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THE MASTER MOLECULE
RESONANCE SPECTROSCOPY
PSYCHOLOGICAL SPEECH COMMUNICATION
EYES MADE FOR DARKNESS Westinghouse scientists expect that airplane pilots are going to be able to see the ground clearly on a cloudy, moonless night. Astronomers will be able to see vastly beyond the present range of their telescopes, perhaps to the final boundary of the universe, if there is one. Policemen will peer into dark alleys and see through special binoculars. Scientists at Westinghouse are working on the proposition that no matter how dark it looks to us, there is plenty of “light” everywhere: on a black night, in a coal mine, in a sealed room. We just have the wrong kind of eyes to see it all. So they have developed a device that “sees” infrared light which we can sense only as heat...another device that “sees” ultraviolet light, which we can detect only when it gives us sunburn...still another that picks up a single “packet” of light, the smallest amount that can exist, and multiplies it into a visible flash. You can be sure...if it’s Westinghouse

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Cover Note
ROSE POLYTECHNIC INSTITUTE
Terre Haute, Indiana

HIGH SCHOOL GRADUATES OF 1963

You are cordially invited to visit Rose Polytechnic Institute where you can earn a degree in:

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MATHEMATICS
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"attitude check"

The present atmosphere of suspicion and concern into the nature of a student's attitude is not normal and not to be expected at a small school where ideally student-faculty relationships should be cordial if not close. From my point of view both students and faculty are at fault. I do not believe that an inquisition into a student's attitude is a necessary part of his schooling.

From the student's point of view, the student's attitude cannot be extremely poor just by the nature of the school. For one thing, Rose is not a play school, either in reputation or reality. Also, engineering educations can be had at cheaper cost and less sacrifice. The willingness of the students to make Rose so much a part of their lives speaks well for their desire to be superior in the engineering profession. A student's willingness to undertake the necessary steps towards understanding of a subject, i.e., preparation for class and examinations is the limiting factor. This is as can be seen, only one aspect of a student's attitude.

From the faculty point of view, a class instructor has the right to expect up to and including two hours of efficient preparation for an hour of credit. He has the right to look for creative thinking as opposed to mere attendance from those students seeking above average recognition.

The clear perceptions by both students and faculty of these two points of view cannot help but make the situation less critical.

R. R. F.

the throng thing

There has been some talk in the past that has filtered down through the student body concerning required attendance at convocations. Thankfully, this has never materialized.

It seems as though there are many reasons why everyone should be happy that convocations are still a matter of personal preference. First of all, the convocations committee should feel very proud when the programs, offered as convocations, are well received; but they could feel little pride to see a full auditorium of "required attendance" bodies. And the school should be proud that, in a day when everyone from the federal government to the local HELP organization minds everyone else's business, the art of free choice is still taught and encouraged on our campus. The student body also should be pleased that they have the prerogative of all their leisure time. This situation seems to make it easier and more pleasant for all parties concerned.

If the government were handling the problem, possibly they would say, "Convocations are good for everyone; everyone doesn't attend; we'll enforce attendance whether everyone wants it or not." There certainly is the argument that part of the funds of the Institute are directed toward acquiring enjoyable entertainment for the student body. So it is somewhat unjustified to provide money to support a program designed for every student when very few participate.

But it has been our observation that participation in the convocation program has been better for the past few convocations than it has been for quite some time. The quality of the programs, and particularly their appeal to an engineering college, play no small part in bringing about the increased attendance. So let's hope that if the "free choice" or "pride" arguments do not settle the hearts of those who might want to enforce attendance, the new throng of participation will quell the required-attendance idea for a long time.

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To a casual visitor, the most attractive feature of Rose is perhaps its campus—certainly one of the finest in the country. A far-sighted policy of the Board of Managers and the administration early in the century, together with the generosity of the Hulman family, resulted in the acquisition of a suburban campus which compares favorably with those of Haverford, Hanover, Lawrence or Lake Forest, to name some of the best.

The effectiveness of the Rose campus as an educational environment, however, still leaves much to be desired. The lack of co-eds (as noted in a recent issue), unfortunate as this may be, is not of necessity a high priority matter. A number of excellent schools, such as Dartmouth, Cal Tech, Wabash and Harvard College, manage very well without them.

For a student's years at Rose to be as meaningful as possible, the college must develop an educational community designed for the express purpose of facilitating the broadest kind of education — intellectual, social, cultural and physical. The comparative isolation of the campus provides both the need and the opportunity for what might be termed a total educational environment of a kind impossible in large schools such as Purdue or Illinois, or in urban schools such as M.I.T. or Case.

Rose does not intend to operate in isolation — to cut itself off from Terre Haute or the community. Aside from other considerations, there would be no point in duplicating bowling alleys or similar recreational facilities which already exist. But our dormitories, our athletic plant, our reading and study facilities, our laboratories, and our teaching equipment must be not just good, but the best. This does not mean the most expensive or the most luxurious. In fact, Rose has always leaned toward a kind of Spartan simplicity which has important virtues which must not be lost. Our objective should be, however, to provide a campus that is effective, stimulating, and aesthetically satisfying.

Starting a new decade of expansion provides an opportunity for our engineer-architects to take advantage of new materials and new concepts, and for the faculty to utilize the latest developments in laboratories, classrooms and teaching devices. The Rose concept of excellence in science and engineering should be fully reflected in its plant.
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Jim Koller, 25 years old, came to American Oil right out of the University of Wisconsin where he earned his Bachelor of Science degree in Chemical Engineering. An Evans Scholar at Wisconsin, Jim describes his job at American Oil this way: “I work on basic chemical engineering problems, specializing in reactor design and process development problems. Before a process can go commercial, it must be tested in pilot plants. That’s where I come in.” Jim wants to stay in the technical research area, and plans to enroll in the Illinois Institute of Technology night school for courses in advanced mathematics.

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- Solid propellants for use with missiles
- Design and economics: new uses for present products, new products, new processes
- Corrosion mechanisms
- Development of new types of surface coatings.
the rainbow

by Will Stratten
Junior Physics

Object:
In the present age of manifold dilemmas of the complex world, I might be prejudiced enough to say that the student is burdened with the majority; but I will limit myself and say that the student has several. One of the major perplexities of the successful student is "psyching-out" the instructors. A very illustrative example is the "scholar" who is required to submit a formal report on one of his laboratory projects. The question arising concerns the mentality and the scholastic background of the reader. Should the paper be put in "See Spot run" language or should you dig out all the technical material and try to snow your professor and at the same time chance illustrating your ignorance by using material which you do not understand? Well, the answer is obvious; use both and be sure. A good example follows in the introduction-history-theory format of such a report.

Introduction:
Taking the statement of C. Sharp Cook, the covering of the subject of modern physics has one of two purposes. First, to give a base to a student planning advanced study; or second, to acquire a speaking acquaintance with the structure of the atom.

The guy who wrote my book in this course says that I should learn something, and that something should be about the atom. An atom is a little speck of something that everything is made of, like one grain of sand in a mountain of sand.

In the introduction to the subject, the easiest and most logical step is to acquaint yourself with the simplest structure, the hydrogen atom. It is basically a two body system of a nucleus having a positive charge (proton) and a much smaller electron with equal and opposite charge. It seems that classical mechanics could be easily applied. In this experiment we will use the basic theory put forth by Bohr for the hydrogen atom, to compare the masses of hydrogen and deuterium. Deuterium is the second most elementary atom with a proton and a neutron in the nucleus and one electron. Both elements are hydrogen-like and after looking at the theory, should conform to Bohr's theory.

The first step will be to talk about an atom of hydrogen. Hydrogen is a gas, like air. Air is a lot of atoms scattered in space. Hydrogen is made of two balls, a little one spinning around a big one. The big one has one kind of charge and the little one has a different kind. Charge is the stuff that lets you pick up little bits of paper with a comb after combing your hair. This experiment uses the ideas of a man named Bohr who says that when the little ball jumps nearer or farther from the big one, wavelengths of certain length are given off. Wavelengths are like different colors of light. We use this experiment to compare the masses of hydrogen and another gas deuterium because we can't weigh them on a scale. Deuterium is supposed to have two big balls in the middle and a little one spinning around them. One of the big balls has no charge.

