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МЕТОДИЧНІ ВКАЗІВКИ
до самостійної роботи з дисципліни «Англійська мова»
для здобувачів вищої освіти освітньо-наукової програми третього рівня
(підготовка докторів філософії) для усіх спеціальностей

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Розповсюдження і тиражування без офіційного дозволу ДДТУ заборонено.

Методичні вказівки до самостійної роботи з дисципліни «Англійська мова» для здобувачів вищої освіти освітньо-наукової програми третього рівня (підготовка докторів філософії) для усіх спеціальностей / Укл. – старший викладач Лещенко О.П., Кам'янське : ДДТУ, 2018, 77 стор.

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Протокол № 8 від «06» вересня 2018 р.

Коротка анотація видання: методичні вказівки складено відповідно до освітньо-наукової програми третього рівня вищої освіти (підготовка докторів філософії) для усіх спеціальностей. Вони містять тексти для читання за різними галузями науки і техніки, а також тренувальні вправи та завдання на розуміння прочитаного матеріалу, написання коротких ессе та оцінку використання мови у обговоренні прочитаної інформації. Видання призначене для самостійної роботи аспірантів та здобувачів.

Contents

The book is designed for advanced students of English as a foreign language if they have already received a definite amount of training in English.

The book contains texts for reading on various aspects of comprehension work, such as basic reading technique, summary-writing, and the appreciation of a writer's use of language through class discussion or intensive vocabulary work.

The texts cover a wide range of different types of modern scientific English writing, and have been specially selected for the interest and variety of their subject-matter and style.

Notes on 'reading comprehension'

To be 'good at comprehension' means that one can read accurately and efficiently, so as to get the maximum of information from a text with a minimum of misunderstanding.

Language is not the only factor in successful comprehension: people may be bad at comprehension even in their own mother tongue. There are several things that can go wrong:

- Some students find it difficult to 'see the wood for the trees'. They may read slowly and carefully paying a lot of attention to individual points, but without succeeding in getting a clear idea of the overall meaning of the text.
- Other students (especially those who read quickly) do not always pay enough attention to detail: overlooking important small words (e.g. a conjunction, a negation a modal verb) they may get a completely false impression of the meaning of a part of the passage.
- Some people are 'imaginative readers' : especially if they know something about the subject, they may interpret the text in the light of their own experience and ideas, so that they find it difficult to separate what the writer says from what they feel themselves.
- Most people, even those with a good knowledge of the language and adequate comprehension skills, need special training in order to be able to do effective summarizing or develop their discussion activity or produce both of them properly.

Some suggestions for teachers.

Obviously the texts in this book can be used in various ways, and experienced teachers will adopt whatever approach is best suited to their style of teaching and the needs of their classes.

Note that the texts vary in length; with some of the longer ones it may be necessary to begin the text in class and ask the students to finish it for homework using the appropriate dictionaries.

While developing the comprehension aspect it is advisable for students to do their comprehension class-work without dictionaries. It is important for advanced students to get used to dealing confidently with unfamiliar vocabulary (e.g. guessing unknown words).

For progressive advancement, timing is important and it is a good idea to give time limits for the reading of a number of texts until students are able to work efficiently at speed. It is also a good idea to read a comprehension passage at least twice: once to get an overall impression on what it is about, and then a second time to concentrate on the details. Time spent on reading is saved later in the further purposeful perfection in language acquisition.

The approach used throughout the book is essentially an oral one, in view of the fact that oral work adds variety and interest to the English classes providing better mutual understanding and communication in oral scientific English. So the texts are designed to stimulate critical thought, to encourage both the audience and students to take an active interest in their own discipline and its relationships with other sciences and with society as a whole.

Thus it is hoped that the book will serve a broadly educational purpose as well as its specific linguistic one.

I. Ways of Understanding Our World

Values and Science

To many outsiders, science is an arcane body of knowledge that has little relevance to day-to-day living. And many outsiders think that the scientist's work sounds dull and uncreative. Still others see science as a mysterious realm not easily understood by the general public.

The truth of the matter, however, is that science is an exciting field that requires tremendous creativity and insight. It is also essential to our understanding of the modern world and the many issues before us. And it is not that hard to master, once we become acquainted with its special vocabulary.

You don't need to become a scientist to understand what science is all about, but the time you spend improving your understanding of this fascinating field will pay lifetime dividends. Science many help you decide what type of house to build or what type of energy to heat your water with. It may even help you vote more intelligently on important issues. Almost without exception, the more you know about science, the better off you will be. Society as a whole benefits from science, too, as it charts a safe course into the future. Without it we could bumble from one mistake to another.

Throughout this book you will learn both some fundamental principles of science and many of the scientific fact behind the headlines. The laws of ecology, the laws of thermodynamics, and the principles of toxicology—to name a few—will make you a more informed citizen.

Your study of science will yield many insights into human society and nature. What you do with that information, however, depends in large part on your values. Values are subjective. They dictate what is right and wrong. Science, on the other hand, is supposedly objective. It does not tell us what to do, but tells us only what the impacts of our actions will be. Environmental science helps society see what is not obvious, for instance, the importance of forests in maintaining carbon dioxide levels. Science can give us information on which we can plot action, but that action is the result of our values. Our values forge political and economic decisions that determine the course of the world. Unfortunately, the link between science and values is not always so clear-cut. For example, Thomas Aquinas's view of nature reflected the feudal hierarchy that prevailed during the 13th century. Organisms, he said, are diverse but unequal. Each has a distinct obligation and role that benefits others. Furthermore, he believed that change was unlikely, just as it was unlikely for a serf to become a knight. Nature was viewed as rigidly structured and independent, unchanging.

The scientific interpretation of nature was heavily tainted by the social conditions of the time.

Just as social conditions may have molded scientific thinking, so did science mold or reinforce social values. In 18^{th} -century England, for instance, the theory of evolution was seen as a process of change that led to superior forms of life, a view that scientists now see as erroneous. To the 18^{th} -century English, however, evolution meant that some life forms were better than others. This view of science was used to justify the prosperity of a small elite class of business owners while workers were suffering in dangerous factories. This disparity was justified as a form of the survival of the fittest. The application of the theory of evolution to social ethics is called social Darwinism.

This misapplication of Darwinian evolution suggests that scientific information must be carefully understood and not loosely used to justify social practices. Many scientists would agree. Societal values can and should be based on laws of science, especially the practical rules of ecology. Values that do not take into account the scientific principles that govern life can be destructive and may limit the future of humanity.

A.Comprehension

1 .How can science help us in day-to-day living? 2.Can science help society as a whole? If so, in what way? 3.1s there any link between science and social values? 4.Why is it necessary to take into account the scientific principles that govern life?

B.Discussion and Criticism (Reasoning)

1 .Do you think it is important for everybody to get some knowledge about science?

2.What helps you to make a decision-your system of values or scientific information?

3.Do you agree that social conditions and scientific thinking are interrelated?

4."Values that do not take into account the scientific principles ... can be destructive". Do you agree with it? If so, give examples.

The Methods of Science

The study of science is often orderly and precise. The process begins with observations and measurements of the world - the rate of oxygen consumption by cells, the growth of tree rings, or the rate of soil erosion (Figure 1). From observations, scientists often formulate generalizations or hypotheses. A hypothesis is a tentative explanation of what scientists observe, for example, an explanation of why a rattlesnake shakes its rattles or why a desert plant sheds its leaves in dry spells. Hypotheses based on observation and measurement are derived by a type of thinking called inductive reasoning. Inductive reasoning includes any thought process in which generalities, such as hypotheses, are derived from specific facts and observations.

Even though the term inductive reasoning may be foreign to you, you have probably been using the process for many years. It may have allowed you to solve the mystery of an anonymous love note in high school, for example, or perhaps to reason why a good friend was angry with you.

Let's look at a simple example. Suppose that you were driving your car at night. Each time you hit a bump in the road, one of your headlights flickered. But when you were on newly paved blacktop, the lights worked fine. Without begin aware that you were engaged in the scientific method, your mind quickly searched for answers. Within seconds you arrived at a hypothesis: perhaps bumps in the road were jiggling the filament in the headlight, causing it to flicker. This simple exercise is inductive reasoning.

Once a hypothesis is made, it is up to the scientist - in this case, you - to determine how valid it is. To test the validity of their hypotheses, researchers perform experiments. You would no doubt do the same. For example, you might experiment by replacing the headlamp and then by taking your car out on the same roads to see if the problem had been corrected. If the headlight continued to flicker, you would conclude that your hypothesis was invalid.

In similar fashion the results of scientific experiments either support or refute initial hypotheses. If a hypothesis is refuted, a new one is generally substituted. In your case you might conjecture that the electrical wiring was faulty. By simply wiggling the electrical wires connected to the headlight, you could test your new hypothesis. If the lights flickered, you would know that your new hypothesis was correct (and that you had wasted your money buying a new headlamp).

Scientific study is a lot more involved than finding reasons why your car stalls or your garbage disposal leaks. But the methodology is still the same . Observations lead to hypotheses , which are tested by experiments.

In many scientific experiments it is necessary to set up experimental and control groups of animals or people to test the effects of various treatments. The experimental group is the one that you "experiment" on, perhaps giving a new drug treatment. The second group is treated identically, except that it is not given the drug. This group is the control group. By setting up their experiments in this manner, scientists teat the effect of a single variable, the drug. Any differences disease in rates should be the result of the experimental treatment.

Through careful study, scientists check out the validity of their own hypotheses. Other researchers might also test them by setting up the same experiment. Scientific knowledge grows little by little. As the facts accumulate, they often begin to create a larger picture of reality - a unifying concept that ties the facts together. This is a theory. A theory, therefore, is an explanation that accounts for the assembled facts. Atomic theory, for example, is the current explanation of atomic structure, knitting together many observations about the atom. Theories are not immutable, as you shall soon see.

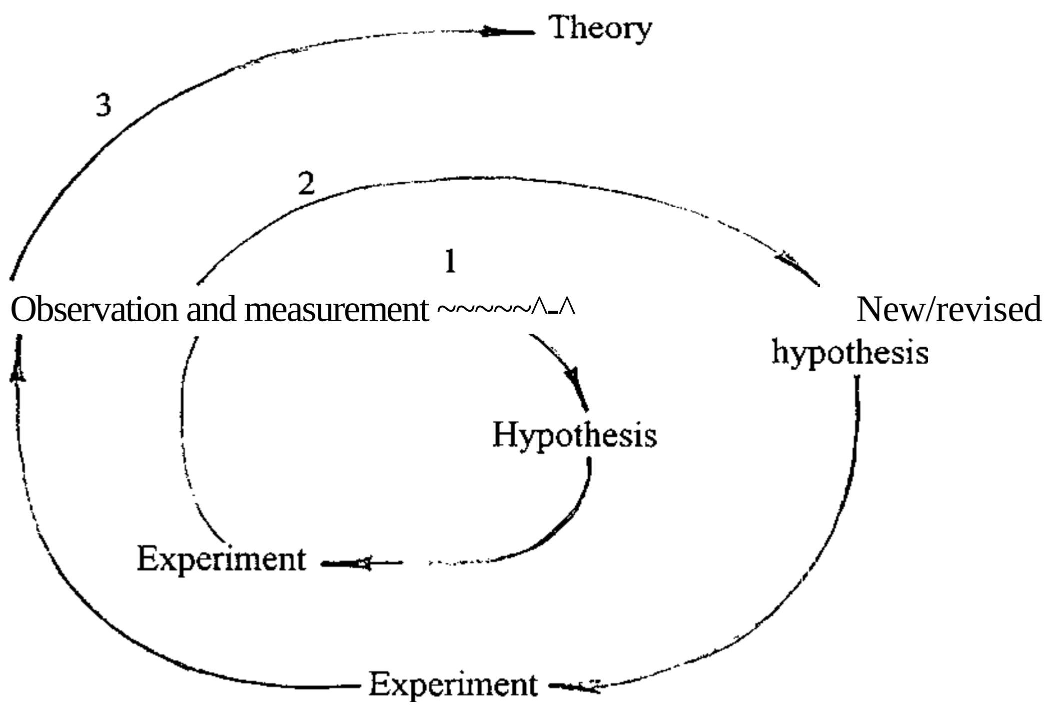

Figure 1. The scientific method starts with observation and measurement, from which scientists develop hypotheses, or tentative explanations. The scientist next tests the hypothesis by experimentation. If the results do not support the hypothesis, a new or modified hypothesis is created, which can then be retested and refined until a theory is formed.

A.Comprehension

1. What does inductive reasoning include?

2.What is the best way to test a scientific hypothesis?

3.1n what way are theories formed? What are the stages of this process?

4.Can you explain the difference between the "experimental group" and the "control group" in scientific experiments?

B.Discussion and Criticism (Reasoning)

l.Do you agree that experiments are of great importance to scientists?

2.Do you think formation of a new theory is a slow process or it is a brain-wave?

