senior science enthusiasts qualified. The course ran three equivalent periods per week on non-school time. It was the first time that these students met any degree of logico-deductive method of modern science, such as a brief development of the kinetic theory of gases and an algebraic treatment of Bohr's theory. Many concepts, such as angular momentum, were involved and had to be taken *on faith* for the time being. College systems of mechanical and electrical units proved difficult, but students could comprehend essentials without benefit of detailed insight. After two essay type examinations, there were twelve who survived until May, and half of these were high school juniors. If there were available laboratory apparatus for experiments such as the Milliken Oil Drop device for charge to mass ratio, I feel confident that they could have performed well in them. High school juniors at Exeter have done these experiments and more. This perhaps illustrates the interest and potential of these fourteen or fifteen year olds. They will work and they want to be challenged. To show that colleges are interested, Columbia's Engineering School by competitive test has combed the city's high school talent and is to give Saturday morning lecture-laboratory series to those who qualify. Information can be obtained from: Joint Program for Technical Education, Columbia School of Engineering, New York 27, N.Y., c/o John Barr, Dir.

Another significant experiment will start this semester in the schools of the *New York Province:* a sophomore science honors group. These students will take a year's introductory course covering the basic concepts of both chemistry and physics. This will open the way for more advanced work in both during third and fourth year. Fr. Harry Boyle, the originator, taught a pilot course at Canisius High School and his results merited this provincewide program. The real significance of the program lies ahead in the advanced program now to follow.

Some Possibilities for the Honors Level, Especially Through College Correlation

Three possibilities will be looked into. It is in these that we will see the need for closer high school-college articulation.

The first possibility would not comprise such immediate big steps. It would consist of the much needed getting together and mutual analysis of syllabi for the purpose of correlating honor programs with minimum duplication. This method presupposes a homogeneous grouping of some sort for both high school and college. It would also be the main way of better correlating the regular courses. Thus a single council of high school and college teachers would discuss both levels. Starting with an analysis of our mutual syllabi, a few initial decisions could be reached. Colleges could take the initiative, clarify their own prerequisites and programs, and invite high schools to participate in them, offering help perhaps in attaining them.

The second possibility on this honors level is the fast growing advanced placement program. In May 1958, 3700 students from 360 schools took 6900 examinations and will enter about 280 different colleges. The *ivy league* high schools and colleges have taken the greatest advantage of this program. Among Jesuit schools the greatest progress has been made in the mid-western provinces. Detroit, Xavier and St. Louis High Schools all have advanced placement agreements with their corresponding colleges, according to J.E.A. Proceedings (Denver Headmasters and Principals Meeting), August 1958. In the New York Province, both Prefects of Students, Frs. Glose and Reed, have shown interest in its possibilities. A policy statement was issued at the St. Peter's College Dean's meeting of June 1958, which accepted the program according to the stimulations of the program syllabus. Students are required to take advanced placement tests of the College Entrance Examination Board; grades of 5, 4 or 3 are required in these. Sophomore standing will be awarded those who qualify in three subjects, provided that the requisites for the particular course are satisfied. Consult the Minutes from the Meeting of the Deans of the Liberal Arts Colleges of the New York Province.

Applied specifically to physics, the program mentions two levels: Type B, a first year college course without calculus; and Type C, with calculus. The program advises getting together with several colleges in the area for choice of textbook. Choate, Exeter and the Bronx High School of Science use Hausmann and Slack's *Physics;* others use White's *Modern College Physics.* The possibilities for our own Jesuit schools, especially with their earlier start in physics and chemistry, seems excellent. A look at the Exeter syllabus for their *Physics 3* course, started in 1940 and now perfectly aligned with advanced placement, would offer our schools a real challenge. (Write to Dr. Richard F. Brinckerhoff, Phillips Exeter Academy, Exeter, N.H. It might well be abstracted for the BULLETIN.) Our colleges could certainly guide and counsel our high schools in working out such a program and perhaps even help them some way in the teaching of it. A once in a lifetime opportunity is presenting itself this Fall in the National Broadcasting Company's nationwide television *Physics for the Atomic Age* being telecast daily, 6:30 to 7:00 A.M., Oct. 6 through June 5. This course, equivalent to two four-semester hour college level courses, is primarily designed for high school teachers, but is also admittedly within the reach of talented high school students. Information on this program may be had by writing to Mr. Jack Arbolino, Director A.P. Program, 425 W. 117 St., New York 27, N.Y.

The third possibility is the early admissions program, a Ford Foundation Project, founded in 1951. In this program in which the very capable high school student is admitted early to college (usually after the completion of his junior year), the top private schools are again the prime experimenters. I have heard that several of our colleges, such as Boston College, have tried such a program, but always with a few hand picked students of rare ability. Administrators in the New York Province are considering its possibilities, but no policy has as yet appeared. In fact, there is no New York State policy on this program. The possibilities for our schools, especially through close high school and college cooperation are evident. The first reports of secular institutions that have tried out this program are favorable. Consult *They Went to College Early*, the evaluation report for 1957. Copy is available from: The Fund for the Advancement of Education, 699 Madison Ave., New York 21, N.Y.

The Regular Course Level

The New York Province syllabus is basically that of New York State. Like the present first year college syllabus, it is still fundamentally the same course given fifteen to twenty years ago. The present trend is to revise it. According to Dr. Zacharias the director of the program at Mass. Inst. Tech., a similar revision is needed in the first year college program and he hopes that the high school trend will force the issue in the colleges. The outlines of Dr. White's NBC-TV program manifest a similar revision on the college level, namely the emphasis given to modern atomic and nuclear concepts.