History:
Spectroscopy has contributed considerably to the study of atomic structure. It began in 1666 when Sir Isaac Newton discovered that different colors were refracted at different angles through a prism. With the study of the sun's spectrum the Fraunhofer lines were mapped. Kirchoff put forward his absorption law and from it were developed the following: (1) The rays emitted by a substance excited in some way or another depend upon the substance and the temperature; and (2) every substance has a power of absorption which is a maximum for the rays it tends to emit. The first is of the greatest significance to us.

When the light shines through a prism it makes a rainbow, somehow this same sort of thing can let men study how atoms are made. Sir Isaac Newton, the guy who had the apple fall on his head, showed that certain colors always went off in a certain direction. When the light from the sun was looked at, some rules were thought up that the light seemed to obey. I couldn't understand them.

In 1882 a beginning of a new era in spectroscopy was marked with Rowland's development of his ruling engine and good gratings. It was with the use of such equipment that Balmer discovered the existence of a hydrogen series in 1885. In this year Balmer stated a simple relation defining these lines.

In 1882 a new way to make a thing called a grating was invented. The grating did the same thing to light that the prism did. A guy named Balmer then thought up a plug which told where these lines were on the film which took the picture of the rainbow. He must have been a genius.

With the introduction to the quantum theory by Planck in 1900 in his derivation of the law of "black-body" radiation, it was postulated that radiated or absorbed energy is a whole multiple of an elementary quantum of energy. Making use of this hypothesis, Bohr developed the theory of the hydrogen atom.

In 1900, Mr. Planck, another genius, made a law which said that when the small ball jumped around, it gave off or took some energy, which was related to the color of the light.

(Continued on page 29)
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the master molecule

by Curt Jones
Jr. Ch.E.

Man has always been characterized by an insatiable quest for knowledge concerning his environment, both macroscopic and microscopic. Never before have scientists touched upon a field of study which brings them so near to satisfying that quest. Their subject is deoxyribonucleic acid, known as DNA. It is believed that through the study of DNA scientists will someday break the most wondrous and mysterious code on earth — the code of inheritance. Even more important is the possibility that they will discover the secrets of DNA which are now known to be the very basis of life itself. Many scientists in the fields of virology, biochemistry, and genetics are engaged in research with DNA, striving to solve the mysteries of heredity and of all living matter.

Very little was known about DNA until the middle of the twentieth century. However, in 1868, a chemist named Frederick Miescher unknowingly performed experiments with DNA. He found that a dark, insoluble sediment always remained after living matter was soaked in acids and shaken in ether. He then surmised that this substance might
have something to do with heredity, but his knowledge was too limited to enable him to follow up this hunch.\footnote{Rutherford Platt, “DNA, The Mysterious Basis of Life,” Reader’s Digest, (October, 1962), p. 142.}

Early in the twentieth century, scientists using their most powerful microscopes could only detect very fuzzy images of what they believed to be the genes of heredity. Finally in 1951, Dr. Maurice Wilkins of King’s College, London, was able to bounce X-rays off a DNA molecule and onto film.\footnote{“Biology’s Rosetta Stone,” Newsweek, 60 Oct. 29, 1962), p. 83.} In this manner he was able to obtain a hazy visualization of the structure of a DNA molecule. Two years later, Dr. Wilkins, again using X-rays, was able to catch the reflections of the atoms of a DNA molecule.\footnote{Platt, p. 142.} During the same year, Drs. James Watson and Francis Crick constructed a model of the DNA molecule which aided other scientists in linking the pieces of the DNA puzzle together. Since these initial disclosures, the advances in the study of DNA have been so numerous and so rapid that one could keep abreast of them only by noting day-to-day progress in the field. For this same reason, this paper will probably be outdated upon its completion.

Scientists have proposed various theories for the creation of DNA, but most of them are expressed in the theory presented by Dr. Nils A. Barricelli of Vanderbilt University. He states that DNA probably evolved out of simpler, self-reproducing molecules that struggled with each other for the chemicals of life on the surface of the primordial sea. The winners grouped together into the DNA system which then eradicated every competitive system of life on the earth. Then the DNA, by cross-breeding and accidental changes, gained new powers of growth and new complexities, eventually producing cells. Later, by the same process, DNA produced organs and organisms.\footnote{Ibid., p. 148.}

Although DNA is a somewhat complicated molecule it is composed of only five common chemical elements: hydrogen, oxygen, carbon, nitrogen, and phosphorous. These elements are combined in different chemical groups so that they ultimately form a double helix structure. (See figure 1). The double helix resembles a twisted ladder. The two chains of the molecule are made of alternate sugar (deoxyribose) and phosphate groups, the phosphate group being composed of a phosphorus atom surrounded by four oxygen atoms. The chains are held together at regular intervals by crosslinks, called nucleotide bases, which are of specific composition. All of the bases contain nitrogen, which gives them their basic properties by virtue of the two free electrons on each nitrogen atom. (Bases are electron donors.) There are only four specific kinds of nucleotide bases in the DNA molecule. They are: adenine, thymine, guanine, and cytosine. Each crosslink actually

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![Diagram of DNA structure](image-url)
consists of two nucleotide bases, and there may be many thousands of these crosslinks in a single DNA molecule.

Drs. Watson and Crick found through experimental methods that in every DNA molecule the amounts of cytosine and guanine and of thymine and adenine were always the same, but that the two pairs referred to above did not necessarily exist in the same proportions. From this evidence, they proposed the Specific Pairing Hypothesis, which states that cytosine pairs only with guanine and thymine only with adenine.\(^5\) The cytosine is held to the guanine by three weak hydrogen bonds, and the thymine is held to the adenine by two such hydrogen bonds. (See figure 2.) Each crosslink is thus either cytosine-guanine or thymine-adenine. The crosslinks are joined to the two chains of the double helix only at the sugar molecules. Therefore, the phosphate sections of the chains are never connected to the nucleotide bases of the crosslinks. The entire structure of the DNA molecule with its long chain of repeating units, with side groups attached, is referred to as a long chain polymer.\(^6\)

DNA has two basic functions which it must perform in human beings and animals. First it must pass on all hereditary information from parents to their offspring. Second, it must direct the formation of proteins, which are basic to life.\(^7\) DNA must have a composition that will vary at will. It must also be able to initiate all the different chemical processes involved in cell chemistry. Finally it must have the power of self-multiplication. In plants, DNA still performs essentially the same two functions. However, hereditary traits are not transferred by means of a reproductive system like that of animal life.

DNA acts very similar to a computer, i.e., it stores a tremendous number of directions and issues them at the precise time and place to start the building of all cells and structures within a body, to make them grow, and to synchronize their operations at every instant during their lifetime. DNA exists in all living cells except red blood cells and certain viruses. Scientists theorize that if the instructions in the DNA of a single human cell were put into English, they would fill an entire one-thousand volume encyclopedia; and there are approximately sixty-trillion living cells in an adult human.\(^8\) The above is indicative of the vast command system incorporated into a single molecule of DNA.