The Rise and Fall of Theories. Supertheories

Scientists must be open-minded about theories and must be willing to replace their most cherished ones with new ones should new information render them obsolete. As new results are published, scientists often find that different interpretations of natural events and biological processes emerge. These interpretations may replace explanations that have prevailed for decades. As a result, it is often necessary to alter or even abandon theories that have enjoyed a faithful following for many years.

New research techniques cause much of the turmoil in the scientific community. The findings from such techniques shine light on old theories and shaky hypotheses, which sometimes crumble as a result.

Perhaps the best known example of changing theory is the Copernican revolution in astronomy. The Greek astronomer Ptolemy hypothesized in AD 140 that the earth was the center of solar system (the geocentric view). The moon, the stars, and the sun, he argued, all revolve around the earth. This notion held sway for hundreds of years. In 1580, however, Nicolaus Copernicus showed that the observations were better explained by assuming that the sun was the center of the solar system. Copernicus was not the first to suggest this heliocentric view. Early Greek astronomers had proposed the idea, but it gained little attention until Copernicus's time.

The new view of the universe proposed by Copernicus was condemned as heretical by the Catholic Church. When he published his theory, it was placed on the papal index of forbidden books.

The dominant set of assumptions that underlies any branch of science is called a paradigm, a word coined by the philosopher and historian of science Thomas Kuhn. A paradigm is likened to a "supertheory". It is the basic model or reality in any science. Evolution is an example from the life sciences.

Paradigms govern the way scientists think, form theories, and interpret the results of experiments. They govern the way non-scientists think, too.

Once a paradigm is accepted, it is rarely questioned. New observations are interpreted according to the paradigm; those that are inconsistent with it are often ignored. However, phenomena that fail to fit conventional wisdom may amass to a point at which they can no longer be ignored, causing scientists to rethink their most cherished beliefs and, sometimes, toss them aside. This unsettling event is called a paradigm shift.

The central ideas of biology, ecology, chemistry, philosophy, health, and education are all paradigms; sacred as they may seem, they are not immutable. As scientists make new observations, new theories emerge that may shake apart the foundations of a society.

A.Comprehension

1 .Why is it necessary sometimes to alter or even abandon a well-establised theory?

2. What was Ptolemy's view on the solar system?

3.What is the difference between the geocentric view and the heliocentric view?

4.Can you give examples of the "life sciences"?

B.Discussion and Criticism (Reasoning)

1. lies changing theories a painless process? Substantiate your answer.

2. Explain what a paradigm is.

3. What influence has a paradigm shift on human civilization?

Critical Thinking Skills

Science provides a great deal of information to modern society. One of the chief tools of a good scientist (and of a great many other professions) is critical thinking: thought based on logic and a careful analysis of factors that get in the way of logic. There's no single formula for critical thinking, but most critical thinkers would agree that several key steps are required for this important process.

The first requirement of critical thinking is a clear understanding of terms. Define all terms. Make sure you understand them and demand the same of others.

The second requirement of critical thinking is that individuals question the methods by which facts are derived. Were the facts derived from experimentation? Can they be verified? Was the experiment correctly ran? Or is a generalization derived from a single observation? How easy is it for a single event to make a lasting impression and taint our thinking? A newscast showing an angry mob in New York, for example,may give the impression that the entire country is in turmoil.

A third rule of critical thinking requires us to question the source of the facts, that is, who is telling them. When the American Tobacoo Institute argues that the link between cigarette smoking and lung cancer hasn't been proven, a critical thinker would be skeptical. When a business says that their pollution isn't causing any harm, one might again question the assertion. Even environmentalists are prone to exaggeration. They are fair game for your critical thinking skills. Sadly, bias taints our views and creates a distorted view of reality.

The fourth requirement of critical thinking is to question the conclusions derived from facts. Do the facts support the conclusios? There are a surprising number of examples in which conclusions drawn from research simply are not supported by the facts. For example, one of the earliest studies on lung cancer showed a correlation between lung cancer and sugar consumption. A careful re-examination of the patients showed that the wrong conclusion had been drawn. It turned out that cigarette smokers actually consumed more sugar than nonsmokers. Thus, the link between sugar and cancer was incorrect. The real link lay between smoking and lung cancer.

This example illustrates a key principle of science worth remembering: correlation doesn't necessarily mean causation. Just because the economy improves when a certain politician is in office doesn't necessarily mean that the politician and his or her policies had anything to do with the improvement. Bias and assumptions taint how we interpret our observations. They are impediments to critical thinking.

The fifth rule of critical thinking requires us to examine the big picture. In 1988, researchers at Monsanto announced that they had discovered a way to genetically alter wheat, making it resistant to a fungus that causes enormous crop damage each year. To control the fungus now, farmers often rotate wheat from year to year with crops that the fungus does not infect. Crop rotation prevents the fungus from proliferating, keeping the pest in check. With the new genetically altered strain, researchers say, fanners will not have to rotate their crops. They can plant wheat in the same field year after year and can even plant lager crops. This may sound good at first, but when one considers the bigger picture, it is clear that the solution is an invitation to disaster. Why?

Crop rotation helps build soil fertility. Rotating beans, clover, and alfalfa with wheat, for instance, adds nitrogen to the soil. This helps maintain soil fertility. Crop rotation also prevents insect pest populations from getting out of hand, because their food supply is not constant. Eliminating crop rotation could result in an outbreak of insect pests, requiring more pesticide application.

In solving the fungus problem, then, science may contribute to several more problems. A careful examination of the bigger picture - the ecological relationships - often throws into question the apparent wisdom of new actions.

A.Comprehension

1 .Can you explain what critical thinking is? 2. Give two synonyms of the verb "to derive". 3 .The expression "fair game" is used figuratively here. See if you can explain its meaning.

B.Discussion and Criticism (Reasoning)

1 .What are the five rules of critical thinking?

2."Just because the economy improves when a certain politician is in office doesn't necessarily mean that the politician and his policies had anything to do with the improvement" - the text runs. Are you of the same opinion?

II. Science

The Scientific Attitude

What is the nature of the scientific attitude, the attitude of the man or woman who studies and applies physics, biology, chemistry, geology, engineering, medicine or any other science?

We all know that science plays an important role in the societies in which we live. Many people believe, however, that our progress depends on two different aspects of science. The first of these is the application of the machines, products and systems of applied knowledge that scientists and technologists develop. Through technology, science improves the structure of society and helps man to gain increasing control over Ins environment. New fibers and drugs, faster and safer means of transport, new systems of applied knowledge (psychiatry, operational research, etc.) are some examples of this aspect of science.

The second aspect is the application by all members of society, from the government official to the ordinary citizen, of the special methods of thought and action that scientists use in their work.

What are these special methods of thinking and acting? First of all, it seems that a successful scientist is full of curiosity - he wants to find out how and why the universe works. He usually directs his attention towards problems which he notices have no satisfactory explanation, and his curiosity makes him look for underlying relationships even if the data available seem to be unconnected. Moreover, he thinks he can improve the existing conditions, whether of pure or applied knowledge, and enjoys trying to solve the problems which this involves.

He is a good observer, accurate, patient and objective and applies persistent and logical thought to the observations he makes. He utilizes the facts he observes to the fullest extent. For example, trained observers obtain a very large amount of information about a star (e.g. distance , mass, velocity, size, etc.) mainly from the accurate analysis of the simple lines that appear in a spectrum.

He is skeptical - he does not accept statements which are not based on the most complete evidence available - and therefore rejects authority as the sole basis for truth. Scientists always check statements and make experiments carefully and objectively to verify them.

Furthermore, he is not only critical of the work of others, but also of his own, since he knows that man is the least reliable of scientific instruments and that a number of factors tend to disturb impartial and objective investigation.

Lastly, he is highly imaginative since he often has to look for relationships in data which are not only complex but also frequently incomplete. Furthermore, he needs imagination if he wants to make hypotheses of how processes work and how events take place.

These seem to be some of the ways in which a successful scientist, or technologist thinks and acts.

A. Comprehension

1. Name two ways in which science can promote society development.
2. How can you describe a person who wants to find out how and why the universe works?
3. What is the role of curiosity in the work of a scientist?
4. Does a scientist need imagination? If he does, explain, what for

B. Discussion and Criticism (Reasoning)

1. Do you know of any famous scientist whose work demonstrates (demonstrated) some or all the qualities mentioned in the passage? Give details.
2. In what ways do other scientists affect the particular science you work in? Give examples.
3. Do you agree that' the man is the least reliable of scientific instruments'? Give good evidence for your point of view.
4. Give a clear explanation of what you think the word ' authority ' means.

What Coming Years Hold for You

U. S. News & World Report (Washington, D. C.)

The 1990s, they say, are emerging as pivotal years in deciding the shape of things to come - in technology, economics, politics and lifestyles - and therefore must be carefully assessed.

A wide array of predictions has surfaced during the past year in a series of reports by independent commissions from the United Nations, the Council on Environmental Quality, and a group headed by West Germany's former Chancellor Willy Brandt. More recently, glimpses of what lies ahead came at a gathering of 5000 members of the World Future Society, a growing tribe of scholars and officials in government and business who study the present to foresee the near future and - at a longer distance - the 21st century.

Among the predictions in major areas on which most futurists reached consensus, some just years away, some decades distant:

<u>Food and Resources.</u>

Faith runs high that technological advances now under way will enable the world to feed its people and fuel its industry. Underwater fanning of high-protein algae and 'superfish' is under consideration. So are better seed grains to spur more productive agriculture, new agents to control parasites, and crops that manufacture their own fertilizer.

Also on the horizon within five years: A tablet to provide famine relief in disaster-struck areas. Victims would still feel hungry, but slow and painful death from starvation would be prevented.

'Nonfood food', consisting of substances that cannot be absorbed by the body, are now being tested in the US and abroad. The supplements will be incorporated into diets to allow persons to eat large and nourishing meals yet not gain any weight.

Synthetic proteins from bacteria and yeast will be made to taste like any existing food. Artificial steaks can be manufactured to look and taste like the real thing, but will have high concentrations of protein and little fat. New crop strains that are resistant to all diseases are being developed, as well as animal-plant hybrids that will genetically invest meats with higher nutritional value.

<u>Energy and Natural Resources.</u>

Big breakthroughs are imminent. Many believe that synthetic fuels will gradually replace oil, and that the use of nuclear power will spread under supertight government restrictions between now and 2000.

Among other prospects on the drawing boards: Ocean floors will be dredged for metal content, icebergs will be towed to water-scarce areas, and even the moon and asteroids may be mined for minerals. Cities will purify sewer gas into methane that can be used to fuel vehicles at a cost of 50 cents a gallon, says one expert. To ease urban congestion, 'sailing cities' that drift with tropical currents between the continents are under consideration. Such cities can generate their own electric power, desalinate their water and recycle their waste.

On the other hand, scholars raise a number of reservations about such developments. Increased food production, they note, will come at a cost of pesticide-fouled waterways, and the air will be filled with pollutants as energy use is increased to keep pace with population.

Average temperatures in coming years and decades will be warmer than for the past 1000 years because of higher concentrations of Carbon dioxide in the atmosphere, some biologists contend, and acid rain will continue to drip onto crops and lakes. Deserts will spread as forests are cut down for firewood and soil is eroded and depleted. Even a drink of fresh water will be unavailable in many less developed countries because of salt deposits that already plague half the planet's irrigated lands.

Communications.

The day is coming soon when electronic links could connect every home on the face of the earth, experts believe. Computers, television and satellites will cut down the need for travel, allowing people to work and shop at home. Postal services may close down, and a worldwide battle seems to be shaping up for broadcast frequencies on the electromagnetic spectrum, which already is rapidly filling up. Home computers will be in 80 per cent of US dwellings by 2000, technologists say, assisting with everything from office and school work to the family budget. Electronic banking, education course work by television , and a long list of games and entertainment options will be available at the punch of a switch.

Medical scientists say, doctors will be able to make electronic house calls, using TV and special devices that monitor pulse, blood pressure and other vital signs, and check them against computer records.

Concern is developing, however, over the impact of a communications era dominated by television, the computer and other electronic technologies. High-speed communications in oncoming years, some critics fear, can either produce the most informed and aware generation in history - or reduce the globe to a second ' tower of Babel', collecting and transmitting much information but offering little comprehension of what it all means.

Technological Advances.

Prognosticators assert that many of the most dramatic breakthroughs will be in such fields as medicine, engineering and aviation.

Already on the drawing boards or in the testing stage: A diet supplement that can improve memory, a totally safe and nonfattening artificial sweetener and a drag that retards the aging process.

Some researchers even believe that severed limbs may, in this century, be regenerated by using electrical impulses that spur growth of new tissue. Artificial implants are being designed to replace more and more human organs.

Research is moving toward new materials that are lighter, stronger and more resistant to decay than the hardest metals - enabling further exploitation of space, according to aviation experts. By the year 2000, factories set up between the earth and the moon will be using robot-operated manufacturing processes capitalizing on weightlessness. Foreseen in this decade is a nuclear-powered 'flying wing' aircraft that will carry 1700 passengers and 600,000 pounds of freight at speeds greater than 600 miles per hour.