The main problem stems from certain areas of duplication both in theory and in the laboratory. The real solution would seem to lie in the trend to upgrade high school science even if it meant the invasion of college territory. The student constitutes the prime interest of both the high school and the college. If he is capable and interested, why deny him his chance? The average student in our schools is capable of a mathematics and science curriculum of greater depth (quality-wise rather than by quantity of matter). My conclusion would then be, rather than to delay science until college, start it earlier. This would tend to an almost universal sophomore introductory course. The boys showing proficiency and interest could go on to the advanced high school program, perhaps closer to the present first year college level. There would be the additional vocational advantage of making an earlier choice. Much closer correlation is sorely needed for possibility to eventuate in reality. The college must be ready to receive such groups into its own more closely correlated and homogeneously grouped course. An *honors level* would have to take the more talented boys not yet ready for an advanced placement as well as any *supertalented* early entrees. There would have to be a lower level course for those with little or no high school physics, as well as for those with only secondary interests, such as pre-medical students. Such correlation will now enable the colleges to lead their own students into an analogous advanced placement for graduate work.

Conclusion

After all of the possibilities are explored, the real test is whether our Jesuit schools can get closer together and help one another more, especially with the talented student. Nor can we forget the non-Jesuit schools. We must start slowly and individually according to our own capabilities, such as many of the mid-western schools are doing. For example, do we even know one another's syllabi? Would a college department be willing to help its neighboring Jesuit high school in upgrading its science course? Are they interested enough to send a teacher or perhaps a talented student to help give a course to an advanced high school group—to help follow up the coming TV college level course—to invite high school honor groups up to the college for lecture and laboratory work, such as is being done at Columbia University? Would anybody be interested in forming an intra-city branch of this Association, including our laymen, to analyze further this problem of correlation and its possibilities? Perhaps there could be an intra-city meeting during the holidays. St. Louis has conducted one. What college science department will announce requisites for the advanced placement program, the early admissions program or the honors program in physics? With all our schools scattered nationwide, what school or system of schools could compare with our potential—and this for science too?

THE THEORY OF SPONTANEOUS GENERATION
Parts II. and III*

Francis X. Quinn, S.J.

PART II. THE ANCIENTS

I. The Account of Genesis and Abiogenesis

As we read the first book of Genesis we realize the great emphasis placed on Divine causality. God brought about the existence of light (v. 3), divided the light from darkness (v. 4), made the firmament and divided the waters above and beneath (v. 6 & 7). He ordered the appearance of dry land (v. 9), commanded the earth to bring forth vegetation (v. 11) and created the aquatic animals, birds, beasts and man (v. 21, 25 & 26).

God is the first cause of everything. This does not mean that He does not use secondary causes. Concerning the origin of life, Scripture

* Part I appeared in two instalments: vol. 34, p. 49 and vol. 35, p. 84. This instalment concludes the contribution.

definitely asserts that these were produced with the concourse of the active power of inanimate matter. It was the earth which brought forth sprouting grass and living animals.

II. St. Basil

Scholars conclude that Genesis teaches a type of spontaneous generation for the origin of living things from inorganic matter. In commenting on the earth bringing forth living creatures, St. Basil, in his ninth homily writes:

> "Let the earth bring forth the living creature." This command has continued and earth does not cease to obey the Creator. For, if there are creatures which are successively produced by their predecessors, there are others that eevn to-day we seen born from the earth itself. In wet weather she brings forth grasshoppers and an immense number of insects which fly in the air and have no names because they are so small; she also produces mice and frogs. In the environs of Thebes in Egypt, after abundant rain in hot weather, the country is covered with field mice. We see mud produce eels; they do not produce from an egg or in any other manner, it is the earth alone which gives them birth.[48]

St. Basil would not be surprised at many of the modern evolutionary ideas. He also held that birds come from reptiles.

III. St. Ambrose

St. Ambrose appeals to the metamorphoses of insects and other animals, such as the phoenix, in order to show that the resurrection of the dead is not impossible.[49] In his Fifth Homily he talks of the origin of plants on the third day:

> How efficacious, how strong is the word, "Let the earth germinate the grass of the field," that is, "let it germinate of itself, without the help of any other, or the assistance of any thing."[50]
>
> It was spontaneously that the earth produced its fruits . . . For then it was by a spontaneous production that the earth everywhere hung out its fruit, for so it was ordained by Him who is the plenitude of all things. . . . How numerous are the things which even now are generated spontaneously.[51]
>
> God therefore says, "Let the waters produce reptiles with living souls according to their genus, and birds flying along the firmament of the heavens. The order comes and immediately the waters hasten to accomplish the prescribed births: the rivers engender, the lakes give life, the sea itself begins to bring forth the various kind of reptiles and pours forth according to its kind each one of these things it has formed. Even the smallest streams and the muddy marshes had no rest until they made use of the power to create granted to them.[52]

St. Ambrose goes on to say that the waters also produced animals which live on the earth: "Also mosquitoes and frogs croaking round the marshes which have generated them."[53]

And after saying that the whale was produced at the same time as the frog and without any greater difficulty, he adds that God and nature do not despise the small things for they are generated without pain.[54] He then passes in review the aquatic animals and ends by agreeing with St. Basil that birds were formerly reptiles.[55]

IV. St. Augustine

St. Augustine, in his discussion of the origin of plants and animals, tells us it was the earth, not seeds in the earth, that was given the power to produce plants:

> For He does not say, "Let the seeds in the earth germinate the pasture grass and the fruitful tree," but He says, "Let the earth germinate the pasture grass sowing its seed.[56]

Accordingly, plants were then created causally or potentially. *Causaliter ergo tunc dictum est produxisse terram herbam et lignum, id est producendi accepisse virtutem.*[57] St. Augustine further says that even those minute animals which arise from the corruption of other bodies were created potentially in the beginning:

> Caetera vero quae ad animalium gignuntur corporibus, et maxime mortuorum, absurdissimum est dicere tunc creata cum animalia ipsa creata sunt, nisi quia inerat jam omnibus animatis corporibus vis quaedam naturalis, et quasi praeseminata et quodammodo liciata primordia futurorum animalium quae de corruptionibus talium corporum pro suo quaeque genere ac differentiis erant exortura, per administrationem ineffabilem omnia movente incommutabili Creatore.[58]

The doctrine of potential creation became quite common in the Church by the end of the fourth century. Pope Anastasius II wrote a letter to the Bishops of Gaul at the end of the fifth century and pointed out the distinction between the production of all things in their causes at the beginning of time and their subsequent appearance under the influence of Divine Providence as explained by St. Augustine.[59]

The themes of Basil, Ambrose and Augustine can further be found in Venerable Bede. There is a general and firm conviction in the Fathers that life arose from inorganic matter by virtue of special powers given to matter by the Creator.