Each of the cells of a living body is made up of two main portions, the nucleus and the cytoplasm, which is the outer portion of the cell. The cytoplasm is the region in which most of the cell's activity takes place. It is sometimes referred to as the factory of the cell.\(^9\) The nucleus of the cell controls all the cell's activities, including cell multiplication. Inside the nucleus are contained the chromosomes, which are the largest units that exercise control over hereditary characteristics. The normal chromosomes themselves are made up of smaller units known as genes, which are strung out along the chromosome like beads on a string. Each gene is made up of a nucleic acid and is responsible for a distinct hereditary characteristic.\(^10\) Most of the genes are made of DNA, while some viruses have genes consisting of another less complicated type of nucleic acid. The way in which the DNA is packed into a chromosome still remains an unsolved problem. One thing scientists are reasonably sure of is that it must be packed very tightly, for it is estimated that one human cell contains enough DNA to measure almost two yards if stretched to full length.\(^11\) Some suggest that the chromosome may contain two twisted chains, while others suggest up to sixty-four chains. An alternative idea is that the chromosome may have a central core to which a number of DNA helices are attached.\(^12\) Perhaps the arrangement of DNA within a chromosome, when learned, will assist scientists in unraveling the unknown facts concerning the exact function of genes and their actual size.

When examining the importance of DNA in the processes of life, one should consider two basic cell activities, those of meiosis (sexual reproduction) and mitosis (cell division). These will be considered separately since they each involve a different aspect of DNA.

In sexual reproduction the sperm joins the egg of the same species and DNA from each parent forms the code for a new life. The sperm and egg each contain twenty-three chromosomes and thus exactly half the DNA present in other body cells.\(^13\) When they unite, the resultant cell contains the natural complement of forty-six chromosomes and DNA from each of the parents. In the development of the sperm and the egg, twenty-three pairs of chromosomes, called bivalents, divide to make two cells with twenty-three chromosomes each. This process known as meiosis occurs only in the formation of the sperm and egg.\(^14\) In the above manner the parents pass their hereditary characteristics to their children. It is easily seen that, since the DNA in every chromosome differs in some way from every other DNA, no two children are born with exactly the same characteristics. Once the first cell of a new life is propagated, all the cell division (mitosis) ensues with the new DNA's containing exactly the same information as the beginning DNA's. The activities involved in cell division are decidedly more complicated than those in sexual reproduction. When the home cell begins to divide, the DNA within the chromosomes untwists and separates, leaving two separate chains having a particular sequence of nucleotide bases connected to it. Each of these chains attracts groups from the fluid sur-

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6 Ibid., p. 18.
7 Ibid., p. 14.
8 Platt, p. 144.
11 Hutchins, p. 12.
12 Ibid., p. 40.
13 Hutchins, p. 39.
14 Ibid., p. 38.

(Continued on Page 33)
The October, 1959 issue of the Technic contains an amusing article written by Prof. A. R. Schmidt. This article displays the ability possessed by Prof. Schmidt which makes him a favorite of Rose students.

Much Ado About Nothing

Scribbled by Al Schmidt, Prof.

[Editor's note: As in all worthwhile writings, footnotes should be read where they occur.—For the Editor, ARS.]

Having just completed a mil\(^1\) of college teaching, it seems appropriate to reflect a bit on the business of college education today as contrasted with "back when I was in school." (Admittedly, such a statement—particularly that in quotes—is a surefire method of losing readers, but then the appearance of the author's name may have already induced the same effect.)

Since the Second War,\(^2\) the general philosophy of this country has seen many changes. Paralleling the passing of the old coal heating-stove and cracker-barrel of an earlier period, more recently we have buried such archaic notions as:

a) "Man does not live by bread alone."

b) A day's pay for a day's work.

c) The essentials of life are food, clothing, shelter, car, TV, mad-money, etc., etc.

d) An apprentice aspires to the skill of the master craftsman.

e) Education for the educatable. (Sp?)

f) "I am the captain of my fate." \(^4\)

g) "No taxation without representation." \(^5\)

h) Obligations and responsibilities are always attendant to position.

i) Others equally as old-fashioned.

In the stead of these, more commonly we find the following less painful and easier list:

a) Man is entitled \(^6\) to steak.

b) "Forty hours" pay for thirty-six hours\(^7\) work.

c) The essentials \(^8\) of life are food, clothing, shelter, car, TV, mad-money, etc., etc.

d) An apprentice deserves the pay of a master immediately upon learning the names of the tools.

e) Everyone who breathes is entitled to at least an M.S. if he wants it—so conjure up curricula, teachers!

f) I am a first-class passenger (non-paying) on the ship of life.

g) Why worry about taxes—it's take-money pay I bargain for.

g2) Guarantees against everything it is needed.

from 'conception to resurrection.' \(^10\)

h) The "rights and privileges" app-

taining to position are:

1) No time-clocks.

2) No dirty, messy work.

3) Higher pay for less work.

4) ................................ (Other)

i) Others such as:

1) "Who, me sweep the floor clean for only a buck an hour? How can I run my Caddy on that?"

2) "Whaddya mean I gotta dress and undress on my time?"

3) ................................ (Other)

Strangely enuf,\(^11\) these metamorphoses have not left college students unaffected (or is it uneffected?) On the contrary—time was when one borrowed money to cover the essentials\(^12\) of a college education. However, nowadays one finds that some scholarships are not scholarships but needships—money is borrowed for engagement rings, wedding costs, etc.\(^13\) In other ways these chameleon characteristics are noticeable—college is the alternative to "going to work"; college curricula should not cause a psychosis by being too demanding; teachers should spell out everything in detail and not expect (or even anticipate) outside study or promptness or atten-

\(^1\) A mil = (1/10) cent = 100 yrs. / 10 = 10 yrs. = 1 decade.

\(^2\) How the origin for counting wars came to be fixed at the war of 1916 or thereabouts is not entirely clear.

\(^3\) The reference would be meaningless if

\(^4\) From the song "Invictus."

\(^5\) Historically, this concept may have disappeared even before the coal heating-stove and cracker-barrel.

\(^6\) A birthright, no less!

\(^7\) Including coffee-breaks, killed time, john trips, etc.

\(^8\) Ask any student about the essentialness of a car.

\(^9\) "Ability" is passé.

\(^10\) This is more inclusive than the outdated "womb-to-tomb" coverage.

\(^11\) The phonetic spelling is used out of respect for Col. McCormick and for those unable to recognize the correct spelling.

\(^12\) Use the "archaic" definition here.

\(^13\) "Marriage nowadays is something one is 'entitled' to leap into immediately upon escaping puberty (but not necessarily adolescence whether financially able or not."—An Old Bachelor.

Edited by
Bill Royer
tion to detail or scholarly inquisitive ness or anything that smacks of interference with TV westerns of yesteryear or with general “live-it-up-time.”

Wellsirree Bob! (or is it “Bub”?) , with all these changes taking place, it is high time someone charted the course on how to make a B. This goal is not beyond any student, given a bit of luck at finding the “right” curriculum and some intelligent (but unprincipled) friends. So in the interest of raising the “all-men’s average,” several suggestions are forthcoming, to-wit:

a) Admit girls so that boys have some competition and so that instructors can escape having to look at twenty-five wardrobes taken from “Mad.”

b) Always encourage the instructor to think he’s running the show (under your direction, of course).

c) When you copy someone else’s work, alter it slightly or re-

14 Word has it that author doesn’t know arrangement it—it’s the format that counts, not the content.

d) Come to class late, shuffle your feet as you move forward and drop into your favorite front-row seat—this breaks the monotony of an otherwise dull lecture. (It helps to prop your feet on the instructor’s desk—this lends a sort of “buddy-buddy” atmosphere to it all.)

e) Complain about the way the instructor graded your paper —this tactic demonstrates your interest in the instructor’s work. (A good opening question on such an occasion is “Where on your ouija-board did you find this grade?”)

f) When you go to an instructor for extra help and he asks “What part seems to be troubling you?”, always reply “All of it.”—this leaves plenty of room in which he may maneuver.

g) Have your parents write (or better still, come down to see) the instructor and ask that time

This list of suggestions is not intended to be exhaustive but merely a basic set (or “starter set” in the china trade) of devices to get you on your way. After some five or six years in undergraduate school, you will find that you can write a much longer list (of reasons why you have not graduated).

So for those (few though they may be) who are so decadent as to believe in the dignity of the individual and the value of hard work, remember that the rewards promised in the next decade are described by the luring chant “We Give TV Stamps.” However, keep your water-wings inflated and be patient and you will survive when the tidal wave of realism returns once more.