The face of the earth, itself, will be transformed by some of the largest projects humanity has ever attempted.

Engineers are planning bridge and tunnel links between Africa and Europe via the Strait of Gibraltar, and England and the Continent across the English Channel. The Congo and the Amazon rivers will be dammed to produce hydroelectric power and irrigation in Africa and Latin America.

Russian scientists have suggested a global electrical grid that could increase efficiency by leveling out the peaks and valleys in electricity demand caused by the alternating of day and night.

Most ambitious of all is the proposed Grand Canal between Hudson Bay and the Great Lakes - a joint US-Canadian project.

Population.

Forecasters say most people will live in dense urban areas as world population soars from 4 billion today to nearly 7 billion by 2000, with at least 10 million persons each in 25 cities. Biggest of all: Mexico City, with 31 million.

A. Comprehension

1. Do you think the predictions described to be very distant?
2. Name at least two important consequences of industrialization.
3. What is 'nonfood food'?
4. What will medical scientists be able to make in future? Give examples.

B. Discussion and Criticism (Reasoning)

1. Discuss, quoting actual examples, the dangers to people if the average temperature will be warmer.

2. Why is concern developing with high-speed communications in oncoming years? Try to state, prove exceptions if there are any.

3. How do you think the problem of artificial implants can be tackled?

Scientific Method and Methods of Science.

It is sometimes said there is no such thing as the so-called 'scientific method'; there are only the methods used in science. Nevertheless, it seems clear that there is often a special sequence of procedures which is involved in the establishment of the working principles in science. This sequence is as follows: (1) a problem is recognized, and as much information as appears to be relevant is collected; (2) a solution (i.e. a hypothesis) is proposed and the consequences arising out of this solution are deduced; (3) these deductions are tested by experiment, and as a result the hypothesis is accepted, modified or discarded.

As an illustration of this we can consider the discovery of air-pressure. Over two thousand years ago, men discovered a method of raising water from one level to another by means of vacuum pump. When, however, this machine passed into general use in the fifteenth and sixteenth centuries, it was discovered that, no matter how perfect the pump was, it was not possible to raise water vertically more than about 35 feet. Why? Galileo, amongst others, recognized the problem, but failed to solve it.

The problem was then attached by Torricelli. Analogizing from the recently-discovered phenomenon of water-pressure (hydrostatic pressure), he postulated that a deep 'sea of air' surrounded the earth; it was, he thought, the pressure of this sea of air which pushed on the surface of the water and caused it to rise in the vacuum tube of a pump. A hypothesis, then, was formed. The next step was to deduce the consequences of the hypothesis. Torricelli reasoned that this 'air pressure' would be unable to push a liquid heavier than water as high as 35 feet, and that a column of mercury, for example, which weighed about 14 times more than water, would rise to only a fourteenth of the height of water, i.e. approximately 2.5 feet. He then tested this deduction by means of the experiment we all know, and found that the mercury column measured the height predicted. The experiment therefore supported the hypothesis. A further inference was drawn by Pascal, who reasoned that if tins 'sea of air' existed, its pressure at the bottom (i.e. sea-level) would be greater than its pressure further up, and that therefore the

height of the mercury column would decrease in proportion to the height above sea-level. He then carried the mercury tube to the top of a mountain and observed that the column fell steadily as the height increased, while another mercury column at the bottom of the mountain remained steady (an example of another of the methods of science, the controlled experiment). This further proof not only established Torricelli's hypothesis more securely, but also demonstrated that, in some aspects, air behaved like water; this, of course, stimulated further enquiry.

A. Comprehension

1. What does the establishment of the working laws of science often involve?
2. What does a scientist collect when he tries to establish a scientific law?

3. Give an approximate date for the invention of the vacuum pipe.

4. Is it possible to raise water from the bottom floor of a building to the roof 50 feet above, using a vacuum pump? Why?

B. Discussion and Criticism (Reasoning)

1. Do you agree that there is no one scientific method? Give reasons and examples.

2. Describe Torricelli's famous experiment in a clear and orderly way. This should include his method of forming a vacuum.

3. Draw a simple diagram, or series of diagram, of an experiment you know. Exchange this with another student (or group); you then describe his experiment, while he explains yours.

Pure and Applied Science

As students of science you are probably sometimes puzzled by the terms 'pure' and 'applied' science. Are these two totally different activities, having little or no interconnection, as is often implied? Let us begin by examining what is done by each.

Pure science is primarily concerned with the development of theories (or, as they are frequently called, models) establishing relationships between the phenomena of the universe. When they are sufficiently validated, these theories

(hypothesis, models) become the working laws or principles of science. In carry out this work, the pure scientist usually disregards its application to practical affairs, confining his attention to explanations of how and why events occur. Hence, in physics, the equations describing the behavior of fundamental particles, or in biology, the establishment of the life cycle of a particular species of insect living in a Polar environment, are said to be examples of pure science (basic research), having no apparent connection (for the moment) with technology, i.e. applied science. Applied science, on the other hand, is directly concerned with the application, of the working laws of pure science to the practical affairs of life, and to increasing man's control over his environment, thus leading to the development of new technique, processes and machines. Such activities as investigating the strength and uses of materials, extending the findings of pure mathematics to improve the sampling procedures used in agriculture or the social sciences, and developing the potentialities of atomic energy, are all examples of the work of the applied scientist or technologist.

It is evident that many branches of applied science are practical extensions of purely theoretical or experimental work. Thus the study of radioactivity began as a piece of pure research, but its results are now applied in a great number of different ways - in cancer treatment in medicine, the development of fertilizers in agriculture, the study of metal-fatigue in engineering, in methods of estimating the ages of objects in anthropology and geology, etc. Conversely, work in applied science and technology frequently acts as a direct stimulus to the development of pure science. Such an interaction occurs, for example, when the technologist, in applying a particular concept of pure science to a practical problem, reveals a gap or limitation in the theoretical model, thus pointing the way for further basic research.

Often a further interaction occurs, since the pure scientist is unable to undertake his further research until another technologist provides him with more highly-developed instruments.

It seems, then, that these two branches of science are mutually dependent and interacting, and that the so-called division between the pure scientist and the applied scientist is more apparent than real.

A. Comprehension

1. What is often implied by the terms 'pure' and 'applied' science?
2. What is the aim (object) of pure scientific investigation?
3. How are the working laws of science established?
4. Give two other words meaning the same thing as 'hypothesis'.

B. Discussion and Criticism (Reasoning)

l. How are the following sciences applied for technological purposes: geology, meteorology, chemistry, psychology? Give details.

2. Name some materials used in engineering. Why is it important to test their strength?

3. Do you agree with the conclusions of the last paragraph? Give reasons for your answer.

4. Give examples of how the following are applied in the discipline you study yourself: radio-activity; statistics; optics; electricity; magnetism; psychology.

III. Man in Nature

The Human Pedigree

We hold these truths to be self-evident, that all men are created equal.

- Thomas Jefferson, the American Declaration of Independence. The progress of biology in the next century will lead to a recognition of the innate inequality of man. This is today most obviously visible in the United States.

-J. B. S. Haldane

The real content of the proletarian demand for equality is the demand for the abolition of classes. Any demand for equality which goes beyond that, of necessity passes into absurdity.

- Friedrich Engels Heredity is the last of the fates, and the most terrible.

- Oscar Wilde

The subject of human genetics is both huge and very small - huge because it embraces the physical creation of every one of us, small because nothing is known about the great bulk of our inheritance. As a science, genetics has flourished , only recently: as an ad hoc procedure for breeding better plants and animals, it has a history stretching back to the first efforts in crucial direction.

Human genetics is looking in the baby carriage to detect likeness. Human genetics is us. More important still, it is those who will come after us. Much of modern biology will permit other aspects of human choice to manifest themselves, for good or for ill.

There is no point in the birth of infants devoid of brain; there is no value in any other equally miserable ill fortune. If counseling can reduce their incidence, so much the better for counseling.

Within this paper, the purpose is to present new facts and the new problems they bring with them. The simplicity of old standards has gone forever. The medical profession is being forced into new decisions on our behalf but is also reluctant to yield up its role as moral arbiter. The legal profession is being cautious in altering old laws to cope with current change. How remarkable, for example, that a child conceived by artificial insemination of donor sperm is classed as illegitimate and has fewer rights than any adopted infant. The rest of us will have to make the pace.

The logic behind these future pages is to introduce a range of topics that impinge upon human genetics, thereby enabling possible conclusions to be founded upon a certain breadth of information. It is important to look at mankind's evolution, at race, at genetic truths and their converse. The current debate on ethnic intelligence is probably less revealing but an extraordinary story, all the same.

The actual details of man's inheritance become more intriguing in this wide ranging context. Six fingers, baldness, myopia, stature, idiocy, earwax, dwarfism, digital hair, nevi, deafness, albinism, diabetes, epilepsy - there seems no end to the examined oddities of heredity. But reading of them makes any decision easier about troublesome genetic problems.

Strict scientific writing is full of qualification and keeps halting in its flow; general scientific writing should be smoother, more ready with a generalization, less willing to stop and define at every turn. This is a book of facts far more than views. Ethics, as Bertrand Russell said, should be founded on understanding of the truth, not vice versa.

The business of breeding is of creating - yet again - a further array of biological differences. These, in themselves, need not create injustice. What constitutes an injustice is the emotion aroused by an inequality, not the inequality itself. If we could give up our ideas of superiority and inferiority, we might start to appreciate our differences for the colorful things they are. As the British psychiatrist Eliot Slater wrote, 'Biological differences are basic; what we need to do is to adjust our world to make the utmost of them and to enjoy them', i.e. to enjoy those differences.

From the outset there is dilemma. We strive for equality of opportunity, but we know that we are born unequal. We struggle for freedom, for the individual to do as he pleases, but impose restrictions upon society for the greater good of all. We feel that each man and each woman should marry whom they wish, breed as they please, and create another generation by this form of willful chance; but we also wish to restrict numbers, to curtail hopeless imbeciles, to hand down fewer problems to our descendants.

The conflict of human genetics is now coming to the surface. The current enthusiasm for equality and for improving the environment of all our lives has led to considerable rejection of the idea that there is fundamental inequality. To suggest, as some have done, that intelligence is 80 percent inherited is to be attacked with violence. To imply that the environment is everything and inheritance is trifling is to be met today with the kind of applause normally reserved for political polemics. As a society we attempt to lavish all possible care upon the newborn child, to nourish its mind and body, to safeguard its rights and virtues; but we are loath to interfere with its conception.

Genetics, when it arose as a science (the word being coined in the earliest years of this century), was hailed much as a new drug is hailed. It was a cure-all. Pragmatically it had achieved fantastic results in the breeding of crops and animals; scientifically it would solve mankind's majorills. It would rid the world of inherited deficiency, of drunkenness and lawlessness, idleness and stupidity. All geneticists (more or less, but notably in the United States) became eugenicists, and many eugenicists moved over into politics, the better to advance their various enthusiasms. There was considerable talk of the Nordic race, the particular grouping of mankind that had done so much to subdue the planet. There was heavy argument notably from this same band of people, that other groups were not only less adequate but less estimable as migrants, less suitable as breeders and less worthy even to live.

As a result, the science of genetics became tarred with some of this evil.

Its findings were thought suitable for animals but irrelevant or unwarranted for human beings. However, there is no remedy for wishing to deny the findings of genetics.

Eugenics went wrong when its promoters put politics before science, and it may be necessary to feel more wary of politicians than scientists. Human genetics cannot of itself be wicked; nor, as the rest of us hold the strings to legislation, should human geneticists.

The science has even been condemned for its potentialities. There is frequent mention of clones, of factory incubation, and of sterilization of all but a few selected studs. Such practices may have become feasible, or will shortly be so, but there is total doubt about their likelihood. What kind of society would permit cloning - the production of identical individuals? There have been tremendous changes in our manner of life, but there are still predilections for the family, for having one's own children, for the differences inherent in mankind.

Some prospects of reproductive biology are less distant, such as the ability to choose the sex of future offspring. The future is already here with some of these techniques. With the others, and with many more of similar advancement, their future is not embroiled in some distant culture quite foreign to our own but will be with us either tomorrow or very soon.

We have genetic counselors, and we will have more of them. We are manipulating our reproduction more than ever before and will continue to do so, increasingly.

We are therefore confused. The suddenness of things has caught us, ethically, on the hop. We have no idea whether legislation of abortion enhances or lessens our respect for life. We abort healthy fetuses by the million and then, so help us, keep even anencephalics alive for weeks on end despite their total lack of any brain. We like handling moral decisions to our doctors and then dislike their unwillingness to do as we please. Can we - should we - improve the human race through genetics? To some, 'meddling' in our own evolution suggests serious threats of social and political abuse. Yet recent advances in genetics hold great promise for controlling hereditary diseases and otherwise benefiting mankind.