PART III. THE MIDDLE AGES

I. Saint Bonaventure

Due to the influence of the Arabs, the thirteenth century was marked by a revival of interest in the works of Aristotle. In 1231 Gregory IV issued a commission for the preparation of an expurgated edition of the works of Aristotle. This, of course, re-kindled the fires of the abiogenetic theory. St. Bonaventure joined the Aristotelian theory of the spirit-movers of the stars to the seminal reasons from which plants and animals have risen. The resulting heavenly powers intervened to excite and assist the active power in the earth.[60]

II. Saint Albert the Great

Similar ideas are to be found in the writing of Albert von Bollstadt, known to his contemporaries and to posterity under the names of Albert the Great or Albertus Magnus. He goes one step further in setting up his abiogenetic theory. Bonaventure had ascribed very little influence to the heavens in the production of life. Albert, while still holding that there is a *virtus semenitiva* in the earth in the case of plants, maintains that in the case of the lower animals the real active cause is the motion and radiation of the stars, and that even this does not suffice in the case of the higher animals.

> Plants are not necessarily produced by plants, but for the production of a plant a proportionate combination of active and passive factors in the lower regions, and of the moving stars suffice. But in an animal it has to be produced from an animal.[61]

III. Saint Thomas Aquinas

Before we consider the ideas of Albert's great disciple, St. Thomas Aquinas, on the origin of life, there are a few preliminary points to be made. Thomas held that the heavenly bodies are moved by angelic spirits, and for this reason have the power of producing life on the earth.[62] As to the kind of life the heavenly bodies are able to produce, St. Thomas held, as did Aristotle for the most part, that animals which arise from spontaneous generation are incapable of reproducing their kind. He therefore confined the active efficiency of the heavenly bodies to the production of plants and the lower animals. When commenting on the first Book of Genesis, Thomas seems to hesitate; in fact he sometimes offers alternative explanations.[63] When commenting on the causality of heaven and earth he said that plants were produced by the active power of the heavens and the passive potentiality of the earth.[64] As for the origin of animals, Thomas agrees with his master, Albertus Magnus, that inferior animals arise by spontaneous generation through virtue of the heaven.[65]

Both the theories of Albert the Great and Thomas Aquinas can be summed up together. These two scholastic doctors teach that the active cause of abiogenesis is to be sought in the heavens. Following Aristotle they thought that bodies spontaneously generated were incapable of generating their kind.

IV. Franceso Redi and John Needham

On the biological plane, in the seventeenth century Franceso Redi (1629-1698) proved that maggots in rotting meat do not rise as a consequence of putrefaction but out of fly-eggs. Yet this eminent biologist firmly believed that intestinal worms and gall flies were spontaneously generated.

John Needham (1713-1781), an English priest and microscopist, endeavored to prove in 1748 that single-celled creatures were generated spontaneously in sterilized and sealed broth. Today we would say his broth solutions were imperfectly sterilized, but Spallanzani (1729-1799) attacked Needham's theory in 1767.

V. Pasteur

As the giant of the battle, Pasteur began his experiments, leading biologists set out to prove that micro-organisms arising upon fermentation and putrefaction were spontaneously generated. There was even extensive talk of the philosophical necessity for abiogenesis in the beginning of life. But Pasteur was determined to show that the present possibility was not to be reckoned with.

Pasteur's experiments, however, did not crush the theoretical possibility among natural philosophical speculators. But they did show that what was supposed to be lifeless matter actually harbored abundant microscopic life. The larger issues implicit in the theory, the interrelation of the animate and inanimate and the possibility of the creation of life *in vitro,* are by no means closed.

In passing it might be mentioned that should science prove abiogenesis to be a fact, it would enable Catholics to give complete assent to the teaching of the Fathers.

Notes

48. Stegmann, Anton, Basil the Great (Munich: Kostel & Pustet, 1925), II, p. 141; *vid.,* also n.35.
49. S. Ambrose, Hexaemeron, Lib. VI, Cap. II, n. 64-67.
50. *Ibid.,* Lib. II, Cap. VI, col. 166.
51. *Ibid.,* Lib. III, col. 174.
52. *Ibid.,* Bk. VII, col. 205.
53. *Ibid.,* col. 207.
54. *Loc. cit.*
55. *Loc. cit.*

56. S. Augustine, *Opera Omnia* (Paris: Migne, 1884) *De Genesi ad Litteram,* III, Lib. V, col. 324-325.
57. *Loc. cit.*
58. *Ibid.*, Lib. III, 14, col. 288-289.
59. Denzinger, *Enchiridion*, n.170.
60. S. Bonaventure, *Opera Omnia* (Ad Claras Equas (Quaracchi), 1885), II Sent. dist XIV, Pars II dub, 2. p. 366.
61. S. Albertus Magnus, *Summa de Creaturis*, Tract. IV, q. 70, a. 2.
62. S. Thomas Aquinas, *De Potentia*, q. 3, a. 11, ad 4; q. 6, a. 6, ad 10; *Summa*, I, 70, a. 3, ad 3.
63. S. Thomas Aquinas, *Summa Theologica*, I, 69, 2.
64. *Ibid.*, I, 115, 2, ad 3.
65. *Ibid.*, I, 71.

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S. Albertus Magnus, *Summa de Creaturis*.

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(*Concluded on page 76*)

Obituary

REV. GEORGE J. SHIPLE, S.J., CHEMIST, 1891-1958

Father George J. Shiple who had been stationed at the University of Detroit since 1929 passed away on May 18, 1958. He was known to eastern Jesuits of his generation through his studies at Woodstock and at Fordham and for his activity in this ASSOCIATION at about the time of its founding, giving his memory a claim on our respect in these pages over and above that usually accorded great Jesuit scientists.