P.S. If the author is still around, a sequel to this literary masterpiece will follow sometime in the future.

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Barbara is a member of the A.C.E., and a pledge of Alpha Omicron Pi.

Her vital statistics are: height 1.805 yards, mass 3.325 slugs; possessing critical perimeters of 0.0429 Guntrr’s chains, 0.0253 links and 8.13x10^9 angstroms arranged in the usual fashion.

(Photography by Andy Breece)
magnetic resonance spectroscopy

by Jack Hobbs

In 1946, Block, Hansen, and Packard introduced the concept of nuclear magnetic resonance (N.M.R.). N.M.R. is similar in many respects to the more conventional forms of spectroscopy, such as ultraviolet and infrared, and thus may be considered a branch of spectroscopy. N.M.R. occurs in the radio frequency range and is the result of induced transitions between the spin levels of a nucleus in a fixed magnetic field; however, in ultraviolet spectroscopy the absorbed or emitted radiation is the result of electronic transitions.

Some atomic nuclei, in addition to acting as point electrostatic charges, possess magnetic moments. This concept was originally advanced as a hypothesis of Pauli to explain some of the details of hyperfine structure found in optical atomic spectra. If an external magnetic field is applied to a system of nuclei with magnetic moments, these nuclear magnets will experience torques and will tend to be lined up parallel to the field. Although direct observation of such alignment is difficult, it is possible for these magnets to absorb energy from a magnetic field oscillating with a frequency in the radio-frequency region. These absorptions give rise to what are called nuclear magnetic resonance spectra. If the nucleus has no magnetic moment, no magnetic resonance spectrum can be observed.

If a nucleus which has a magnetic moment is placed in a magnetic field, it behaves as if it were undergoing precession around the field axis of an angular velocity which is directly proportional to the magnetic field of the nucleus. This precession is analogous to the precession of a spinning gyroscope when allowed to topple in the gravitational field of the earth. The direction of precession of a gyroscope depends upon the direction of its angular momentum vector, and the angular velocity depends on the magnitude of the angular momentum vector and the strength of the gravitational field. For nuclei, the proportionality constant between the velocity of precession and the field strength depends on the angular spin momentum of the nucleus. This constant of proportionality is called the gyromagnetic ratio. All nuclei of the same charge and mass number have the same gyromagnetic ratio. For example, all protons act as though they precess at the same angular velocity when the magnetic field strength at the nucleus is the same. The gyromagnetic ratio may be either positive or negative, corresponding to different directions of precession.

Information concerning such precession can only be obtained if the sample is subjected to an external field alternating at the precession frequency, often called the Larmor frequency. Under such excitation all the nuclei of the isotope are caused to precess together in phase with the applied field. Their combined effect is strong enough to induce a detectable signal in the radio receiver. This is actually a form of resonance and hence the name, nuclear magnetic resonance.

An N.M.R. spectrometer consists basically of a magnet, a radiofrequency (rf) oscillator or transmitter, and a suitable rf detector. When a sample of material comprised of atoms having nuclei with the necessary magnetic properties is placed in the magnet pole gap and subjected to the rf field of the oscillator, absorption of rf energy (resonance) occurs at particular combinations of the oscillator frequency and the magnetic field strength and the rf signal is picked up by the detector. Usually the detector output is measured at constant oscillator frequency as a function of the magnetic field strength, although there are advantages to the alternative procedure of a constant magnetic field and variable oscillator frequency.

The actual detection is done in the following manner. If a fixed frequency radio frequency oscillator is employed, one “sweeps” through the resonance by varying the total magnetic field through injection of the linearly varying output from a
THE BELL TELEPHONE COMPANIES
SALUTE: CAL CRIMP

Michigan Bell makes few moves in Southfield without consulting Engineer Cal Crimp (B.S.E.E., 1957). Cal makes studies on where to put new central offices, how to expand old ones, what switching equipment to order.

To make these decisions, Cal must interpret forecasts of customer growth. He must also know his equipment and operating costs closely. Such responsibility is not new to him. On an earlier assignment, for instance, he skillfully directed a drafting section of 32 people.

Cal Crimp of Michigan Bell Telephone Company and the other young engineers like him in Bell Telephone Companies throughout the country help bring the finest communications service in the world to the homes and businesses of a growing America.
Psychology is basically the study of the behavior or reaction of the human being to externally applied stimuli or inputs. These inputs are received by the body through various channels referred to as organs of sensation or perception. The widest of these channels is usually considered to be the sense of sight, which is receptive to the small band of electromagnetic radiation called light. The perceptive channel having the next largest “bandwidth” is the sense of hearing which, like sight, responds to a small portion of a physical spectrum; in this case acoustical vibrations. It is the purpose of this paper to indicate how the methods and ideas of the mathematical theories of information and communication can be applied to the analysis of the perception of hearing, with particular attention to how this sense serves as a selective receiver of speech.

As mentioned above, the “bandwidth” or range of the sensations of hearing is a “small” portion of the acoustic spectrum called sound. Physically this amounts to a frequency range of 20,000 cycles per second and to an intensity range, relative to the minimum, of a million billion. Needless to say, this still seems to include a large amount of something, even if it is physically small. As it turns out, this allows for a high rate of information transmission (in the technical sense), actually faster than the brain can keep up, so that it appears to be a very adequate channel of communication. More will be said about this later.

We will now take up the question of the distinguishing physical characteristics of speech. This subject has received significant study only for about the last fifty years, due in large to the advances made in the adjacent fields of telecommunication and information theory. The study of speech has revealed it to be an amazingly effective and reliable means of communication. This is due mainly to the complex redundancies inherent in the articulated sounds and in language structure. Add to this the marvelous ability of the brain for filling in the holes, so to speak, and it results that human speech is relatively impervious to the deleterious effects of interference, masking and distortion.

**Mathematical Aspects**

Before going into a more detailed analysis of speech characteristics, it is worthwhile and of interest to have a quick look at the mathematical ideas of information and information measure. Hartley defined information to be the successive selection of signs or words from a given list. So defined, the idea of information is independent of the idea of meaning. Thus the word information can refer to sequences of words having no meaning at all. Now, since it is reasonable to talk about an amount of information, it is desirable to define a basic unit of measure. In communication theory, this unit is defined to be the smallest distinguishable change of a signal being received through a specified channel and is called a logon. What is important in communication theory is how many combinations or patterns of these logons are possible. Thus we want to know how many different ways a number of logons can be stored in a given number of storage locations. Since the number of patterns may be very large, we ask simply how many numerical digits are necessary to express it. If, for example, the number of patterns is 1,000,000, then the information measure or capacity is decimal 7 or 7 to base 10. The customary number base used in communication theory, however, is 2 instead of 10 and we talk in terms of so many binary...
digits or bits. Thus the number "decimal 1,000,000" would require 20 binary digits to express it and therefore the information capacity would be 20 bits. If we want to know how fast this information is being transmitted, we just divide by the time necessary for the information to pass a given point. If the above 20 bits of information took 2 seconds to pass a given point, then the information rate would be 10 bits per second. When it happens that not all patterns of information are equally likely, then information capacity and rate are determined by a statistical averaging process, in which the various patterns are weighted according to their relative frequencies of occurrence. Just to give a few examples, we have the following estimated information rates: for reading, 52 bits per second; for listening to speech, 20 bits per second; the human eye in general, 4 million bits per second. For reference, a television receiver operates at about 200 million bits per second.

Anything which tends to decrease the number of possible patterns of information of an information system, decreases the system's delivery rate. In the case of speech communication, any kind of random sound or noise that gets mixed in with the speech reduces the fineness with which the ear can detect changes in the amplitude of the meaningful sound and thus decreases the rate at which information can be accepted. Therefore, there is a limit to the speed of understood speech depending on the amount of background noise. Since the information communicated by speech depends on frequency as well as amplitude, the masking effect of noise depends on how much of the speech bandwidth it covers. For example "white noise", which effectively covers the whole speech bandwidth, does a more complete job of masking than a single tone of the same intensity. Under most circumstances, subjective meaning in the content of the masking sound seems to have little added effect. What effect meaning does have depends on what are called psychological sets.