Deep research into the problem will arm the scientists concerned with the knowledge required to confront the complex of moral, radical, legal, and political problems inherent in the controversial issue of genetic engineering. There are two potentially dangerous situations making the problem even far more difficult. The first involves two parents who must decide whether or not to allow their profoundly defective infant to live; the second concerns the marriage of two people whose combined genes may condemn their off springs to a fearful disease.

Actually, such situations arise quite frequently - at least 1,500 genetic diseases have been identified - yet deciding how to deal with them intelligently is impossible without the kind of insight into man's genetic past, present and future. Scientists thoroughly explore our human inheritance and delve into such fascinating areas as the curious but extraordinarily successful attempt to recreate another

Leonardo da Vinci...

3lt's upon the future of this science to decide if anew eugenics based on human and humane principles is possible ... or desirable.

A. Comprehension

1. What is genetics in its general sense?
2. What differences exist between human genetics and that of breeding better plants and animals?
3. Describe the role of genetics from pragmatic/scientific point of view.
4. What is eugenics; how are its promoters called?

B. Discussion and Criticism (Reasoning)

1. You are asked to ponder the words of the most socially-minded man of his time, the English scientist J. B. S. Haldane (the words given at the beginning of the text).
2. Does 'eugenics' mean the same as 'genetic engineering'?
3. How is human genetics likely to affect the future of mankind?

Man and Environment

Many a man has dreamed of owning a square mile or two of land that was unmodified by human activity, but it is doubtful if such a place exists today outside of such inhospitable environments as Antarctica or some unsealed Himalayan peak. And if a man owned such an area, he could not know it, for as soon as he entered it to enjoy it, -his visit would immediately remove it from the pristine. Even in the remotest jungles and most barren deserts, man's influences from hunting and the transmission of disease have been felt. Man has become a species whose environment, includes essentially the entire world. With his developed power of transportation, he has not only invaded all of the tolerable places on the face of the earth but has also come to depend on most of them to meet some of his needs. In practically any modern city, foods and beverages come from almost the entire world. Minerals such as iron, tin, and copper are shipped throughout the globe, and tobacco and medicines pass from one person to another around the world. The entire earth is rapidly becoming a single global human community. The population of man on earth is at present still in its logarithmic phase, but perhaps some actual figures will make the picture clearer. Although no exact count is possible, it is estimated that the world's present population is nearly 4 billion. The birth rate exceeds the death rate - for every fourteen people who die, thirty-four babies are born. As a result, the human population is now increasing at a rate of about 2 per cent a year. Nearly 80 million people are added to the world's population each year. Mankind is thus a rapidly expanding population occupying a region that is limited in size. As every organism does and must, he utilizes the resources of his environment, but he is able to exert over his environment than any other animal.

Environmental Resources

The resources of the environment are of two basic types: renewable and nonrenewable. The ordinary biological community is a self-maintaining system, dependent on the sun as an initial source of energy, but otherwise essentially self-sufficient. Such elements as carbon, oxygen and nitrogen are constantly recycled. Almost nothing is lost but instead is passed through a series of cycles from one organism to another and between organisms and the inorganic environment. The types of resources available to such a community are said to be renewable, for they can be used over and over again.

When man developed the use of metals, he began to exploit non-renewable resources. When iron is minded, there is less in the earth than there was before, and although it is true that the iron atoms are not destroyed when an old car is allowed to rust and weather into the soil, the iron is still beyond economically feasible recovery. Also, with the industrial revolution, man sliifted from wood (renewable) as a fuel to fossil fuels such as oil, and gas (essentially nonrenewable).

Renewable Resources

One renewable resource of the human community is the forest. The clearing of forests for timber has not yet reached and may never reach the stage of universal depletion. Man has turned from wood as the primary source of building materials and fuel, and even though it is still extensively used for building and for making paper, people are now growing timber at a rate that exceeds their harvesting of it. On the other hand, man has cleared much of the forest for other purposes, resulting in serious depletion in some areas. Land cleared and maintained for agricultural purposes is lost as forest.

Because soil is continuously being formed in natural communities, it is generally considered a renewable resource. But man has, in places, tended to overcultivate and overgraze his lands to such an extent that soil is eroded away and carried ultimately to the sea faster than it is being formed.

Resources of the sea, including the plankton, have hardly been utilized (except for the over-exploitation of the great whales). Man does not farm the sea. Although its agricultural practices have undergone extensive revolution, his fishing methods are still rather primitive.

Man's treatment of renewable resources differs most from that of other animals in the interruption of natural cycles and food webs. When a natural grassland is plowed under and replaced by wheat, the result is not simply that wheat now grows where native grasses grew before. Organisms that used the natural grasses as the first step in the food pyramid are forced to move on; other organisms that eat wheat move in and increase and new food webs are formed. When wheat is harvested, essential materials are removed from the community instead of remaining in the biogeochemical cycles.

A. Comprehension

1. What are the basic types of the resources of the environment?
2. How does man's treatment of resources differ from that of animals?
3. Why are pessimists (optimists) mentioned in the text?

B. Discussion and Criticism (Reasoning)

1. What can you say about a present-day growth rate of human population?
2. Do you think optimists are right? If they are, give your reasonable evidence.

Man and Pollution

When we analyze pollution we find that it fits into three major categories -natural pollution; results of utilization of energy ; and litter.

Natural pollution is that resulting from natural causes and not from any of man's cultural activities. Volcanoes and forest fires started by lightning bring particulate matter into the air as pollution. Natural seepage of oils from crevices in the bottom of the sea has added nearly a billion liters (a quarter of a billion gallons) of petroleum hydrocarbons to the oceans.

For as long as we use energy we will have some pollution. The Second Law of Thermodynamics as stated by Kelvin and Planck says ' No cyclic process is possible whose result is the flow of heat from a single heat reservoir and the performance of an equivalent amount of work on a work reservoir'. In other words, we can never get as much useful work out of a machine as we put into it. Some energy is always lost in the form of heat or converted into some other form of energy. Thus coal-fired furnaces give off smoke, nuclear plants give off heat, and animals must defecate to rid themselves of undigested remains . Chemical wastes from manufacturing plants can be very destructive. With increased technology we may improve the situation, but we will not be able to eliminate pollution entirely.

Only the third form of pollution, litter, is under our complete control. This we can contain by educating the public and by legislative action.

In Retrospect and Prospect Probably at no other time in the earth's history could man have reached his present stage of physical and cultural evolution. Not until late in the Paleozoic had enough fossil fuels been formed to permit an industrial revolution. Not until late in the Cenozoic had

A Lifetime of Health

We are now witnessing the most rapid scientific and technological development in the history of Man - a development that could lead to a greater fulfillment of human aspirations than Man has ever known. To achieve it, however, Man must apply his newly gained skills with care, he must avoid whenever possible the creation of new problems, and he must find satisfactory solutions of those problems that have already appeared.

At no time in history has Man's future held such uncertainty as it does today. Modern technical and medical advancements have proven to be a mixed blessing. Technology and education have, on the one hand, raised standards of living and freed millions from degrading menial jobs; on the other, they have created social upheaval, the threat of nuclear annihilation, and a physical environment so poisoned that continued survival is being seriously questioned by prominent authorities. Medical science has been able to overcome many of the traditional causes of illness and early death, but that has resulted in a world population growth rate that threatens with massive famine and populations so dense that living can become a burden instead of a pleasure. All these developments relate directly to our physical and emotional health and so are an important part of our study of health science.

Meanings of Health

Health has many meanings and definitions. To the man on the street it usually means freedom from disease. To him who has lost health it means the loss of his most priceless possession: he may have every material possession, but without health he has nothing. To the psychologist health is principally the normal functioning of the mind; to the physician it is principally the normal functioning of the body.

The problems faced by Man today require that health be defined in very broad terms. Health cannot be defined as merely the absence of disease or as a purely personal condition. The World Health Organization's constitution defines health as ' a state of complete physical, mental, and social wellbeing and not merely the absence of disease or infirmity'. The health of the individual and society are mutually dependent. Individual health cannot reach its fullest development within an ailing society, nor can a society composed of physically or emotionally ill individuals be truly healthy. The health of the individual contributes to the health of society; the health of society helps build the health of the individual.

Another definition of health is 'the ability to function effectively within man's environment'. Health is seen as the consequence and the evidence of a successful adaptation to the conditions of physical and emotional existence and disease as a failure in adaptation. Since the environment is constantly changing, this definition of health implies an ongoing, continuous process of adaptation. When one's ability to adapt to a changing environment fails, then his health is affected. Such failure could result from an individual loss of adaptive ability (physical or emotional) or from an environment that changes beyond the inherent limits of a person's adaptive potential.

Factors Influencing Health

Mental outlook on life.

Mental health is recognized today as an essential and inseparable part of one's total health. Poor mental health is at least as handicapping in life as is poor physical health. Not only do emotional problems severely limit the pleasure one derives from living, but also they frequently result in physical illness. The abuse of alcohol or other drugs is today properly regarded as an emotional health problem.

Intelligent use of foods.

Today's methods of growing, processing, and shipping foods make possible good nutrition for people of even modest income; yet there are those in all income brackets who show signs of poor nutrition. Commonly observed today is the symptom of over-nutrition, excessive weight. Nutritional deficiencies also are common, especially among families of low income or poor education and among those who rely upon nutritional fads.

Living with others.

Individual , national, and world welfare depends strongly upon people's understanding each other socially, because social stresses can becloud the lives of millions. A high level of emotional health is essential for pleasant relationships among members of different ethnic and social groups. As the world population increases, international tensions increase. The quest for world peace requires finding solutions to many problems that relate to physical and emotional health.

Disease prevention.

Among the most traditional factors promoting health is the prevention of disease. Methods for the prevention of most communicable diseases are now available. Some of them are public health concerns, such as the control of mosquitoes and the assurance of safe foods and drinking water, but much disease prevention remains the responsibility of the individual as, for example, the procuring of immunizations and the prevention of venereal diseases. The prevention of the chronic degenerative diseases, now still largely in the research stages, will, when understood, probably rest mainly upon the efforts of the individual.

Choosing best health services.

The individual is responsible for selecting the best health services from those available in the community. Individuals must choose their medical practitioner carefully, checking his training, skill, and ethical standards. Quacks still flourish in many cities. Even among legitimate practitioners a wide range in skills exists. The choice of hospitals often determines the quality of care received. Many of the nation's hospitals do not meet the minimal standards for accreditation. The choice of a poor practitioner often restricts the patient to a poor hospital, which compounds the situation. The quality of care received often depends upon the ability to pay, which, for the average family, depends upon the type of health insurance it carries: health insurance policies vary greatly in coverage and value received, and many people unsuspectingly select very poor health insurance plans.

Protecting the environment.

Man's continued survival on earth depends upon his maintaining an environment favorable to his welfare. Fortunately, in recent years there has been an increasing awareness of the relationship between Man and his environment. One of the most critical problems is the pollution of that environment. Man can afford no further pollution of his air, soil, and water; it is not only esthetically unpleasant but also a definite health hazard.

Greater attention must also be given the significant problem of world population dynamics. There must be worldwide recognition of the fact that we live on a finite earth with finite resources and that even with the most efficient application of those resources there is a limit to the number of people the earth can support.

A. Comprehension

1. What does it mean 'Modern technical and medical advancements have proven to be a mixed blessing'?
2. How is the health defined in a truly healthy society?
3. What factors influence health?
4. What is the relationship between Man and his environment?

B. Discussion and Criticism (Reasoning)

1 .Do you think Man must avoid the creation of new problems? 2.'... a world population growth ... threatens with massive famine and ... living can become a burden instead of pleasure'. Try to approve or disapprove this statement. 3. Try to dwell upon the following: 'Prevention is better than cure'. Give examples

IV Earth, Seas, Oceans

Origin of the Hydrosphere

Hydrosphere is the collective name for all the water of the Earth including that which forms the seas, oceans, lakes, ice-caps and water vapor in the atmosphere.

Earliest Ideas.

During the seventeenth century the Irish churchman Archbishop James Ussher declared with complete confidence that the Earth, including the oceans, was created at 9 a.m. on 23 October 4004 BC. But long before the Archbishop's pronouncement, men had pondered deeply about the origin of the Earth, the oceans and life generally. In world mythologies one of the most striking similarities is the creation myth where mankind arose out of a primeval abyss or waste of water. This legendary watery creation can be observed in races as for apart in time and geography as the Egyptians, Jews, Hindus, Celts and North American Indians. Herodotus said that it was Thales who first proposed that everything was made of water. Anaximenes thought that the oceans were older than the land masses; fish were the first form of life which appeared on Earth , and when dry land rose out of the primeval waters, some of the fish adapted themselves to living on land; hence man evolved from fish.