Fr. Shiple was born in Perrysburg, Ohio on June 10, 1891; he entered the Society in Florissant, Mo. in 1912; he was ordained from Woodstock, Md., in 1926, possibly in the Dahlgren Chapel at Georgetown. In 1918 he received his A.B., and in 1919 his A.M., both from St. Louis University, and it was from Fordham University that he received the D.Sc. degree in 1922. Other studies were made at Indiana University, the Jefferson Medical College in Philadelphia and Jesuitenkolleg, Sankt Andrä, Austria. He is credited with numerous publications, mostly in biochemistry, as documented in items 149 to 159 incl., this BULLETIN, *34*, 93 (1957).

Fr. Shiple's teaching assignments started in an army camp near St. Louis during World War I, where he got his baptism of teaching fire, no less of chemistry, having all he could do as a scholastic to warm up his matter from day to day. Other assignments included Campion College St. John's in Toledo and the University of Detroit. His chairmanship of the chemistry department of Detroit became more and more overshadowed by appointments of an administrative nature, ranging the well known gamut of grounds and athletics, to Board of Trustees, Graduate Council, Regent of the College of Engineering and finally, at the time of his death, Chairman of New Construction. Any number of these and other offices he held simultaneously and one can hardly recall him except as the sound, practical, pioneering, scientific administrator and Jesuit, of whom we are today blessed with not a few—ready and willing for every job—the men who have shaped this ASSISTENCY as we now know it.

Father's professional membership included the American Chemical Society, the Chemical Society (London), The Biochemical Society (London), the Franklin Institute, the Society of Experimental Biology and Medicine and the Detroit Engineering Society. (Writer is indebted to Bill Rabe, Public Information Office, University of Detroit, for many details here included; to Fr. Shiple himself for an insight into what he accomplished.) R.I.P. *bafSJ*

FR. EDUARDO VITORIA, S.J., 1864-1958, CHEMIST

On September 22nd, 1958, the celebrated Spanish chemist, Fr. Eduardo Vitoria passed away at the age of 94 years in Barcelona, Spain. Fr. Vitoria was born in Alcoy (Alicante) and began his studies for a degree in engineering in Madrid when he was called to the Society of Jesus. After completing his ecclesiastical studies, however, he was sent to the University of Louvain where he received the doctorate in chemistry *with the greatest distinction.* He returned to Spain and founded the Laboratorio Quimico del Ebro in Tortosa in 1905. This was transferred in 1916 to Barcelona where it became known as the *Instituto Quimico.* The purpose of the Instituto was graduate work in chemistry, particularly research in preparation for the doctorate. Many hundreds of Spanish and foreign students have been trained there. Fr. Vitoria was a prolific writer. His bibliography up to 1945 has been published substantially (26 items) in this BULLETIN, *23*, 48-50 (1945). Items 189 to 193 incl. in the current instalment of *Jesuit Publications in Chemistry,* this issue, page 60, soon to appear in this BULLETIN, further document his work. He was founder and editor of *Afinidad,* a chemical journal. He also gave a large number of lectures, especially in South America, where his textbooks in many editions, as well as his other writings, had preceded or were to follow him.

Father Vitoria received many honors during his lifetime, among them the Presidency of the Royal Academy of Science and Arts and the Grand Cross of Alfonso el Sabio.

Fr. Miguel M. Varela, S.J., recently of Woodstock College, has published an article on Fr. Vitoria with portrait in the Journal of Chemical Education, *33*, 161-166 (1956).

Editor is indebted to the *Bulletin of the Albertus Magnus Guild* for Dec. 1958 for most of this notice. *bafSJ*

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REV. BERNARD A. FIEKERS, S.J.

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THE QUADRATIC APPROXIMATION IN CHEMICAL EQUILIBRIUM

Rev. Bernard A. Fiekers, S.J.

Most students of qualitative analysis are familiar with the formulation

$$x^2/(c - x) = k \qquad (1)$$

where c is the concentration of a binary electrolyte; x, the concentration of one, other or both ionic species; and k, the ionization constant of a weak electrolyte (pK 4 or greater). Recommended solutions for x are generally quadratic; sometimes the method of successive approximation, involving the elimination of denominator x only and successive substitution of the resulting x until its value repeats; or simply a first approximation of ignoring denominator x when this can be justified.

Alert students often call for a criterion to justify this third alternative. Such a criterion is the percentage error in c due to the neglect of denominator x. In order to control error in variables, rearrange equation (i) to the approximation in which denominator x is omitted:

$$x \cong (cK)^{1/2} \qquad (2)$$

then divide through by the concentration term and apply the 100 factor:

$$\%\text{error}_c = 100\ x/c \quad = 100\ (cK)^{1/2}/c \qquad (3)$$

$$= 100\ K^{1/2}/c^{1/2} = 100\ (KD)^{1/2} \qquad (4)$$

In words: the percentage error induced by neglecting denominator x is 1) directly proportional to the square root of the ion constant (and to the square root of the dilution, D, since D is the reciprocal of the concentration); but

2) inversely proportional to the square root of the concentration. Problem practice might choose percentage error for a given concentration, say 1 M, followed by further error evaluation on dilution for a given substance of fixed ionization constant.

The dilution part of the calculation is reduced to a comparison in which

$$(\%)\ (c^{1/2}) = (\%')\ (c'^{1/2}) \qquad (5)$$

For two pairs of values, the constant 100K cancels.

PROBLEM 1. Evaluate and compare (1st approx.) percentage errors in the hydrogen ion concentrations of 0.1M acetic acid and in 0.1M nitrous acid. $K_{HAc} = 1.82 \times 10^{-5}$; $K_{HNO_2} = 4.5 \times 10^{-4}$.

Solution 1:

HAc: $\% = 100(KD)^{1/2} = (1.82 \times 10^{-5} \times 10)^{1/2} \times 100 = 1.35\%$.

HNO_2: $\% = 100K^{1/2}/c^{1/2} = 100 \times (4.5 \times 10^{-4})^{1/2}/0.1^{1/2} = 6.71\%$

which illustrates both parts of equation (4). Comparison shows that the larger ion constant gives the larger error at identical concentrations. Most textbooks stress the point.

PROBLEM 2. Using data from problem 1, compare percentage errors in 0.1 and 0.001 acetic acid.