As has been said, the rate at which information is being conveyed depends on how many different information patterns are possible. If previous knowledge about an expected event reduces the number of possible outcomes for the event, then any subsequent information received about the event will be reduced in amount. Thus if I know in advance the pattern of one-way streets in a city, then it will be easier for me to decide which way to go at a given intersection than if I were completely unprepared. This same idea is illustrated in the case of airport control-tower operators who could sometimes identify two aircraft call signals arriving at the same time but could understand only one of the two messages that followed. They were set to be ready for just a few possible call signals, but not prepared for any of the many possible messages which could then follow. These are examples of psychological sets; that is, mental anticipations of the possible messages which might be received by the brain in the near future.

**Redundancy in Coding**

An interesting concept in the theory of communication, is that of redundancy in the coding of messages. Coding is the essential part of any communications system. It is the process by which a message, and this is taken to mean any collection of signs, is converted or transformed from one set of signs to another. Thus when we send a telegram we are transforming a message, first in the form of thoughts, to a set of written symbols on paper and then, through the operator's key or telegraph machine, to a sequence of electrical impulses traveling down a wire. At the other end of the wire, the reverse process takes place. Now as might be imagined, and which is proved in theory, there is a minimum number of signs or symbols necessary to code any given amount of information. This is true whether we are talking in terms of the alphabet, words, sounds or electrical im-
pulses. All that is required is that the sender and receiver are availed of the same standards of coding. Any time that more than the required minimum of symbols are used to code a given message, there is said to be redundancy in the coding. This can be expressed quantitatively as the ratio of the extra number of symbols used to code a message in a given way to the minimum number which were necessary. As an illustration of the relative redundancies of a few different languages, we refer to a tally made by Baker of the number of syllables required in each of the languages to express the Gospel of St. Matthew. Thus in Greek it required 39,000 syllables, in German 34,000, in French 33,000 and in English 29,000. As a matter of fact, the language requiring the least number of syllables was Chinese with 17,000.

As can probably be guessed, redundancy does not necessarily produce a net loss in the effectiveness of a communications system. On the contrary, it may add much to the system's reliability. This is because in transmitting information, any practical communications system is not 100% reliable. Errors crop up in messages no matter how well designed the system may be because of the effects of noise. Redundancy, however, when used to advantage can be helpful in detecting errors and, if used in a proper way, give clues about possible corrections.

**Repetition**

One form of redundancy is well known. This is the method of repetition in which various parts of a message are repeated identically once, twice or more times in succession. With this method, the likelihood of transmitting a correct message is improved; however, it is necessary to multiply the number of symbols which have to be passed by the system and thus decrease the information rate several times. It would be desirable, if possible, to reduce the redundancy below 100%, which is what it is for single repetition. One way of doing this is to impose contextual constraints on the symbols of communication. This is well illustrated in the English language in which contextual constraints are found on many levels. Thus it happens that letter combinations such as th, qu and the many diphthongs will occur over and over again as units. Sometimes this is true for groups of three or more letters or even groups of words. For example, in English the noun precedes the verb, which in turn precedes the object. The group of words called the subject precedes the group called the predicate. A singular noun requires a singular verb, and so on. Some of these constraints are imposed by physical factors such as ease of pronunciation; however, others evolve through various rounding and simplifying processes of use. An interesting addition to this point is Zipf's Law which asserts that man is a goal-seeking organism who strives to minimize his efforts. This "law" as applied to language analysis implies that man develops his languages in such a manner as to decrease the amount of effort re-
quired to communicate. Cherry points out the similarity of this theorem with corresponding ones in the physical sciences which refer to certain physical quantities such as energy and time.

**Information Sampling**

As a final point, it would be worthwhile to look at the idea of information sampling. This is a means used by the communications engineer to send several messages over a single communication channel at the same time. It also appears to be a means used by the human ear to discriminate speech. It relies on the fact that technically, information is a quantity which can be divided, transmitted in parts, and then integrated to form its original amount. Several ways of sectioning information are possible, but one of particular interest is called time-division multiplex. In this method, several messages are sent alternately in the form of intermittent sample pulses. That is, the different messages are sampled periodically, one after the other, and then sent as a chain of pulses down the transmission line. At the other end of the line they are resampled and integrated separately to form the different messages.

As mentioned above, it is possible that information sampling is a method used by the human ear to discriminate speech. It is known that speech is generated by the vocal chords as a series of short, periodic breath pulses. These breath pulses are formed by the speech apparatus of the throat and mouth into syllables and words and sent out as sound energy to the receiving ear. Now, if the brain has the ability to separate the alternate pulses of one particular voice, then we have, effectively, the engineer’s duplex system. Experimental evidence does indicate this to be true and thus suggests at least a partial explanation of the cocktail-party phenomenon in which it is possible for an individual to discriminate one person’s voice above the background noise of many conversations going at once.

The question of how far we can go in explaining why speech and language take the forms they do, is an open one. As indicated in this paper, the theories of information and communication can go a long way in giving reasonable explanations of the physical characteristics of speech. Information can be defined unambiguously and measured as a quantity like length or volume, but meaning or content in human information is very difficult to isolate and describe. The fact that redundancies occur in human communications is known, but how to peel them away and extract essential meaning is still unknown. If this could be done, then it would be possible to construct machines which could “understand” spoken or written words, such as mechanical stenographers or computers with handwritten inputs. Much investigation will go on in the field of human communication in the future by individuals in engineering, science, business, and other areas. It is still a new field and one which promises to have widespread economic and social significance as further developments are made.
"sweep generator" into coils wrapped around the magnet pole faces. The output of the generator is synchronized with the trace along the x-axis of an oscilloscope or suitable graphic recorder.

The sample is placed within the pole gap of the magnet and subjected to the radio-frequency alternating magnetic field produced by passing a high frequency AC current through the oscillator coil around the sample. The detector serves to pick up changes in the magnetization of the nuclei induced by the radio-frequency oscillator, and the detector signal is fed to the y-axis of the oscilloscope. A nuclear magnetic spectrogram is thus a plot of detector signal against magnetic field at constant oscillator frequency.

Information of chemical interest arises from the fact that nuclei of atoms in different chemical environments are also generally in quite different magnetic environments and come into resonance with a fixed-frequency at different values of the applied magnetic field. By measuring N.M.R. spectra, one is using a nucleus as a magnetic probe to investigate local magnetic effects inside a molecular system. This form of spectroscopy is of potential value in problems involving the investigation of molecular structure and environmental effects, and its application to many diverse branches of chemistry has increased our knowledge in the field of molecular structure and chemical bonding. N.M.R. techniques are constantly improving and with the possible exception of gas-liquid chromatography, no new experimental method has been so rapidly accepted, or proved so widely applicable.

Since this form of spectroscopy has been in existence approximately twenty years, we can certainly look forward to great improvements and advances in the field of nuclear magnetic spectroscopy.

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Are the so-called “electronic air purifiers” really electronic in nature? The answer to this question can be either “yes” or “no.” Some of the devices on the market are definitely electronic in nature and do an effective job of purifying the air. To call some of them “electronic,” we would also have to call fluorescent lights electronic. These devices are the ones which use ultraviolet lights, and using the present connotation of “electronic,” they are definitely not electronic devices.

What are some of the reasons for wanting the air to be cleaner than ordinary mechanical filters can make it? To allergy sufferers, the reasons are self-evident. The particles which cause sinus and hay-fever irritations are much too small to be effectively stopped by mechanical filters. Electronic air purifiers also provide the air with negative ions. Present medical research is in a debate as to the effectiveness of negative ions in producing allergy relief. Some medical studies have shown that when the number of negative ions exceeds the number of positive ions, some allergy sufferers achieve relief. Although there are no definite medical opinions on this, a couple of theories have been put forth to explain the relief caused by the presence of negative ions. One theory suggests that the negative ions increase the amount of oxygen in the blood. The other suggests that the negative ions attach themselves to the irritating particles causing a feeling of relief.