According to the Greek poet Hesoid (eighth century BC), the first to come upon the vacant Earth were children born of the union of Earth and Heaven, and among them was Oceanus, the deep swirling ocean river that encircled the Earth. Aristotle posed the question: Could the sea have come from one source? He was puzzled about the origin of the Earth's water. He knew about the rivers as a source of water - the Nile in particular -and the underground water which supplied the wells. Intuitively he guessed that the seas were different, since they ebbed and flowed, although actually Aristotle had no real understanding of tides.

Aristotle also wondered whether some day in the distant future the seas might dry up. Other Greek philosophers pondered whether the seas were the sweat of the Earth, and in doing so came close to the modem ideas on the subject, but Aristotle thought this notion was absurd. Plato, attempting to analyze the idea logically, said that if the sea ran out of the depths of the Earth, the water would have to perform the proverbial impossibility of flowing uphill.

But to the Greeks the sea was considered the terminal and not the source of the Earth's waters, because all rivers flowed into the sea. However, there remained the fundamental question: If the sea was the terminus, and all the immense rivers poured their water into it, why did it not become progressively larger? Aristotle's explanation was that this was due to evaporation, a phenomenon he understood well: he knew the sun drew up water to the upper regions, where it condensed and later fell again as rain.

But perhaps the greatest puzzle to the Greeks was the saltiness of the seas. Although it was attributed to an admixture with 'salty earth', why then were the rivers not also salty? And how could the effect be limited to a vast body such as the oceans and not extend to the inland seas? Although the Greeks often came up with the wrong answers, they posed the right questions, which is a fundamental part of the processes of science. It was the framing of questions about the occurrence and origin of natural phenomena that led to the Greeks providing the groundwork of most modern scientific thinking.

Modern ideas.

Although our general knowledge about the nature of the Earth and its oceans has increased enormously since Greek times and the seventeenth century when Archbishop Ussher made his pronouncement, theories about the earliest years of Earth history are still only very speculative ones.

To trace the early history of the Earth we must first examine ideas about how the solar system and the Sun itself came into being before the Earth became a separate cosmic body. The Sun was formed as a result of the coalescence of a cloud of cosmic dust and gas. Most of the gas consisted of hydrogen and helium. At the present time we can witness similar star births taking place in various parts of our own galaxy and, perhaps ironically, we know a good deal more about the various processes involved in star formation than we do about the formation of cool bodies such as the Earth.

Speculation really begins with the ideas describing how the Sun became the central parent body to the host of planets plus all the other multifarious constituents like comets, meteorites, etc., that now belong (at least gravitationally) to the solar family. What seems likely is that the planets were formed from the condensation of a similar cosmic dust cloud to that which formed the Sun. Much of the material of this dust cloud was matter created by the first stars that formed the galaxy. Inside their thermonuclear-furnace interiors, these early stars synthesized all the ninety-two chemical elements which now exist. Subsequently, when these early stars died or exploded, the 'finished' elements were scattered throughout space. Then at a later date they provided material from which new stars and planets evolved.

Still in the realms of speculation is the mystery surrounding the early conditions on the primeval Earth. Was it a hot or a cold body? During the nineteenth century all theories about the origin of the Earth considered that it was born in a fiery state; then through the immensity of time it slowly cooled to become the world we know today. Nowadays, however, an opposite view is held. Many consider that the Earth came about by the gravitational contraction of a cold cloud of dust and gas particles, or was the result of a gradual accretion of a number of different-sized, cold, smaller bodies called planet esimals (large chunks like meteorites) which had solidified during the earlier history of the solar system. But neither hot nor cold theories of the origins of the Earth can account for the present-day composition of the Earth's atmosphere or the oceans. It seems that the atmosphere and the oceans are of secondary origin. Either the Earth originated without an atmosphere, or it lost it during a later terminal episode.

We do know that the age of the Earth is about 4.6 aeons (1 aeon = one thousand million years). The oldest known rocks are 4.0 aeons so that we have a missing 600 million years in the Earth's history.

However, the continuous existence of sedimentary rocks dating back for more than 3,000 million years demonstrates a continuity of the atmosphere and hydrosphere over a period of at least that length of time, for they otherwise could not have formed, as they did.

Present-day Atmosphere and Hydrosphere Origin.

The origin of the present-day atmosphere and hydrosphere began with a melting of the crustal rocks of the Earth which occurred after the missing 600 million years. Such a melting of the rocks would release the volatiles locked away since the Earth's formation. The source of heating can be accounted for either by radiogenic heating or tidal friction (when gravitational energy would be converted into heat). If the Earth had captured the Moon about this time, this particular event could well explain the source of tidal heat.

One clue to the date of the possible capture of the Moon by the Earth - bringing about the event of tides - are fossil stromatolites, which are dome-shaped sedimentary structures of algal origin found on beaches only between tidal limits. In recent forms they have relief heights of about 0.7 meters (27 inches). However, pre-Paleozoic stromatolites have a much greater amplitude than the recent ones, ranging from about 2.5 to 6 times as great. This points directly to the belief that tides in ancient times were generally much bigger than now. For this to occur the Moon must have been much closer to the Earth.

Rocks in the Swaziland System of south-east Africa show evidence of large tidal amplitude, and evidence provided by the oldest known metamorphic and granit rocks by lead-isotope dating methods indicate that the Earth suffered some thermal event about 3.5 to 3.6 aeons ago. The effect of the Earth capturing the Moon at this time would give rise to sufficient tidal frictional heat to cause subcrustal melting. The melting would promote outgassing of the rocks and the gradual build-up of both an atmosphere and a hydrosphere. Any pre-existing terrestrial atmosphere and hydrosphere would have been lost before the new one was triggered off. Such a close encounter between the Earth and the Moon 3 aeons ago would also cause a temporary atmosphere to form on the lunar surface.

In the early years of the Earth, oxygen was locked away in chemical sediments, and free oxygen did not appear in the atmosphere until it later escaped via the oceans. If the hydrosphere and atmosphere began 3.5-3.6 aeons ago, life on Earth must have followed fairly quickly, for microfossils dated at about 3.2 aeons have been identified in ancient rocks.

Although the theories that account for the mechanism and method by which the first free water that composed the oceans found its way into the basins must be speculative, no speculation is required to account for the presence of the water itself, for water is no rarity in cosmic space in any of its fundamental states as a solid, liquid or vapour . Meteorites similar in composition to planetesimal material contain water, and the variety known as carbonaceous chondrites contain water bound up in the form of the hydroxyl chemical groups. The rocks comprising the

Earth hold vast quantities of water, and many of these rocks are composed largely of silicate material which contains hydrated crystals, so that water is incorporated as part of the natural atomic structure. Crystalline rocks contain from 4 to 8 per cent water by volume. This locked-up water can only be released by heat, and it is possible to account for all the waters of the hydrosphere in terms of the amount of thermal energy released by radioactive decay processes occurring inside the crust or by volcanism without invoking the energy brought about by the Moon capture theory.

Thus the simplest picture is one where the Earth's hydrosphere was formed as a direct result of the 'sweating out' of water from the crustal rocks from energy derived by radio- active decay and/ or volcanism. This began as a slow process which today is continued and added to by the additional action of the great subcrustal machine responsible for sea-floor spreading. The mid-ocean ridges are the sources of much fresh material which is drawn up from the depths to the surface where juvenile primordial water is then released. The fact that the oceans are not saltier than they are is an indication that much of the free water now on the Earth's surface arrived at a comparatively late geological stage, and indeed many believe that the rocks fonning the continental masses are at least ten times older then the water contained in the present-day ocean basins.

A. Comprehension

1. So, could the sea have come from one source? Explain the question posed by Aristotle.
2. What is the modern theory of the Sun formation?
3. What is the modern theory of the Earth formation?

B. Discussion and Criticism (Reasoning)

1. Compare the earliest and modern ideas of the hydrosphere origin. Express your own opinion to that point.
2. Speculate on the ideas how the Sun became the central celestial body.

The Seas and the Oceans

The seas and oceans have always held a fascination for mankind, and in modern times we are sometimes inclined to forget that ancient man had intimate knowledge of the sea routes of the world. Much of this early knowledge was lost for, apart from intriguing snippets of evidence, most of their voyages are not recorded, and extant documents relating to almost every voyage prior to about AD 1000 are extremely rare.

Some of the ports from which early man set sail are no longer at the sea edge, such as the great delta ports in the Persian Gulf, which reached their peak in about 4,000 BC. Recently pre-historic have been traced from these ports across the ancient ocean trade routes which extended to the far corners of the Earth, and this evidence is fully supported by radiocarbon darings. The later mediaeval voyagers referred to sailing 'the seven seas', and the term was reintroduced into romantic literature about the sea at the end of the nineteenth century when Rudyard Kipling used it as a title for a book of his poems. The ancient 'seven seas' were the Red, China, Mediterranean, West Africa and East Africa seas, the Indian Ocean and the Persian Gulf. The modern unofficial 'seven seas' comprise the Antarctic, Arctic, North Atlantic, South Atlantic, North Pacific, South Pacific and Indian Oceans.

The first scientific ideas about the seas were formulated by the Greeks, and several of these remain the basis of present-day ideas. During the past decade, ocean science in particular has had considerable influence in changing some of the long-established concepts about the Earth, and the revolutionary phenomenon of sea-floor spread has been described as the trinity of the Earth sciences. Sea or ocean science is nowadays called 'oceanography', or by an even newer word, 'oceanology', coined in the 1960s. Some like to differentiate between the use of these terms, using 'oceanography' to describe the more academic aspects of ocean science, and 'oceanology' to describe modern ocean technology, including the political, legal, financial and economic aspects of the seas and oceans. Sir John Murray, one of the principal scientists of the H.M.S. 'Challenger' Expedition (1872-6), believed he had invented the word 'oceanography' in about 1880, but he later discovered that the word 'oceanography' was first used in France about 1584, but then dropped out of usage. The term 'ocean engineering' has also been in use in recent times. It has been defined as the ability to do useful work on, in and under the seas and oceans.

In popular literature it has become a journalistic cliche to refer to the enormous untapped and inexhaustible resources of the oceans, and the great role they will surely play in man's life in the future. As a generality it is a cliche which is almost true. The part which is not true, regrettably, is that the resources of the oceans are inexhaustible. Common greed has already decimated vast populations of marine life to the point of extinction. Many of the world's fishing grounds have been overfished and transformed into underwater Saliaras. The great whales - the largest animals ever to live on the Earth - have been ruthlessly slaughtered so that the once-important commercial fishery is now uneconomic to pursue. Pollution is manifest on a global scale. Even fish and seals in remain. Antarctic waters show dangerously high concentrations of man-made toxic wastes and, nearer to land, local pollution disasters are commonplace occurrences. When Thor Heyerdahl sailed his papyrus boat 'Ra' across the Atlantic, he found the sea covered with lumps of coagulated crude-oil spillage.

The seas and oceans have been colloquially called inner space as opposed to outer (cosmic) space. Man's economic and social future hinges on inner space far more than on the hostile environment of outer space. Now that the technological challenge of reaching the Moon and Mars has been realized, scientific technology is now being rechannelled into the hydrosphere. Economic and social pressures have already made many nations look hurriedly towards the oceans. By the year 2000, at the present rate of population growth, most of the water drunk by the Earth's inhabitants will come from desalinated sea-water. Already chemical and mineral exploitation of sea-water is big business. Most of the world's magnesium and bromine come from the seas, and the harvesting of common sea-salt is a fast growing industry in many countries. But it is in the realms of hydrocarbon fossil fuels that the richest commercial rewards are at present being reaped. By 1978 over 40 per cent of the world's oil and gas originated from beneath the ocean bed. Awaiting exploitation in the ever hungrier future is a whole range of valuable economic and strategic minerals such as manganese, diamonds, iron ore, tin, etc.

Yet, perhaps, the most exciting scientific and technological challenge is to find ways of exploiting the various basic resources of marine life at present untapped by man's economy. The great whales have almost gone, but the vast stocks of protein-rich krill, on which they feed, now remain only a partially exploited food source in the ocean's food chain. So far man's invention and technology has been unable to provide economic methods of exploiting this vast resource. Although the Soviet Union at present harvests

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Invention and Innovation in Modern Oceanography

One of the challenges of modern oceanography is the development and invention of new devices and techniques in order to exploit the oceans' resources. As stated already, there are numerous parallels between the problems in outer space and those in hydrospace. In particular,without the modern development in micro-electronic technology it is doubtful if exploration in either realm would have progressed as far as it has today. The electronics industry provides the ways and means of control and observation where man cannot control and observe. This blind underwater groping of yesteryear has been replaced by television and a whole complex of electronic gadgetry.

The development of sonar has provided man with an important underwater probe with many applications. All early experiments with sonar were little publicized because of its military importance. Nowadays its civil and research applications as an underwater probe are numerous. Sonar can be employed in fish hunting, fish counting and navigation, and in marine geophysical and geological investigations. Side-scanning sonar, using beams at right angles to the ship's track, is one of the most important geological bottom-mapping tools at present in use. Side-scanning sonar is also one of the best methods of surveying new seabed pipeline routes. By using high resolution sonar, it is possible to recognize the nature of unseen targets by their characteristic patterns of sonar echoes, thus producing pictures in sound in situations where television cameras cannot operate usefully.