Solution 2:

By equation (5): $\%0.001 = 1.35 \times (0.1/0.001)^{1/2} = 11.35\%$.

This shows that a one hundredfold increase in dilution enlarges the percentage approximation tenfold (square-rootwise). Few textbooks stress this part of the problem. A likely reason for this is the common use of approximately tenth molar reagents and the avoidance of more dilute solutions on account of ion adsorption on glass or "glass-ion" contamination of dilute solutions, which the advent of polyethylene-ware may change.

It is further to be noted that this method involves approximations itself and that high percentage errors may involve equally high errors, due to the linear approach we have taken. All of this, however, provides practical background for the instructor and for his more inquisitive students.

PROBLEMS BASED ON CHEMICAL EQUATIONS. A CLASSIFICATION

Rev. Bernard A. Fiekers, S.J.

If the data in problems based on chemical equations involves weight data only, it can be classified as a weight/weight problem (W/W, as in Timm,* p. 124, no 3). If only volume data are involved, it is classified V/V (Timm, p. 125, no. 12). If only the number of moles is involved, it is classified n/n (Timm, p. 124, no. 7). The following diagram exhausts the combinations of these three types of data in basic problems.

W	V	n
W/W	V/V	n/n
W/V		V/n
	W/n	

Refer to the following examples: W/V, p. 124, no. 11; V/n, p. 124, no. 10; W/n, no example.

Where volume data are involved, problems can become complex when gas law data are included (p, T, partial pressure of water, standard conditions). The V/V type of problem is generally independent of such data. It is an application of Gay Lussac's Law of Combining Volumes. In the W/V type of problem which requires standard conditions, the use of the ideal gas law equation, $pV = nRT$, where $n = w/M$, permits the direct calculation of results more often than not.

SYLLABUS OF 16 MM. FILMS FOR BEGINNING CHEMISTRY

Rev. Bernard A. Fiekers, S.J.

1. SAFETY IN THE CHEMISTRY LABORATORY. (A-V Ctr., Indiana Univ.), 15 min., b & w, sound, rental $3.75 from Audio-Visual Center, Indiana University at Bloomington. Reviewed in Hormone, *20*, 33 (1957).
2. THE ANALYTICAL BALANCE. (Univ. Minnesota), 15 min., b & w, sound, Audio-Visual Center, University of Massachusetts at Amherst (restricted to subscribers, 1 unit). Reviewed in Hormone, *20*, 13 (1957) and in Jes. Sc. Bulletin, *34*, 67 (1957).
3. WEIGHING IS COMPARING. (Condor Film Ltd., Zurich—English sound), ca 10 min. color, sound, Audio-Visual Depart-

*Timm, John A., General Chemistry, 3rd ed., McGraw-Hill Book Co., Inc., New York, 1956.

ment, Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa. Excellent illustration of the dependence of sensibility on load in conventional balances. This balance is contrasted with almost automatic constant load/constant sensibility balance.

4. THE SLIDE RULE, Multiplication and Division. (Castle Film), 24 min., b & w, sound, Audio-Visual Center, University of Massachusetts at Amherst (not restricted); also A-V Ctr., Indiana University at Bloomington: rental $2.75 (USOE, 21 min.). Reviewed in Hormone, *20*, 13 (1957) and in JES. SCI. BULLETIN, *34*, 67 (1957).
5. A IS FOR ATOM. (John Sutherland Production for General Electric Co.), 16 min., color, sound, no. 2065, General Electric Co. (many cities), 140 Federal St., Boston 1, Mass.; also $1.00 rental A-V Ctr., Indiana Univ. at Bloomington. Reviewed in Hormone, *19*, 12 (1955).
6. CHEMISTRY OF FIRE. Damage Control, Reel A. (USN), ca 18 min., b & w, sound, (Mn 61-A in Holy Cross NROTC Film Library), U.S. Navy Training film from most naval bases. Reviewed in Hormone, *20*, 13 (1957) and in JES. SCI. BULLETIN, *34*, 67 (1957).
7. THE ULTIMATE STRUCTURE. (X-ray diffraction and x-ray spectrography), ca 25 min., b & w, sound, NORELCO, North American Philips Co., Inc., 100 East 42nd St., New York 17, N.Y. and Atlantex Corp., 625 McGrath Hwy., Somerville, Mass. Reviewed in Hormone, *20*, 13 (1957) and in JES. SCI. BULLETIN, *34*, 67 (1957).
8. EYE TO THE UNKNOWN. (Mass Spectrograph). 33 min., color, sound (produced by Jack Copeland & Assoc. for Consolidated Dynamics Corp.), Modern Talking Picture Service, Inc., 3 East 54th St., New York 22, N.Y. and available (many cities) Ladd Visual Service, 235 Stuart St., Boston, Mass. Reviewed in JES. SCI. BULLETIN, *35*, 43 (1958).
9. BEYOND URANIUM. (KQED-TV, San Francisco, Cal.) 30 min., b & w, sound, Audio-Visual Ctr., Indian University in Bloomington, $5.00 rental.
10. CHEMICAL INSTRUMENTS. (University of Southern California), 14 min., color, sound, Audio-Visual Ctr., University of Massachusetts at Amherst (Restricted to subscribers, 2 units). Reviewed in JES. SCI. BULLETIN, *35*, 44 (1957).
11. PRINCIPLES OF CHROMATOGRAPHY. (Whatman, England). 20 min., color, sound, Dept. F, H. Reeve Angel and Co., 52 Duane St., New York 7, N.Y. Reviewed in JES. SCI. BULLETIN, *34*, 112 (1957).

FURTHER REEL AND FILM NOTES

Chemistry in College, prepared in 1956 by the audio-visual film unit of Indiana University, surveys the laboratory and class work that is included in a college major in the field of chemistry; points out related courses as well as those that provide opportunities for a well rounded education; and is designed for guidance counselors. Presumably this film is available by rental from the Audio-Visual Center, Indiana University Bloomington, Indiana.

Assignment Weights and Measures, 16 mm. color, sound, 16 min., and *Understanding the Physical World through Measurement*, similar, 33 min., are available on loan from the National Bureau of Standards, along with other such films by writing to NBS office of Technical Information, Washington 25, D.C.