Clean air is also very important to department stores, hotels, apartments, and office buildings. Many office buildings spend hundreds of thousands of dollars yearly to have their interiors washed and cleaned. Some large department stores have losses of up to half a million dollars annually in soiled merchandise even with the use of dust covers. By getting rid of the very small particles which cause this soiling, electronic air purifiers could greatly reduce these losses.

As was mentioned earlier, there are a number of air purification devices which are termed electronic but which are little better than a mechanical filter. They usually consist of a glass fiber filter, ultraviolet lamps, and a small circulating fan. Many of the ads for these claim that the ultraviolet light kills germs and some even go so far as to claim that they produce negative ions. Even though an intensive dose of ultraviolet light can kill germs, studies have shown that the mere four seconds that the germs are subjected to the ultraviolet light in one of these air purifiers is not enough to have any effect on the germs, and there is definitely no ionization produced by the ultraviolet. There are however, certain benefits which can be obtained from this simple an air purification device. For one, the glass fiber filter does filter out the larger dust and dirt particles. Also, the ultraviolet lamps do produce a small amount of ozone which acts as a deodorizer. There is also a psychological factor associated with this type of air purification device. Since many allergies are purely psychological, the mere presence of a device which has been advertised as having beneficial effects may bring relief to the allergy sufferer.

The second type of air purification device, which is truly electronic, is based on the Cottrell apparatus which has been used for many years in industry to lessen the smoke nuisance. The Cottrell apparatus was installed in the chimneys of factories and got rid of the dust by giving the particles an electrostatic charge and then attracting them to the oppositely charged electrode. The present electronic air purifiers make use of this concept. The dust particles are circulated through the system by a small fan. The particles are given a negative charge by a thin wire in the incoming air stream. The reason for using a thin wire is to generate a strong electrostatic field without offering a large surface area to which the particles could cling. The dirt is then in the form of negative ions which can be attracted to the positively charged plates. These electrostatic plates have an advantage over mechanical filters in that they offer little resistance to the air flow. The dirt which is collected on the plates can be easily washed off whereas mechanical filters have to be changed periodically.

There are many diversified ways of using the electronic air purifiers. Some of them can be installed in the present heating or air conditioning ducts of a business or home. Some of the air purifiers are equipped with a built-in washing device which automatically rinses off the plates from time to time. Even though these air purification devices can remove very small particles from the air, they cannot remove a true gas. Therefore they are sometimes used in conjunction with a chemical filter for removing gases. These are generally in the form of activated charcoal which absorbs the gas. The ozone produced by ultraviolet lights is also sometimes effective in removing the odors of gases.

There seems to be a good future for electronic air purification methods. With its excellent germ and pollen removing qualities together with its ability to prevent losses due to soiling, the electronic air purifier could become as common as the air conditioner for home and business.
GRATING DIFFRACTION
(Continued from page 10)

Bohr used this idea to invent his plug.

Theory:
In his scattering experiments, Rutherford showed the atom to consist of a heavy nucleus and a "cloud" of electrons occupying space about $10^{13}$ times that of the nucleus. Both experiment and theory showed the major interbody force in the atom to be the electrostatic. Classical theory predicted that with the electrons revolving about the nucleus, the emission of energy would result in a continuously spiraling motion of the electron toward the nucleus. This does not occur, however, because in 1885 Balmer showed the spectrum of the simplest atom, hydrogen, to be discontinuous. Not only was this true; but for a given type of atom, the spectrum was always the same. Empirically it was shown that a line of a hydrogen-like atom on the spectrum could be represented by a wave number which is equal to the product of a constant, the square of the nuclear charge, and difference of the reciprocals of two different integers squared.

When a man named Rutherford shot bullets of four large balls (two were charged) into a thin sheet of gold, he found that his bullets were scattered. He figured for a thing like this to happen, the atom had the little balls spread out and the big ones all squeezed in the center. The charge caused the electrons to stay in the neighborhood of the center. Mr. or rather Sir Newton and the plugs that he invented said that the moving little balls would give off all kinds of light instead of only certain colors. These colors were at certain places on the film and after looking at it for a long time another genius thought up another plug. Boy there's a lot of plugs.

Bohr attempted to explain this phenomenon for hydrogen with a revolutionary theory. He began with two assumptions which were in agreement with the radical theories of Planck and Einstein. First he
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stated that the electron occupied an orbit for which the angular momentum is equal to Planck's constant divided by two pi and times some positive integer. These are static states with no energy emitted. Second he stated that the only emission or absorption of radiation occurred when the electron changes from one of these states to another. Or the energy is quantized.

Bohr used Planck's and Einstein's ideas to develop his plugs. First he said that the angular momentum (Angular momentum is the speed the little ball moves around the center multiplied by the ratio of the force pushing it around the center to the increase of speed produced.) is equal to some one digit number times a constant. Then he said that the only energy increase or decrease was when the digit changed value, and the energy was the same for any change.

As we said previously, classical mechanics should apply to this simple atom. If so, the electrostatic force is \( F_e = -\frac{Ze^2}{e_0 r^2} \); the centripetal force is \( F_c = \frac{mv^2}{r} \); and in a static state these are equal. Remembering our assumptions and equations for quantization we can solve \( r \) and \( v \) in terms of the mass, charge, and quantum number of the state. Remembering that the total energy of the electron is the sum of the potential and kinetic energies, and using coulomb's law to find the potential energy and the previously solved \( v \) to find the kinetic energy, we find the total energy to be \( W = -\frac{Ze^2}{2e_0} \). This can change by substituting our previous value of \( r \); and we get the energy in terms of the mass, charge, and quantum number. Using Einstein's quantization principle, we get a solution for the wave number:

\[
\frac{2 (\pi)^3 m e^4}{\hbar^3} \frac{1}{1} \frac{1}{n_1^2 n_2^2}
\]

If we consider relative mass, however, as we must in our calculations, we substitute \( m' \) for \( m \); \( m' = mM + m \) where \( M \) is the mass of the nucleus.

Oh, no! More plugs, and cranking, too!
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library notes

"I no sooner come into the library, but I bolt the door to me, excluding lust, avarice, and all such vices, whose nurse is idleness, the mother of ignorance, and melancholy herself, and in the very lap of eternity, amongst so many divine souls, I take my seat, with so lofty a spirit and sweet content that I pity all our great ones and rich men that know not this happiness."


We sincerely hope that you watch the "NEW BOOK SHELF" each week in order to keep up with the many books being added to our shelves. We place far more technical books on our shelves than any other, but we know the interested faculty is notified and the students browse often through the sections where the books on their fields are placed. Here are books from fiction to history that you may have missed.


Here is a book that brings together for the first time the results of intensive researches into the Soviet economy by thirty-one American scholars. It traces in systematic detail the rates and patterns of growth of Russia's economy to date, and appraises the prospects and potentials of the Soviet economy for the next twenty years. Some of the outstanding authors include Edward Ames, Alexander Erlich, Donald R. Hodgman, Norman M. Kaplan, Wassily Leontief, Vladimir P. Timoshenko and Lazar Volin.

Fusfield, Daniel R. *The Economic Thought of Franklin D. Roosevelt and the Origin of the New Deal.*

"Nowadays it is a common thing among historians," Professor Fusfield says, "to assert that Roosevelt had no economic philosophy, knew little about economics, and derived his program of economic legislation either from his advisers or from his ability to grasp the desires of an ever-shifting public opinion." Professor Fusfield seeks to dispel this notion by tracing a number of influences that shaped FDR's economic thinking. This book will give you a good idea about the policies on labor, big business, welfare legislation, conservation and power, and regional planning during the Roosevelt era.