Thus, side-scanning (side-looking) sonar is now a powerful new underwater tool. Pulsed acoustic signals are radiated by transducers carried in a towed 'fish'. The beams intersect the sea floor where energy is then back-scattered. As the ship progresses on its course, the back-scattered echoes are recorded permanently and continuously on a paper strip recorder revealing the nature of the sea-floor geology in a remarkably vivid way. Using this technique, undersea geological mapping can be carried out in a similar way to aerial photography on land surfaces. Routes for underwater pipelines can be planned with great accuracy; in addition there are many other technological and biological applications. Electronics have also provided the means of submarine wireless. Nowadays, using electrical pulse transmission, underwater communication between vessels can take place over distances of up to 50 kilometers. Automatic weather stations will soon replace more traditional weather sliips; they are much less expensive to operate, less hazardous to human life and can remain in commission for long periods without maintenance.

Contemporary marine technology has a wide spectrum of new invention and innovation. For example, a new kind of electromagnetic underwater shark barrier has been developed, which has already been erected near Durban in South Africa. Pulses pass through a cable on the sea floor, and these are transmitted to sharks above, causing them intense pain. Detailed research has revealed that sharks are vulnerable to particular electro-magnetic pulses to which humans fortunately remain immune. Another new anti-shark device is the 'Shark-Dart', which is claimed to be safest and most effective defense against sharks and other marine predators. The 'Shark-Dart' can be used as a dagger or as a lance and loaded with a CO_2 cartridge; the impact releases the CO_2 gas which expands, rupturing the shark's organs and forcing it to the surface. Its main advantages over other methods of killing sharks is that it is noiseless and bloodless, killing one shark will not attract others, and the weapon can be reloaded underwater very quickly.

Another innovation employed in sea-floor exploration is nuclear prospecting for minerals - using the uranium isotope, californium-252. The isotope has a half life of 2,5 years. Neutrons emitted during its decay are absorbed by minerals which then in turn emit characteristic gamma-rays. Californium-252 is a good isotope source for underwater prospecting, since it is compact and therefore highly portable, and at present it is used in probes which may be operated either from surface vessels or submersibles. Sea-floor mineral deposits can be calculated very accurately simply with a sensitive germanium-lithium detector sealed in the probe head. Results so far reveal concentrations as low as 3 parts in 100,000. Its application to metallic elements and minerals is very wide, including gold, silver, uranium, vanadium, copper, aluminum, fluorine, tin, silica, sodium and iron.

For construction and mining operations undertaken in shallow depths, bulldozers and excavators have been designed for excavating foundations and for concentrating mineral deposits. They may be operated from the surface by remote control, and thus do not involve men working at ambient water pressures.

A. Comprehension

1. Does the modern technique allow to exploit the oceans' resources? Give examples.
2. What is 'underwater probe with many applications' ; is it an instrument or an engine?
3. What is the source of the means of submarine wireless provision?
4. Which will be preferable in future, weather stations or weather ships?

B. Discussion and Criticism (Reasoning)

1. To be a modern oceanographer which fields of science and engineering should you devote yourself to?
2. Does the word 'invention' mean the same as that of 'innovation'? Prove, giving details.
3. You are an expert in geological prospecting. Will you be able to work as a sea-floor explorer? What is your own opinion?

V. Man in Industry

What is Industrial Psychology?

Psychology is a study of human behavior and, in general, can be considered as embracing two major facets. In the first place, psychology is concerned with the discovery of information relating to human behavior. This involves research, and can be considered as the scientific aspect of the field of psychology. The other phase is concerned with the application of information about human behavior to the various practical problems of human life. This facet can be thought of as the professional aspect of psychology, in much the same way that physicians, engineers, and others are concerned with the application of knowledge about some field to the practical problems of the real world.

One of the major areas of the application of psychological information is in the field of industry. During the last few decades industry has experienced very significant changes, and it has been during this period that the field of industrial psychology has developed. The applications of psychology to problems of industry generally cover the following areas: personnel psychology, which is concerned with such matters as the selection, placement, training of personnel, and related matters; social-industrial psychology, which is concerned with the behavior of people within organizations, and in groups; the design of man-machine systems and other equipment, facilities, work environments, and the job, in consideration of human capabilities and limitations; and consumer psychology, which is concerned with the behavior of people when they are serving in their role of consumers in the economy.

Thus industrial psychology is concerned with the study of human behavior in those aspects of life that are related to the production, distribution, and use of the goods and services of our civilization.

The Scope of Industrial Psychology

Unfortunately, the term 'industrial' psychology has certain restrictive connotations, in the sense that it implies what is conventionally referred to as 'industry'. This term, however, is used here in a very broad sense to embrace all aspects of the production and use of the goods and services of the economy. Operationally, human behavior is meant in all types of 'industry', including manufacturing, transportation, communications, utilities, agriculture, extraction of minerals, all types of services, institutions of various types, trade, government, and others.

We should view industrial psychology in this broad context, including the human problems associated with employee selection and placement, training, motivation, moral, supervision, and evaluation, and with related problems of organizations, financial remuneration, working conditions, and equipment design. Industrial psychology studies human behavior in these areas in order to obtain information that can be applied to the very practical objectives of helping to resolve industrial problems. Just as research in the physical sciences and engineering provides information that is useful for resolving engineering problems, so research in human behavior can provide information that can help to resolve some of the human problems in industry.

The human problems associated with industry have gone considerable changes over a period of years. The industrial revolution brought about a major change in the nature of human work and in work environment. Some of the functions that were formerly carried out by hand with the use of hand tools became mechanized thereby creating jobs involved in the operation and maintenance of machines.

The current trend towards automation undoubtedly will bring about major additional alterations in the nature and organization of human work, in the use of goods and services, and in the over-all pattern of human life.

The Development of Industrial Psychology.

The field of psychology has developed largely since the turn of the century.

During the several years after World War I, the interest in psychology (P) as applied to the human problems of industry was relatively sporadic.

In general terms, the field of industrial psychology had become fairly well established by the 1930's. The dominant emphasis during the early years, and continuing through the 1930's and the 40's was that of employee selection and placement, with particular reference to the development and the use of tests for these purposes. This has continued to be an important facet of industrial psychology, and undoubtedly will continue to be important in the years to come.

During and since World War II there has been a parallel development of what is sometimes called engineering psychology or human factors engineering. The focus of engineering psychology is on designing of physical equipment and facilities in terms of considerations of human abilities and limitations, in order to facilitate their use by human beings. The increased concern with such design problems has been brought about by the rapidly changing technology, and with the accompanying development of new and more complex types of equipment for people to use.

In recent years, however, there has been a tendency toward viewing human activities within the context of 'systems'. In this context the intent is not to adapt human beings to any predetermined configuration of physical equipment or to predetermined procedures and operations, nor, on the other hand, is it to adapt equipment, procedures, and operations to human beings. Rather, the intent is to develop a 'system' that provides an optimum blend of people, equipment, procedures, and operations - the optimum blend capitalizing on the relative capabilities of human beings and of physical equipment ill perforating different functions.

It might be added here that, while the system concept is most obviously applicable to circumstances where human beings are to interact with items of physical equipment the concept is also applicable to processes or operations in which little physical equipment is used, such as office operations, service and distribution processes, communication processes, etc. Even a complete organization can be viewed as a system.

A. Comprehension

1. Why are people in great need of psychology?
2. Can psychological information be applied in the real world? Give examples.
3. If it is applied in industry, how is this area of psychology application called?
4. What is meant by 'personnel psychology'?

B. Discussion and Criticism (Reasoning)

1 .Suppose, you are a leader of a working group, which areas of industrial psychology you have to account in your organization work? Why?

2. Explain clearly what is meant by 'engineering psychology'.
3. Give concrete examples of psychological information deriving.

Some More About Integrated 'Systems'

It needs to be pointed out that, at present, the planned synthesis of human beings, physical facilities, and procedures and operations into integrated 'systems' is something that people have talked more about than they have done much about. But this is a development that seems definitely to be in the wind, and as it develops there will be opportunities for industrial psychologists to make distinct contributions to the development of systems, toward the objectives of aiding in the optimum utilization of human talent in the processes of the production of goods and services.

If there is one facet of the systems point of view that is dominant, it is the notion of interactions - interactions between men and machines, interactions between people, interactions between processes, and interactions between units of organizations and between organizations. To put it another way, one should not view specific aspects of a system as being isolated or vacuum packed. Rather, as any single aspect of a system is modified (machines, personnel, processes, organization, etc.), there usually are interactions with other aspects. For example, as a process becomes mechanized or automated, the personnel requirements (both in terms of numbers and kinds of personnel) will usually be affected. As the allocation of functions to different people is changed, organizational relationships may have been altered. As physical equipment is changed, jobs may be changed, thus affecting employment and training requirements. Or the anticipated technological changes in an industry might suggest the need to plan well in advance appropriate retraining and personnel recruitment programs.

While techniques and methods for applying the systems approach to industrial operations are still not well crystallized, nevertheless it is suggested that the systems concept provides something of a point of view or frame of reference for dealing with the human problems in industry.

In brief, it can be seen that industrial psychology deals with a wide, and changing, gamut of human problems involved in the production and use of goods and services. These problems have not been static in the past, and it is unlikely that they will remain static in the future. The changing technology of our times is continuing to alter the nature of human work and of the goods and services people use. Automation undoubtedly will have a major impact, not only in the nature of human work, but also on the entire economy and way of life. Many of the human implications of such changes will become the problems for the industrial psychologist of the future.

Equipment and Work Design.

The nature of jobs is, of course, an important source of variance in work performance. The activities that comprise a job are the consequence of two primary factors: 1) the design of any physical equipment and physical facilities used, and 2) the job methods that have been established by the organization or that are developed by the worker. Since these factors are amenable to change they can be modified in order to optimize relevant criteria such as productivity, quality, physiological costs, or employee safety and welfare. There are two general domains of effort that are concerned with work activities: methods analysis and human factors engineering.

Methods Analysis

Historically, the industrial engineers have been concerned with developing work processes, with particular reference to the work activities of people, including work procedures, work layout, work standards, etc. Various techniques of methods analysis are used in developing work methods and layout. The purposes of methods analysis are:

1. Developing the preferred system and method.
2. Standardizing this system and method.
3. Determining the time required by a qualified and properly trained person working at a normal pace to do a specific task or operation.
4. Assisting in training the worker in the preferred method. From ordinary observations and the application of simple logic, it is apparent that different methods of doing a certain job may require different amounts of time and physical energy.

The principles of motion economy are classified in three broad groups:

1. The use of the human body.
2. The arrangement of the work place.
3. The design of tools and equipment.

The design of tools and equipment is relevant to human factors engineering.

Human Factors Engineering.

The second type of effort is that which has come to be known as human factors engineering, human engineering, and (in Great Britain) ergonomics. This field intermeshes with methods analysis, but it is concerned more with the design of equipment and other physical facilities in terms of human considerations. Human factors engineering can be defined as designing for human use. Man has always striven toward designing the things he uses in order that he can use them more effectively and with minimum effort on his part. Since the types of equipment and facilities used in the days gone by were relatively uncomplicated, it was possible to try things out, and if they were not fully suitable for human use, the next version could be modified. Thus, many items of human use (hand tools, etc.) went through an evolutionary process. In more recent years, however, more systematic attention has been given to the design of equipment and other physical facilities from the human factors point of view. This recent concern was instigated primarily by the experience of space exploration. The subsequent development of space programs, and of more complicated industrial and other systems, has focused attention on the need to take human factors into account early in the design of such systems, in order to have greater assurance that the systems can be used more effectively when they are produced. The shift has placed greater emphasis on the use of research as the basis for designing items for human use, since the slow, evolutionary process, predicated on human trial and error, is incompatible with today's fast moving technology. The research that provides the base for human factors engineering comes from such fields as psychology, anthropology, physiology, and biology. The <u>gamut</u> of such research is broad, including such varied topics as visual performance, speech communications, decision-making, performance under weightlessness and psychomotor performance.

A. Comprehension

1. What is the idea of integrated systems?
2. Are they highly contributive to the practical problems of the real world?
3. Do mechanization and automatization affect organizational relationships? Why and how?
4. What criteria should be optimized in the process of work activities?
5. Is economics connected with designing? Explain, give examples.

B. Discussion and Criticism (Reasoning)

1. Can you think of any integrated systems not mentioned in the passage? Try to give specific examples wherever possible.
2. Have you read any published accounts of the investigations into the 'systems' applications? Name some sources of such information.

Sources of Error in Scientific Investigation.

Earlier we examined briefly the sequence of procedures which make up the so-called scientific method. We are now going to consider a few of the many ways in which a scientist may fall into error while following these procedures.