The new Bell System Science Series Program, *Gateways to the Mind*, as well as previous films of the TV series are available for free loan. Apply to local Bell Telephone Co. offices for the address of the regional area distributor or write to the Am. Tel. & Tel. Co., Motion Picture Section, 195 Broadway, New York 7, N.Y.

The foregoing notes have been culled from letter of R. E. Henze, Am. Chem. Soc., letter of Dec. 10, 1958, to members of LS committees on education and manpower. *bafSJ*

TRANSFORMATION METHODS IN ANALYSIS

FREDERICK A. HOMANN, S.J.

Introduction. Two previous papers in this BULLETIN (Functional Analysis and Approximation Methods, *34* (1957), p. 83 ff., and Extremal Methods in Analysis, *35* (1958), p. 74 ff.) discussed procedures for solving certain types of problems in analysis. The first paper indicated how linear problems involving such concepts as finite or infinite matrices or integral equations might be solved by introducing approximating problems whose solutions were accessible, and in some sense not too far from the solution to the original problem. The second paper dealt with variational methods and studied problems whose solution was also that of a properly chosen and more readily solvable problem in the calculus of variations. Both techniques are particular instances of transformation methods in mathematical analysis and schematically they follow this pattern:

$$\begin{array}{ccc} \text{Problem} & & \text{Problem Solution} \\ \downarrow & & \uparrow \\ \text{Transformed Problem} & \longrightarrow & \text{Transformed Problem Solution} \end{array}$$

The present paper discusses some additional examples of this procedure again with emphasis on the characteristics of the method rather than on details of the specific instances.

Some Elementary Examples. A simple example of transformation methods is afforded by the computational use of logarithms. As is well-known they convert a multiplicative problem (one involving products and powers) into an additive problem (one involving sums and multiples). The latter is easily solved and the antilogarithm of the solution then answers the original problem. The first characteristic of this procedure is that the transformation is a "natural" one when viewed in light of the theory of exponents. For (in an extended problem) it is far easier to accomplish the additions and multiplications demanded by the underlying algebra of exponents than to perform the operations initially indicated. However such computational facility does have its price: logarithms generally are irrational numbers and any table of them can have only limited accuracy. In turn this implies that our answers are of limited accuracy even though a solution obtained by direct means might have been exact. Still the distortion introduced by conversion to logarithms is a small price to pay for the relatively easy resolution of a problem which might not even yield to a direct attack.

The next transformation method to be considered occurs in a classical theorem of Green relating line integrals and double integrals. Specifically, if the real functions $f(x,y)$, $g(x,y)$, $\delta f/\delta y$ and $\delta g/\delta x$ are continuous and single-valued over the closed plane region R bounded by the curve C, then

$$(1) \qquad \int_C f(x,y)\,dx + g(x,y)\,dy = \int\int_R \left(\frac{\delta g}{\delta x} - \frac{\delta f}{\delta g}\right) dxdy,$$

where the line integral is taken in the positive sense. Actually the transformation expressed in (1) is a particular case of a more profound relation in the theory of exterior differential forms defined on a manifold; in this context the transformation reflects the structure of the system and is therefore a natural one. (Needless to say, this is hardly apparent to the student in a calculus class who tends to look on the result as a handy if unintelligible trick.) There is no need to enumerate here the many theoretical and practical advantages arising from the possibility of replacing a double integral problem by a single integral problem and vice-versa. Rather, let us observe that in contrast to the first example, use of Green's transformation in a computational problem does not affect the accuracy of the answer, but that the limitation of the method lies in the (sufficiency) conditions imposed. While logarithms could be used successfully in any multiplicative problem, the validity of Green's transformation is guaranteed only under the restrictions stated.

These examples, and those in the papers cited previously, make it clear that a significant transformation method is founded on the structure of the involved system, and shifts the difficulty in the original problem to a place where it can be resolved with appropriate techniques. Ordinarily to accomplish these aims limitations are imposed either on the range of problems handled by the method or on the accuracy of the results. In this way theoretical and practical studies have a point of contact. For historically a number of these methods arose from problems in physics and astronomy. They were applied pragmatically in many instances, and with an imperfect knowledge of their underlying principles. Of course it was only with the study of the latter that the power and limitations of the method were understood. Sometimes too in the course of such research related methods were developed with comparative ease. Heaviside's operational calculus, first applied blindly to problems in electric circuit theory and later refined by mathematicians, provides a good example. We will not discuss this method, but in the next section will examine operational methods based on the Laplace transform.

Integral Transforms. It is instructive to consider next the method of integral transforms which is an important tool of present day research. From a theoretical point of view the method is of considerable use in the study of abstract function spaces, while in applied fields it is being used in an ever-widening circle of problems involving differential and integral equations. Naturally practical and theoretical developments stimulate each other. There is a variety of integral transform methods associated with the names of Laplace, Fourier, Hankel, Hilbert, and Mellin, among others. In this paper our attention will be confined to the Laplace transform which is typical and illustrates the basic ideas. It is defined as follows. If $f(t)$ is a function integrable (either in the sense of Riemann or Lebesgue) in every finite range (O, T), $T > O$, and if the improper integral

$$L_f(s) = \lim_{T \to \infty} \int_O^T e^{-st} f(t) \, (dt)$$

exists for at least one value of s, real or complex, the $L_f(s)$ is by definition the Laplace transform of $f(t)$. Thus for $f(t) = 1$, $L_f(s) = 1/s$ for $Re(s) > O$, and for $f(t) = e^{-t}$, $L_f(s) = 1/(1 + s)$ for $Re(s) > -1$. The transformation is linear, that is, the transform of a sum of elements is the sum of the transforms of each element, provided they exist. Suppose also that $df/dt (= f')$ and its Laplace transform exist. Then integration by parts shows that

(2) $$L_{f'}(s) = sL_f(s) - f(O).$$

Higher derivatives, if they exist, are handled by repeated integrations by parts. Hence the transcendental operation of differentiation of $f(t)$ corresponds to an algebraic operation under the transformation, that is, a problem in calculus becomes a problem in algebra. This has far-reaching applications for the solution of certain classes of problems in differential equations. For example, consider the simple initial value problem of finding $f(t)$ defined in the neighborhood of $t = O$ such that