This is volume one of *A History of The United States Atomic Energy Commission,* that was published by the Pennsylvania State University Press in 1962. As we all know the discovery of atomic energy ranks with the discovery of America in importance. It is a big, fundamental discovery that is sharply changing the direction of history. The pages of this book convey the high excitement of the scientists who discovered, step by step, the nature of atomic fission; of their efforts to convince the government of its possibilities; of the agonizing race to produce a bomb before Nazi Germany produced one; of the delays, breakdowns, checking and rechecking, etc. You will feel as though you are in the conference rooms and laboratories as you read this excellent and worthwhile book.


This offers a collection of articles published by The American Academy of Arts and Sciences in 1962. To list a few of the articles: The Geneva Negotiations on General and Complete Disarmament, by Bernard T. Feld; The Early History of the Pugwash Movement, by Bertrand Russell; Peace with Disarmament - or Without, by Lewis C. Bohn; United States Machinery for Disarmament, by Robert W. Kastenmeier; and the N'th Country Problem Today, by Christopher Hohenemser. For those really interested in disarmament this will offer "much food for thought."


This is an eloquent response to those who are troubled by the destructive potential of advanced technology. It is a devastating reply to those who would like to see all science returned to the bottle. This book makes clear what science and technology are, how scientific discovery and invention occur, and how they affect social change.


This novel is short, with a classical simplicity and economy. It is written about a small town in the Roanoke Basin of North Carolina. Stein, Ralph. *The Treasury of the Automobile.*

This is a book for anyone who ever owned, drove, or yearned for a sublime automobile. It is for the brotherhood of those who are stirred by the beauty of a Grand Marque, by the excellence of an honest design made real in metal, or by the exasperating, exciting individuality of a thoroughbred performer. This book includes cars from the Fire Engines to Sports Cars. The dozens of colored pictures are beautiful. It is a must for any car lover!
THE MASTER MOLECULE  
(Continued from page 14)

rounding it. Each of these groups consists of a nucleotide base connected to a sugar and phosphate portion of a chain. When these circulating groups attach themselves, they have exactly the same sequence of nucleotide bases as the original DNA. This doubling of the DNA had been thought to be the mechanism that started cell division, but it now appears that the cytoplasm instead influences the cell division. (See figure 3.)

The growth of a cell, as already shown, depends on the directions it receives from the DNA within it. The chief material of all living cells is protein, which is found in the nucleus and cytoplasm of every cell, in the enzymes which promote all the chemical changes involved in the use of foods, and in the hormones and antibodies that control body functions. Proteins are complicated, long chain molecules composed of some twenty different amino acids which are arranged in a specific sequence for each type of protein. The DNA in the cell determines precisely what kinds of protein will be made and directs their production every step of the way. Scientists have decided that the arrangement of crosslinks in the DNA molecule directly influences the sequence of amino acids in a protein and thus the type of protein which will be produced in the cell. The DNA then contains coded information to govern the production of proteins. This code of the DNA will be considered more thoroughly later.

DNA does not play the entire role in the production of proteins. Experiments have shown that DNA, which can reproduce itself, produces another nucleic acid known as RNA. Although several types of RNA (ribonucleic acid) have been isolated, the one type which scientists are now concerned with is termed "messenger" RNA. The messenger RNA, formed in the cell nucleus by the DNA, migrates out of the nucleus and takes residence in the cytoplasm of the cell, where, directed by the DNA, it produces enzymes. The enzymes, also following the DNA's blueprint, speed the making of proteins from amino acids that have been broken down from food entering the body. All this occurs within the individual cell. Evidence

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**DIVISION OF DNA IN CELL GROWTH**

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2. 
3.  

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17 Hutchins, p. 52.  
18 Moskin, p. 44.
shows that the RNA, which has only a single segmented strand of nucleotides as opposed to the double strands in DNA, is probably the mechanism by which genes transmit the information that defines the inherited traits of the cell. DNA is often referred to as the designer of life and RNA as the engineer. The main problem now confronting those engaged in DNA research is the breaking of the code controlling the sequence of nucleotide cross-links in the double helix. Once scientists discover how the sequence of the four nitrogen bases in DNA determines the sequence of twenty amino acids in the proteins, they will have taken a giant step toward life’s innermost secret. The remaining step is the linking of the proper amino acid to a particular series of nucleotide cross-links. This will ultimately enable them to produce DNA synthetically, which will function as natural DNA and produce living matter.

Many attempts are being made to break this genetic code but the one which seems most feasible and has been experimentally substantiated is that of Dr. Crick. He proposes that the coded message at a fixed starting point on the DNA molecule, probably at one end of the gene and is simply read three bases at a time. Thus if the reading is started at the wrong point, the message would fall into sets of three and would be hopelessly incorrect. While there is only one correct reading for a triplet code, there are two possible incorrect ones. Thus the addition or deletion of a base in most parts of the gene would make the gene completely nonfunctional. These changes in the structure of the genes are known as mutations. They are responsible for the changes in hereditary characteristics which may be traced from generation to generation; and they will be considered later. Dr. Crick also suggests that there may be a few "nonsense triplets" in his code. These triplets may represent directions such as "Begin here," or "End here," referring only to the reading of the code. It is conceivable also that in the triplet code the message could read in multiples of three bases. This possibility has not been ruled out experimentally. In line with Dr. Crick’s theory, scientists have already, through trial and error methods, determined that the code word for the production of phenylalanine (one of the amino acids) is TTT, three thymine nucleotides in sequence. Every time this word occurs in a DNA strand, phenylalanine will appear in the protein.

When the mysteries of DNA are learned, one can foresee unlimited possibilities for applying its life-giving powers. For instance, in the field of disease prevention, scientists may someday be able to switch amino acids or alter DNA in living cells to wipe out diseases. This idea may be specifically applied to cancer. Some cancers are caused by a change in the cell nucleus which upsets the cell’s normal mechanism for controlling growth and results in wild cell growth; while in other cases viruses take over the cell’s machinery and force the cell to grow without limit. These viruses consist of a nucleus of either DNA or RNA surrounded by a bird cage of protein. They can multiply only by invading a living cell since their multiplication requires both DNA and RNA and they have only one or the other. When they do attack the cell their nucleic acid may kill the cell and cause disease. Scientists are already learning to switch amino acids in virus protein, which is a step toward doing the same thing with living cells.

Although little is known about mutations, natural mutations have been studied and traced through generations for over a century. However, the idea of induced mutations is relatively new. Once scientists know how to fabricate DNA, they will learn how to use the synthetic material to alter human characteristics, to offset inborn defects, to produce children of specified sex, specified characteristics, and even new characteristics. This type of human hybridization is likely to become possible when the DNA code is solved.

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Line 1 is an example of the method by which "words" are read, according to Dr. Crick’s triplicate code, from the sequence of nucleotide along the DNA molecule.

CAT/CAT/CAT/GCA/TCA/TCA/TCA
Line two represents a positive mutation in which another different nucleotide base, G, is inserted into the sequence. Thus, the code word read from the point of insertion onward is TCA instead of CAT as before. The new code word will either trigger the production of a different amino acid in the protein or render the mutated gene nonfunctional.

CAT/CAT/CAT/CTC/ATC/ATC(-)
Line 3 represents a negative mutation in which one of the nucleotide bases, in this case A, is removed from the sequence. The ultimate effect is the same, and the new code word becomes ATC.

CAT/CAT/GCA/TCA/TAT/CAT/CAT(+)(-)
Line 4 represents a positive mutation followed by a negative mutation. By combining the two mutations of opposite sign, Crick could successfully restore the functioning of the gene, if the two mutations were made close together.