In formulating hypotheses, for example, a common error is the uncritical acceptance of the apparently common-sense, but untested, assumptions. Thus in the field of psychology it was for many years automatically assumed that the main cause of forgetfulness is the interval of time elapsing between successive exposures to a learning stimulus. Experimentation, however, was subsequently undertaken, and several other factors, such as motivation and the strength of effectiveness of the stimulus, turned out to have an even more important bearing on the problem. A somewhat similar error arises from neglect of multiple causes. Thus two events may be found to be associated, e.g. when the incidence of a disease in a smoky industrial sector of a city is significantly higher than in the smoke-free zones. A research worker might infer that the existence of the disease is due to the smokiness of the area when in fact it might equally well be found in other reasons, such as the undernourishment of the inhabitants or over-crowding.

Both in collecting the original evidence and in carrying out subsequent experiments, a frequent cause of error is the fact that observations are not continued for a long enough time. This may lead not only to a failure to discover positive items (e.g. Le Monnier's failure to recognize that Uranus was a new planet, not a fixed star, etc.), but may also result in important negative aspects of the investigation remaining undiscovered. In applied science, this latter error may have disastrous consequences, as in the case of the thalidomide drugs, cancer-including industrial chemicals, etc.

Another well-known error in experimentation is lack of adequate controls. Thus a few years ago it was widely believed that a certain vaccine could prevent the common cold, since in the experiments the vaccinated subjects reported a decrease in the incidence of colds compared with the previous year. Yet later, more strictly-controlled experiments failed to support this conclusion, which could have been due to a misinterpretation of chance results. This error is often caused by a failure to test a sufficient number of subjects (inadequate sampling), a disadvantage which affects medical and psychological research in particular.

Errors in measurement, particularly where complicated instruments are used, are common: they may arise through lack of skill in the operator or may be introduced through defects in the apparatus itself. Furthermore, it should be borne in mind that apparently minor changes in laboratory conditions, such as variations in the electric current, or failure to maintain atmospheric conditions constant, may disturb the accuracy of various items of equipment and hence have an adverse influence on the experiment or series of experiments as a whole. In addition, such errors tend to be cumulative.

Finally, emotion in the observer can be one of the most dangerous sources of error. This may cause the researcher to over-stress or attach too much importance to irrelevant details because of their usefulness in supporting a theory to which he is personally inclined. Conversely, evidence disproving the view held may be ignored for similar reasons. Even routine matters such as the recording of data may be subjects to emotional interference, and should be carefully checked.

To sum up (summarize), the multiple possibilities of error are present at every stage of a scientific investigation, and constant vigilance (care) and the greatest foresight must be exercised in order to minimize or eliminate them. Additional errors are, of course, connected with faulty reasoning; but so widespread and serious are the consequences that may arise from this source that they deserve separate treatment in future.

A. Comprehension

1. At what stage of an investigation is the scientist most likely to commit the error of accepting untested assumptions? Give an example of this type of error.
2.Name two broad results that insufficient observation may lead to. Give examples of each. What is meant by 'inadequate sampling'?
3.Name two causes of inaccurate measurements.
4.What other factors can affect the accuracy of instruments?5
5.Name three ways in which emotion can cause scientists to make mistakes.

B. Discussion and Criticism (Reasoning)

1. Can you suggest why medical and psychological researchers are liable to fall into the error of inadequate sampling?
2. Give concrete examples of each of the errors mentioned in the reading passage.
3. Explain clearly what is meant by 'lack of adequate controls'.

How to Improve Your Memory

U.S. News & World Report (Washington, D.C.)
Interview with Robert L. Montgomery, expert on memory training.

Good memory is one of the executive's most immediate needs, but it is vital for others as well - for anyone who meets people on business or social occasions.

Forgetfulness is an irritating and costly problem for a busy person. It produces stress and results in loss of valuable time. The saving of time will come about more easily with a good memory than from any other single ability.

An unreliable memory also cuts a person's self-confidence and peace of mind. Many people are afraid to give a speech because they may forget important points. They dodge others at parties and business meetings because they can't remember names. It affects conversation, too - when people can't recall things they have read of current events or interesting facts about people. That kind of behavior can be a stumbling block for promotion or advancement.

Today one has to remember phone numbers, addresses, ZIP codes, Social Security numbers, bank-account and computer codes, and birth and anniversary dates. That doesn't include all the statistics that a professional person has to remember these days, such as economic and demographic data and budget figures.

Beyond numbers, one has to be able to recollect names accurately: First names and last names - from secretaries and clerks right up to the chief executive officer - as well as their titles.

Then there are all the lists that a person has to keep in mind: Shopping lists, idea lists, jobs to do, meeting agendas, even laws and regulations that affect one's business.

With practice, an individual using simple memory techniques can increase his ability to remember by 300 to 500 per cent.

Before that can happen, however, he has to strongly want a more powerful memory, he must concentrate on improving his memory, and he must learn to care about people. That's vital to remembering information about specific individuals.

I'm convinced that one reason we don't recall the names of people we meet at parties,
is that we don't really hear the names in the first place. We have no real desire to do so. We're lazy.

The three key principles are to **visualize, repeat,** and **associate.**

Eighty-five per cent of what we learn and remember comes through our eyes, 11 per cent through our ears, 3 or 4 per cent through taste,touch or smell. So it's a real advantage to see something we want to remember in picture form or written down.

For example, when you meet someone for the first time, take a look at that person's business card. First, learn the name and form a mental picture of the person. See it in your mind's eye.

Second, repeat the things you want to remember again and again. That's the idea behind rote learning in school - the way most people learned spelling and multiplication tables. And it is the №1 law of advertising. Radio and television commercial rely heavily on repetition to remind listeners about products.

Third - and most important - memory improvement depends on being able to make vivid associations. The ancient peoples of the Middle East realized that the mind is an associating machine. Some of their clay-tablet pictographs - going back 2,500 years before Christ - were memory joggers for planting, and plowing and harvesting. To recall a name, date or fact, what the brain needs is a cue: Something that triggers a connection.

Or use an acronym. One example is the word 'homes'. It contains the first letters of the names of each of the five Great lakes. Once you've learned that you've got a ready-made way to recall each of those lakes. Such abbreviations as GM and AT&T are widely recognized in America.

With a little imagination, anyone can come up with a mnemonic idea that can be used to spark a specific memory.

For names, I use what I call 'ACE' system - which stands for ' action, color and exaggeration'. Whenever someone makes a new acquaintance, these three ideas should be built into the name association. The more ridiculous, the more ludicrous the mental picture, the better. Just grab the first crazy idea your mind throws at you.

Before long, associations pop into your mind like magic. For most names, I find I can come up with an instant idea, and I grab it. The best one is usually the one I think of first. It may be hokey, but that's the way memory works.

How should a man handle the cocktail-party situation, where meeting a succession of people for the first time involves trying to remember each one's name? You need about 15 to 20 seconds of interaction with an individual before an association occurs.

You can't just concentrate on the name to the exclusion of the conversation. But if you can repeat the person's name once or twice, either silently or out loud, that helps. Questions about the origin of a name often help, too.

Let's say you are introduced to 'Colleen Butler'. You might ask: 'Is your first name spelled with two l's? You must come from an Irish Family - right? Delighted to meet you, Miss Butler'.

One of the most successful is the 'stack and link' method. This is a way of linking items on a list in a specific sequence so that they can be recalled consecutively. The basic idea is that whatever you want to remember - a poem, a speech, a batch of sales ideas, textbook material or a shopping list - can be stacked and linked mentally.

You just have to trust your creativity, humour and experience to provide you quickly with ideas for objects to picture. Mark Twain was a noted raconteur who used a version of the stack-and-link idea. He could get up in front of audiences night after night and talk for an hour or two without any written notes.

How did he do it? He used to walk through a park in the town he was visiting, before the time for his appearance on the platform, and he would attach ideas for his speech to items in the park - such as a bench here or a tree there, or a flower bed or water fountain or bandstand. Then when he got up for the speech, he would mentally walk through the park, linking key items in his talk to what he had seen. The associations would just flow out.

One shouldn't memorize a speech, rather, a person should have a theme for a speech that uses key words to link different sections together. With practice, anyone can give a speech without notes, or written text and never have to lose eye contact with the audience.

Six hints to help you remember:

1. Repeat to yourself the facts you want to remember again and again.
2. When meeting anew acquaintance, use the individual's name once or twice in conversation.
3. To link first and last names, create a mental picture - the more ridiculous the better. Example: The name 'Don Bacon' might suggest an image of having bacon at dawn.
4. Don't memorize speeches, but rather key words that introduce various sections.
5. To recall lists, form mental images that use a different object to stand for each bit of information.
6. To remember details, use acronyms and rhymes. The word 'homes', for example, has the first letter of the names of each of the five Great Lakes.

A. Comprehension

1. Why does the expert stress the importance of a good memory?
2. Why are people required to remember more information now than they once did?
3. To what extent can Man improve his memory?
4. How do American/English children remember spelling and multiplication tables?

B. Discussion and Criticism (Reasoning)

1. Describe some of your own basic techniques for memory sharpening. Compare them with those offered by the top expert.
2. Which of his six hints would you chose for memory training? Why?

VI. Society in Problems

Science and the Future

In preceding (previous) extracts, we have examined briefly some of the characteristics, methods, effects and problems of present-day science. At this stage it may be worth considering a few of the ways in which it may develop in the near future, i.e. the next decade or so.

To begin with, we can expect applied science to produce a vast (huge, enormous) increase in entirely new synthetic products of all kinds. These will range from lightweight, high-strength materials for use in the many specialized branches of engineering, to drugs and chemicals with a greatly-increased selectivity which can be used in medicine and agriculture. However, in this latter case in particular, it may be predicted that the wide-spread application and combination of new and more complex products will give rise to unexpected inter-reactions and side-effects. For this reason , greatly intensified programs of research will be required in order to discover and eliminate the harmful results of such combinations.

Another point is that the rapid expansion of industrialization throughout the world must inevitably lead to a progressive exhaustion of natural resources. If we wish to counter-balance these losses to some extent, we shall have to follow two main courses of action: (a) much greater efforts will have to be applied (devoted) to conservation, particularly of such items as soils, fuels and minerals; (b) more efficient methods of exploitation will have to be developed.

In the more developed countries, the automatization of industry (automation) will lead to a high degree of efficiency in the production of manufactured goods, and is likely to have far-reaching social effects. For instance, workers will need to be more highly trained and more flexible - they will probably have to be capable of changing (shifting) from one skilled job to another - and they will also have more free time, as they will work fewer hours per day. This in turn will necessitate a considerable expansion and reorientation and education. Another result of automation should be to accelerate (speed up) the accumulation of surplus capital, which could then be made available for the purpose of assisting the emerging countries to solve some of the problems of underdevelopment. It should, however, be borne in mind that this process itself might involve a chain of difficulties, in this case of a political nature.

In general, the application - or misapplication - of science and technology in all fields is certain to affect the structure of society as a whole. This will remain true whether we are dealing with the application of psychology to advertising and political propaganda, or engineering to the mass media of communication, or of medical science to the problems of overpopulation or old age. This could lead to the development of a special discipline, whose job would be to estimate (evaluate) the social consequences of all major research and development (R and D) projects before they are put into large-scale operation. It should here be pointed out that one of the most powerful trends in present-day science is for separate branches to converge and form inter-related groups of studies. If this trend continues, it may in fact lead to the emergence of an entirely new type of scientist, i.e. he multidisciplinary coordinator.

As we have previously seen, international cooperation has become greatly intensified in recent years, and this tendency will doubtless become even more strongly marked in the future. It is therefore likely that the scientific efforts of individual countries will tend to be unified and coordinated by supra-national entities, and the more this is done, the greater the probability that supra-national governments will eventually be set up.

National governments, also, will be brought into closer and closer contact with science. To quote only one reason, the State will have to provide an increasingly large portion of the money spent on scientific investigation: it can therefore be expected to play an increasingly important role (part) in the planing of R and D programs. It will also tend to determine one of the fundamental questions affecting science in the future, viz. the percentage of the funds which are made available for basic research, and the percentage allotted to development projects. From another point of view, the cumulative use of science in government must have an overall effect of greatly extending the control of the State over the ordinary citizen. All these factors, and many other related considerations, should stimulate a great deal of rethinking on this subject, the result of which could bring about (cause) a scientific revolution in politics , or a political revolution in science - or both.

Science and International Co-operation

One of the most striking characteristics of modern science has been the increasing trend towards closer co-operation between scientists and scientific institutions all over the world.

What have been the reasons for this? One of the factors has already been discussed, i.e. the growing complexity and widening scope of present-day research, which has resulted in the creation of large organizations employing great numbers of scientists and technologists in programs of directed research. Tins has inevitably led to the extension of many items of research beyond national boundaries.