(3) $$df/dt + f(t) = 1$$

and $f(O) = 3$. A result of Picard, fundamental in the theory of differential equations (it is discussed in detail in the next section), guarantees the existence of $f(t)$, but says nothing about the existence of its Laplace transform or that of its derivative. Let us assume that they exist and work formally, reserving justification for this procedure until later. First, the differential equation is transformed into an algebraic equation by taking the transform of both sides of (3):

$$L_{f'}(s) + L_f(s) = L_1(s).$$

Then, using (2) and noting that $f(O) = 3$, we solve algebraically for $L_f(s)$:

(4) $$\begin{aligned} L_f(s) &= (L_1(s) + 3)/(1 + s) \\ &= 1/s + 2/(s + 1). \end{aligned}$$

The solution of the algebraic problem is now converted to the solution of the differential equation. It is easy to see that the function whose transform is (4) is

$$f(t) = 1 + 2e^{-t}.$$

This is verified directly as the solution of the initial value problem, and so the formal procedure is justified.

Although the example is trivial, the method itself is important for equation of higher order, and extensive tables of transform pairs have been prepared for its use. Its scope may be seen by consulting R. V. Churchill's text "Modern Operational Mathematics in Engineering." For the present study the method is of interest as a case in which the use of a transformation is justified by the result. This is not to imply by any means that the method is an artificial one. Actually it is based on the properties of appropriately chosen function spaces and their linear transformations. However these are not yet completely understood. In particular it is difficult to determine whether or not the solution to the problem is an element of the function space on which the transform is defined. Present theory does not provide any general criterion and the answer comes ordinarily only with the solution to the problem. In a large number of applied problems such formality provides no difficulties, and this accounts for the present popularity of transform methods in applied fields.

The Method of Integral Equations. We have now considered the characteristics of transformation methods which change multiplicative problems to additive ones, single limit processes to double limit processes, and transcendental problems to algebraic ones. As a final example we discuss a transformation method which changes a local problem to a global one. This occurs in the Cauchy-Picard theorem for the differential equation $y' = f(x,y)$ in which the existence of a solution is shown by transforming the differential equation (which, like the derivative, is necessarily a pointwise or local phenomenon) to an integral equation (which, like the integral, is a phenomenon defined for a set or globally). This is the Cauchy-Picard result: Let $f(x,y)$ be continuous in x and y in the rectangle $x_0 - a \leqslant x \leqslant x_0 + a$, $y_0 - b \leqslant y \leqslant y_0 + b$, and such that for all x in the rectangle $|f(x,y_1) - f(x,y_2)| \leqslant K|y_1 - y_2|$, K a positive constant. Then in some interval $-c < x - x_0 < c$ (usually $c < a$), there exists a function $g(x)$ such that 1.) $g(x_0) = y_0$, 2.) $-b < g(x) - y_0 < b$, 3.) $dg/dx = f(x, g(x))$.

To prove the theorem we transform the problem into an equivalent problem involving an integral equation. To show the equivalence we first suppose that $y(x)$ satisfies $y' = f(x,y)$ and $y(x_0) = y_0$. Integration gives the equation

$$y(x) = y(x_0) + \int_{x_0}^{x} f(t, y(t))dt.$$

Any existing solution of the differential equation satisfies this equation, and conversely if $y(x)$ satisfies the integral equation it also satisfies the differential equation as is seen by differentiating the former with respect to x. This proves the equivalence of the two formulations.

Next an iteration process is set up which gives a sequence of functions whose limit is a solution of the integral equation. Thus, let $M = \max|f(x,y)|$ in R, and let $c = \min(a, b/M)$, and confine x to the interval $-c < x - x_0 < c$. Under these restrictions the following definition is meaningful for all non-negative integral n:

$$g_0(x) = y_0,$$

$$(5)\ g_{n+1}(x) = y_0 + \int_{x_0}^{x} f(t, g_n(t))dt,\ n = 0, 1, 2, \ldots .$$

Elementary estimates based on the hypotheses of the theorem show that

$$|g_{n+2}(x) - g_{n+1}(x)| \leqslant K \int_{x_0}^{x} |g_{n+1}(t) - g_n(t)|dt.$$

Hence

$$\sum_{n=0}^{\infty} (g_{n+1}(x) - g_n(x)) \tag{6}$$

is dominated by the convergent series of constants

$$b \sum_{n=0}^{\infty} (KC)^n/n!$$

Thus the differences $g_{n+1}(x) - g_0(x)$ which are the partial sums of (6) approach a limit, so that $g_{n+1}(x)$ also approaches a limit, call it $g(x)$. Moreover the uniform convergence of the sequence can be shown by the Weierstrass M-test. Under these circumstances it is possible to interchange limit and integral in (5) to get

$$g(x) = y_0 + \int_{x_0}^{x} f(t, g(t))dt. \tag{7}$$

Clearly $g(x_0) = y_0$. Differentiation of both sides of (7) is justified, and this gives

$$dg/dx = f(x, g(x)).$$

So $g(x)$ is the function we seek, and this completes the proof of the theorem. Under the same hypotheses it can also be shown that the solution is unique.

It is interesting to note the exploitation of the properties of the integral. Estimations on the values of approximating integrals are possible, limit and integral are interchanged at one stage, and later the integral is differentiated with respect to a variable limit of integration. By way of comparison the differential equation does not give us the same facility in estimating approximations to the derivative, nor do we have any assurance of the existence or continuity properties of higher derivatives. Transformation to an integral equation allows us to use advantageously the smoothing properties of the integral and the relatively simpler theory of integration.

Conclusion. These examples are only a small part of the variegated transformation procedures used in modern analysis. It is hoped that the present discussion gives some light on their underlying unity of motivation and structure. By way of bibliography, let it be said that a comprehensive survey of integral transforms is had in the two volumes of the Bateman Manuscript Project entitled "Tables of Integral Transforms". The Laplace transform in particular is the subject of a treatise by D. V. Widder in the Princeton Mathematical Series, while the Cauchy-Picard theorem receives detailed treatment in the "Theory of Ordinary Differential Equations" by Coddington and Levinson.