From the above examples one can easily see why Crick proposed that three consecutive mutations of the same sign, when performed close enough together, would also restore the functioning of the gene. His assumption has been substantiated experimentally.
In order to gain a better understanding of the method of induced mutation, one should return to Dr. Crick’s theory of the triplet code. Crick found that by combining a + (plus) mutation (nucleotide base is added) with a — (minus) mutation (nucleotide base subtracted) he could sometimes restore the activity of a nonfunctional gene provided the two opposite mutations were made close together along the gene.27 (See figure 4). He also found that sometimes the misreading produced in the region of the gene between the + and — mutations might give rise to a nonsense triplet.28 The activity of a gene may also be restored when three mutations of the same sign occur simultaneously, provided again that they are made close together.29 Although the above facts about induced mutations are not infallible, scientists do know one thing for certain — once a cell nucleus is changed by the mutation of a gene within a chromosome, the change persists; and the cell continues to copy the mistake unless this mistake kills the cell.30

Those who have been introduced to the wonders of DNA, and especially those who have worked many tedious hours to unlock its mysteries, can alone realize the consequences that will arise when the secrets of DNA are finally thrust upon the world. To most people, the idea of being able to create life synthetically and to alter the characteristics of living things is both wondrous and frightening. One Nobel Prize winner warns that synthetic life may be exceedingly virulent and strong and may destroy all other life on earth.31 Many feel that scientists are tampering with something which is not intended to be within their realm of power. As Leonard Engel states it, “Before very long, men will have gained nearly godlike power to interfere with nature and change it to suit his whim.”32 Let us hope that the consequences wrought by DNA will always be positive and beneficial toward all living things.

27 Crick, p. 69.  28 Ibid., p. 69.  29 Crick, p. 74.  30 Hutchins, p. 48.  31 Moskin, p. 46.  32 Engel, p. 39.
Bellboy: "May I carry your bag for you sir?"
Husband: "No, let her walk."

Truck driver stopped beside stalled Volkswagen on highway: "What's the matter buddy, need a new flint?"

"Your girl is spoiled, isn't she?"
"No, it's just the perfume she's wearing."

Mama: "I'm glad to see you sitting so quietly while your father naps."
Junior: "I'm watching his cigarette burn down to his fingers."

ME on the way to lecture: "I am going with an open mind, a complete lack of prejudice and a cool rational approach to listen to what I am convinced is pure rubbish."

Overheard in the E.E. lab: "Take hold of that wire."
"This one?"
"Feel anything?"
"Nope."
"Then don't touch the other one. It's carrying 5000 volts."

"Halt, who goes there?"
"American."
"Advance and recite the second verse of the 'Star Spangled Banner.'"
"I don't know it."
"Proceed American."

After watching a drunk try to unlock the door to his house without success, a policeman went over and asked if he might handle the key for him, "No thanks," the inebriated chap answered, "I got a pretty good hold on this key. You try and grab ahold of the housh."

"Lips that touch liquor shall never touch mine."
"Your lips?"
"No, my liquor."

Coed Mottos:
Freshman Girl: Mother knows best.
Sophomore Girl: Death before dishonor.
Junior Girl: Nothing ventured, nothing gained.
Senior Girl: Boys will be boys.

"Grandma, were you in Noah's Ark?"
"Of course not."
"Then why didn't you drown?"

Did you ever hear the story about the farmer who was milking a cow on the side of a mountain? He slipped and would have gone down 500 feet if he hadn't found something to hang onto... the poor cow saved him but the neighbors thought it was an air raid.

A baseball game being played in a pasture broke up into an uproar during the seventh inning when one of the players slid into what he thought was third base.

The Engineer's Psalm
Dr. Rogers is my instructor; I shall not pass.
He maketh me to exhibit mine ignorance before the whole class.
He telleth me more than I can write, He lowereth my grade.
Yea, though I walk through the corridors of knowledge, I do not learn.
He tries to teach me;
He writeth the equations before me in hopes that I will understand them.
He bombardeth my head with integrations,
My sliderule freezeth up,
Surely enthalpies and entropies shall follow me all the days of my life,
And I shall dwell in the College of Engineering forever.
Kodak beyond the snapshot...

The powder is vitamin E. Vitamin E is essential to human life. Also to poultry and livestock. This much is enough for about 200 multivitamin tablets. We make so much of it for the pharmaceutical manufacturers that the operation long ago entered the domain of chemical engineering.

It’s an especially interesting kind of chemical engineering, related to the kind we have been developing over the years in our basic business of manufacturing photographic materials.

Vitamin E is in no way a by-product of photographic manufacturing. Only the engineering skills behind it are a by-product. They come out of the maddeningly sensitive nature of sensitized film and paper. Now they are available for the thousands of other fascinating things we make besides vitamin E.

We need more chemical engineers to indoctrinate in our ways. The snapshot business is excellent, but photography has gone far beyond the snapshot and we have gone far beyond photography. Please drop us a note asking for an explanation of what all this has to do with you.

EASTMAN KODAK COMPANY • Business & Technical Personnel Department ROCHESTER 4, N.Y. • We are an equal-opportunity employer.
An Interview
with G.E.'s
H. B. Miller,
Vice President,
Manufacturing Services

Halbert B. Miller has management responsibility for General Electric's Manufacturing Services. This responsibility includes performing services work for the Company in the areas of manufacturing engineering; manufacturing operations and organization; quality control; personnel development; education, training and communications; materials management; purchasing and systems as well as the Real Estate and Construction Operation. Mr. Miller holds a degree in mechanical engineering and began his General Electric career as a student engineer on the Company's Test Course.


Manufacturing Careers Offer Diversity, Challenge and Opportunity

Q. Mr. Miller, what do engineers do in manufacturing?
A. Engineers design, build, equip, and operate our General Electric plants throughout the world. In General Electric, this is manufacturing work, and it subdivides into categories, such as quality control engineering, materials management, shop management, manufacturing engineering, and plant engineering. All of these jobs require technical men for many reasons. First, the complexity of our products is on the increase. Today's devices—invoking mechanical, electrical, hydraulic, electronic, chemical, and even atomic components—call for a high degree of technical knowhow. Then there's the progressive trend toward mechanization and automation that demands engineering skills. And finally, the rapid development of new tools and techniques has opened new doors of technical opportunity—electronic data processing, computers, numerically programmed machine tools, automatic processing, feedback control, and a host of others. In short, the requirements of complex products of more exacting quality, of advanced processes and techniques of manufacture, and of industry's need for higher productivity add up to an opportunity and a challenge in which the role of engineers is vital.

Q. How do opportunities for technical graduates in manufacturing stack up with other areas?
A. Manufacturing holds great promise for the creative technical man with leadership ability. Over 60 percent of the 250,000 men and women in General Electric are in manufacturing. You, as an engineer, will become part of the small technical core that leads this large force, and your opportunity for growth, therefore, is unexcelled. Technical graduates in manufacturing are teamed with those in marketing who assess customer needs; those in research and development who conceive new products; and those in engineering who create new product designs. I sincerely believe that the role of technical graduates of high competence in the manufacturing function is one of the major opportunities for progress in industry.

Q. What technical disciplines are best suited to a career in manufacturing?
A. We need men with Doctor's, Master's, and Bachelor's degrees in all the technical disciplines, including engineering, mathematics, chemistry and physics. We need M.B.A.'s also. General Electric's broad diversification plus the demands of modern manufacturing call for a wide range of first-class technical talent. For one example: outside of the Federal Government, we're the largest user of computers in the United States. Just think of the challenge to mathematicians and business systems men.

Q. My school work has emphasized fundamentals. Will General Electric train me in the specifics I need to be effective?
A. Yes, the Manufacturing Training Program is designed to do just that. Seminars which cover the sub-functions of manufacturing will expose you to both the theoretical and practical approaches to operating problems. Each of the succeeding jobs you have will train you further in the important work areas of manufacturing.

Q. After the Program—what?
A. From that point, your ability and initiative will determine your direction. Graduates of the Manufacturing Training Program have Company-wide opportunities and they continue to advance to positions of greater responsibility.

Progress Is Our Most Important Product

GENERAL ELECTRIC