A CLASSROOM NOTE ON THE NATURAL NUMBERS

Abstract

JAMES F. SMITH, S.J.

Let N be a set of elements $\{m, n, \ldots\}$, to be known as *natural numbers*, such that the following three postulates hold:

P1. To each $n \in N$ there corresponds a uniquely determined element $s(n) \in N$, called the *successor of n*.

P2. Every nonempty subset M of N contains an element that is not the successor of any element of M.

P3. N contains a unique element, designated as 1 (*one*), that is not the successor of any element of N. (Hence N is not empty.)

From these three postulates there follow these fundamental theorems:

Theorem 1 (*Principle of Finite Induction*). If M is a subset of N which contains the successor of each of its elements, and if $1 \in M$, then $M = N$.

Theorem 2. If $s(m) = s(n)$, then $m = n$.

The Peano postulates are readily recognizable as the propositions here denoted by the labels P1, P3 (apart from the notion of uniqueness), Theorem 1, and Theorem 2. For proofs of P2 and the uniqueness property of P3 under the Peano assumptions, the reader is referred to L. M. Graves, *The Theory of Functions of Real Variables* (2d ed., McGraw-Hill, 1956), pp. 18 f. The purpose of the present paper is to supply the remainder of the proof for an assertion of Graves that the above axiom-system is equivalent to that of Peano. This is accomplished by showing that Theorems 1 and 2 are implied by the postulates P1, P2, and P3.

DOCTORATE DEGREES IN SCIENCE AMONG JESUIT ALUMNI

REV. BERNARD A. FIEKERS, S.J.

Data in the accompanying table have been culled from *Doctorate Production in United States Universities, 1936-1956*, publication no. 582 of the National Academy of Science and the National Research Council (Trytten Report), Washington, D.C., 1958. This survey is concerned with earned doctorates in academic fields and does not cover medicine, law and the like. Data in the table are limited to the baccalaureate origins of doctorate degrees, while the source report also lists the doctorate granting institutions. Legend for the entries follow.

Northwest corner gives the number of alumni doctorates;

Northeast corner gives the rank or place among other schools on *this* list;

Southeast corner, the number of schools in the nation having alumni doctorates in the fields tabulated;

Southwest corner gives the school's rank or place among

Note that doctorates in biochemistry come under the biological science doctorates in the original report, but have been noted (+) under chemistry here as a separate item, since most biochemical doctorates were thought to originate in the chemistry departments of most of our schools. Combined ranks for both chemistry and biochemistry have not been attempted.

Frequency tables in the source report tabulate the number of institutions from which the same number of degrees in a given field originate. In order to determine the rank or place of a given institution, the sum plus one of all institutions of higher rank or place in the table was taken. This might have led to slight inaccuracies in a few cases, as anyone who makes a close study of the original report can see. Etxra work to obviate such slight error did not seem to be called for.

In constructing this table, Jesuit institutions showing fewer than fifty over-all alumni doctorates were not included. Further it would be quite a sizable task to find the standings of institutions *relative* to the number of graduates they produced over this twenty-one year period and thus give due credit to the qualitative work of each of our colleges, apart from this emphasis on quantity. The time lag between bachelor and doctorate degrees alone would complicate such a task tremendously.

A previous study of this sort appeared in this BULLETIN, *26*, 116 (1949), and covers the first Trytten report for the years 1936-1945

	Maths.		Phys. and Astron.		Chem. and Biochem.		Total Biol.		Total Nat. Sci.		Total All Fields	
Boston	2	6	13	1	32 + 4	3	13	6	64	4	193	3
College	195	469	87	576	103	704	188	769	141	903	105	1177
Canisius	2	6	8	4	20 + 2	6	7	10	37	9	64	11
College	195	469	106	576	155	704	305	769	212	903	281	1177
Creighton	3	3	1	11	10 + 4	12	11	8	26	11	60	12
University	147	469	357	576	271	704	211	769	278	903	295	1177
University of	2	6			20 + 2	6	7	10	39	8	65	10
Detroit	195	469			155	704	305	769	207	903	277	1177
Fordham	2	6	7	5	48 + 12	1	50	1	109	1	271	1
University	195	469	138	576	66	704	76	769	92	903	73	1177
Georgetown			5	6	14 + 2	10	11	8	32	10	94	6
University			183	576	208	704	211	769	244	903	202	1177
Gonzaga	3	3	2	9	10 + 0	12	3	13	19	13	84	7
University	147	469	286	576	271	704	466	769	356	903	227	1177
College of the	3	3	4	8	22 + 3	5	12	7	41	7	83	8
Holy Cross	147	469	207	576	141	704	200	769	199	903	229	1177
Loyola (Chicago)	5	2	1	11	18 + 4	8	17	5	43	6	130	4
University	96	469	357	576	173	704	158	769	189	903	153	1177
Marquette	1	11	5	6	23 + 1	4	34	2	73	3	123	5
University	278	469	183	576	136	704	92	769	130	903	164	1177
St. Louis	8	1	12	2	34 + 3	2	24	3	87	2	229	2
University	60	469	93	576	97	704	120	769	111	903	83	1177
Scranton			11	3	16 + 4	9	18	4	46	5	70	9
University			98	576	190	704	143	769	182	903	265	1177
Xavier (Cinn.)	2	6	2	9	14 + 2	10	6	12	26	11	55	13
University	195	469	286	576	208	704	327	769	278	903	316	1177

inclusive. Its data have been quoted in the *J.E.A. Bulletin* and other domestic literature. It is gratifying to see the improved showing of our colleges over the period 1946-1956 inclusive, which can be deduced by difference.

Other surveys of the present Trytten report include a very comprehensive one for Catholic Colleges from the office of Fr. W. V. E. Casey, academic vice-president of Boston College; and one in mathematics from Dr. Patrick Shanahan of Holy Cross, dealing with Catholic mathematicians and including data on the master's degree also.

(*Continued from page 57*)

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