The most important factor, however, has been the magnitude of the problems to be solved. In fact, it is becoming more and more evident that many of the problems affecting the world today cannot be solved except by the pooling of scientific effort and material resources on a world-wide scale. The exploration of space, world finance and the development of new sources of power, such as atomic energy- these are examples of areas of scientific research which are so costly and complicated that no single country or organization, working by itself, can hope to tackle them efficiently.

A third powerful reason has been the increasing political and economic interdependence of nations, both rich and poor. This has had a direct effect on large areas of scientific and technological investigations, such as those connected with armaments, communications, health, agriculture, economic planning and sociological research.

As a result of the conditions outlined above, international co-operation has been greatly intensified during the last 20 years, largely owing to the initiative of the United Nations Organizations (UNO) and its specialized agencies, in particular the United Nations Educational, Scientific and Cultural Organization (UNESCO). Thus the most urgent problem for many parts of the world, i.e. food production, is being dealt with by the Food and Agricultural Organization (FAO). The World Health Organization (WHO), another U.N. agency, not only co-ordinates many research projects on medicine all over the world, but supplies advice and aid in the control of diseases in developing countries. Technical and economic assistance is provided by other U.N. bodies such as Economic and Social Council (ECOSOC) or the Economic Commission for Latin America (ECLA) and similar agencies for other regions of the world.

Apart from the international agencies controlled by the UN, many scientific and technological organizations, both governmental and privately owned, are pooling their resources and incorporating themselves into supra-national bodies: a good example is the Organization for Economic Cooperation and Development with member-countries throughout the world. Universities, too, are tending to develop joint research projects with their counterparts in other parts of the world, and finally, many scientific disciplines have had, for a long time past, their own international unions and associations whose main functions are dissemination of information, the coordination of research and the standardization of measurements and nomenclature.

A. Comprehension

1. Why are natural resources rapidly becoming exhausted? What items are particularly outstanding in this respect?
2. Name some U.N. agencies, and say what work each has carried out.
3. What do you understand by the term 'multi-disciplinary coordinator'?
4. Why might scientists of this type be required in the future?
5. What has been one of the increasing trends in modern science?

B. Discussion and Criticism (Reasoning)

1. Give clear illustrations of the exhaustion of natural resources.
2. How can natural resources be conserved? Give specific examples.
3. Discuss the given ways in which the application of science is affecting the structure of society. Give further illustrations of your own.
4. What are some of the ways in which you think your own (or other people's) profession will develop in the future?
5. What do you know about the International Geophysical Year as an example of scientific cooperation on a world-wide scale?
6. Give examples of international cooperation affecting your own (or any other) country.

Communication

Communication is a use of transport. Until very recently the only method of communication was physical travel. If a person did not travel himself, he would send a message, carried by someone else. The excellent system of Roman roads was forged by the need to communicate over long distances (and to move troops). Today, when we can communicate by radio or telephone, communication and transport are no longer the same thing.

Modern communication is perhaps man's most astonishing achievement. It is amazing enough to know that man has gone to the moon, landed there, and come back; but what seems to me even more incredible is that we can actually see the spaceman as they walk on the surface of the moon and hear what they say at the time they are saying it, 250,000 miles away.Millions of people on earth sitting in front of their TV sets can all watch and listen at the same time. To a man bora one hundred years ago this would have been completely beyond belief. Yet the moon is not the limit. The same thing could have been done at a distance of hundred times greater than that.

There are many different aspects of communication. First there is the matter of distance. Two people can communicate with each other by speech over a short distance, but as the distance increases, speech is no longer sufficient - so the problem is one of overcoming distance or of making speech carry. Second, there is the multiplication aspect. For instance, by the use of radio or TV one man can communicate with millions of others at the same time. Third, there is the recording aspect. Until the invention of wireless and telegraphy, all long-distance communication involved recording the message and then physically carrying this record over the distance (by horse or ship). Recording can also help multiplication, as when a newspaper or book repeats a message and delivers it to thousands of different people. Recording has yet another advantage in that it can conquer time. The recorded message can be kept for an almost indefinite period (and with re-copying for an infinite period).

From a pointed stick used to scratch in the dust or on a clay tablet the transition to a pen is not a great one. It involves the invention of ink and paper. The next step was a pen which carried its own ink with it. This is like going back to the pointed stick, which needs no ink. A pencil can be regarded as a sort of solidified ink stick since the graphite in the pencil is related to the black color in many inks. The first 'lead' pencils did indeed use lead but the switch to graphite came in 1795, and from that day to this pencils have remained exactly the same. From the pencil to the ball-point pen is an obvious step since the ball-point is just a pencil with semi-solid ink. Yet the ball-point was invented only in the 1930s. Why the delay? Probably because the fountain pen was so satisfactory that no one was interested in a new device. That may explain why the ball-point was first manufactured as a high-level 'writing-stick' for the air-force.

Typewriters were first developed for the use of the blind. The earliest ones were slow and clumsy, and could not rival the efficient pen; only if you were blind and could not use a pen would there be any point in using a typewriter. The initial idea for the typewriter came from a machine that was used to number the pages of a book. The transfer from numbering to lettering was the sort of concept-transfer that can be found in many inventions: moving an idea from its original setting to a new one.

From a technical point of view, the step from personal writing to printing is not great: it is still a matter of applying ink to paper. But the effectiveness of the change is incalculable, for at once the multiplication factor is introduced, and there is no limit to the number of people who can receive the written message. As in many other cases, printing appears to have been invented first in China. In the West its invention is usually credited to Gutenberg, though there were evidently others before him.

For three hundred years printing remained more or less the same until new papers made necessary the introduction of mechanical high-speed presses. Even so, the basic process of making and assembling the type did not change until the recent introduction of the photographic methods mentioned above. It is interesting to speculate on what might have happened if inventors had been more active in those three hundred dormant years. For instance, the simple development of a cylinder rolled over many sheets of paper might have made a great difference, and no profound technology would have been required. But since knowledge was regarded as the prerogative of the elite there may not have seemed any need for developing mass printing techniques.

Long before written language, artists had drawn pictures on the walls of caves and elsewhere. Each picture in its place could be regarded as message to the onlooker, just as a musical performance is a message to a listener.

The camera is a most remarkable invention, but a very simple one. The optical side of the camera has existed for a long time as the camera obscure, which projected on a screen a picture of the scene placed before it. All that was required was to capture that picture and make it permanent. Looking for a way to make this happen might have taken a long time, but a chance observation by Niepce in 1816 provided the method. He noticed that a piece of silver chloride paper on the laboratory bench retained the image of a spoon after the spoon had been removed. From the observation came the use of silver chloride paper to react to light and to give a permanent record and from then on it became merely a matter of refinement and improvement on the chemical and optical side. The remarkable thing about the camera is that with one single invention man became capable of recording scenes and pictures, and indeed any material that he could see (including print). It was as if man had been given an entirely new memory system. Some of the traditional functions of art at once became obsolete.

The step from the still camera to the movie camera was a much smaller one. The principle of moving pictures and various devices to activate them had been in

existence long before the camera. All that was needed was to design shutters, sprockets and other mechanical devices to record and then project a series of still pictures in a succession
rapid enough to give the allusion of movement.

Up to this point the communicating devices mentioned above have depended on recording. The essential process was to remove time. Once that had been achieved the message could be delivered at any pace. The coming of electronics made it possible to communicate over large distances without going through the recording stage. (Technically it might be said that the pattern of electric impulses in a telegraph wire or a modulated radio signal is a very brief form of recording.)This meant that it was possible to conquer distance directly without loss of time, so that a message could be spoken and received almost instantly even over very long distances (for instance, as we have seen, from the moon).

The development of electronic communication is a fascinating story of observation and invention, in which it was interested amateurs who made most of the advances. The usual dividing line between scientist and technologist did not exist, for the man applying the scientific principles directly to an invention was often the man who had discovered the principle himself (e.g. Faraday, Marconi, Edison). The telephone was invented by a teacher of deaf-mutes. The telegraph was developed by a retired Indian army man who made anatomical models for a living. His name was Cooke and in partnership with Professor Wheatstone he developed a device in which a current transmitted over wires caused magnetic needles to point to different letters at the other end. This has remained the basic principle of the telegraph: a current altered in some way at the input end operates (via magnetism) some output device at the other end. The invention of the Morse code meant that the input and output devices only had to indicate an on/of signal (for instance a buzzer or light would be on for a long period giving a 'dash' or a short period giving a 'dot'). This excellent idea simplified telegraphy - it was much easier than having magnetic needles pointing to letters. The Morse code is one of those elegant creative ideas which arise directly from the mind without requiring any special technical knowledge.

A telephone is a very much refined telegraph which had to wait the development of microphones and loudspeakers. At the input end the microphone converts ordinary speech into alternations in an electric current and at the output end the loudspeaker changes the current back into the sound of speech.The development of these devices is a story of individual experiments working with magnetic coils and resistances, noticing results, testing them out, refining and developing ideas into a practical form. The microphone has gone through several stages of development but the loudspeaker is in principle exactly the same as when it was first invented.

Once the principle of transmitting electric current through wires was known, the development of the telegraph and telephone was almost inevitable. Because we can think of wires as pipes or tubes, the business of transmitting a message by wire seems very much less extraordinary than transmitting it without any wire at all. The development of wireless or radio is a remarkable story because only three people were involved. A much under-appreciated mathematician, James Cleric Maxwell, had worked out the behavior of all electromagnetic waves from radio waves to X-rays, at a time when neither of these were known. Much later Heinrich Hertz demonstrated radio waves in a primitive manner by showing how a spark across a gap in a loop could excite another spark across a gap on the other side of the room. From this tiny observation Marconi developed wireless to the point where he could transmit messages across the Atlantic and from ship to ship. To do this he had to make a number of inventions along the way, though he benefitted to some extent from the technology developed in the field of telegraphy.

The full development of electronic communication depended on two key amplifying devices which could magnify the tiny currents that were received : the triode valve and the transistor. Both came later.

Transmitting speech and sound were difficult enough, but easy when compared with the complexity of transmitting a picture. The electronic processes were much the same once the picture could be converted into an electronic signal, but how was the conversion to take place? There were two approaches to television. At first the mechanical method seemed possible but eventually the electronic approach, using cathode ray tubes, turned out to be vastly superior. This is an example of how a false start may be sufficiently successful to make the electronic process worth chasing.

Although pictures have always been more complex than speech or sound, the direct recording of sound came much later than the direct recording of pictures in the camera. The gramophone is a mechanical recording device and does not depend on electronics, although these are now used to amplify and refine the sound. The gramophone was invented when Edison was recording Morse dots on waxed paper tape and noticed a hum when this ran past the needle too rapidly. From this he went on to the experiment with waxed cylinders. The path of development was fairly straight to the stereo records of today. True electronic recording of sound involved the magnetic tape. Like the camera, this is basically a very simple invention, and very effective. We think of it as recent but in fact it was invented in 1900 by Vladimir Poulsen, who demonstrated the principle with a steel strip. Nothing significant was done about the invention because gramophone recording seemed adequate. A big impetus was given to the emergence of magnetic tape recording by the computer, which relies heavily on this type of memory. Because the system is entirely electronic there is growing interest in tape recording and the basically mechanical gramophone system may eventually disappear.

Electronics have made a fantastic difference to communication, and yet the world might not have been very different without them. Apart from emergencies, rapid communication may be something of a luxury. Perhaps print technology would have been sufficient when coupled with an efficient transport system. But communication need not be only practical. Musical instruments can be regarded as an aesthetic communicating device for carrying a message from the composer, through the player, to the listener. Today the steps may involve written music, the player and instrument, the electronics of the recording studio, the disc and the gramophone to play it. The essential device is the musical instrument. The history of musical instrument is one of diverse developments and improvements. New families of instruments have arisen from time to tune or been borrowed from other cultures but the basic instruments have remained the same for centuries. Perhaps this is not surprising because it is what the player does with the instrument that matters. Yet new technical developments in instruments - such as the electronic music synthesizer - have opened up whole new areas of musical interpretation and expression. More than anywhere else, musical instruments show technology as the servant of aesthetics.

A. Comprehension

1. Name the main aspects of communication.
2. Describe the process of making and assembling the type for printing.
3. What two devices influenced the development of the telegraph and telephone?
4. What advantages have the triode valve and the transistor?
5. Give other words and phrases meaning approximately the same as: communication(s), researcher, to test.

B. Discussion and Criticism (Reasoning)

1. Give details about the dividing line between scientist and technologist. Does it always exist?
2. Discuss the importance of the development of electronic communication.
3. Describe some of the instruments and tools applied by scientist and technologist.
4. Express the following word combinations ' to chop up a complex piece of...', 'to group different things together to ...' in two single words consequently.

Instruments

Tools are active: man does something with them. Instruments are passive: they provide information and then man does something with the information. Just about the only instrument that has an active function is the thermocouple, which is used to measure temperature but can also be used to generate electricity and is in fact so used in satellites. Instruments fall into two broad groups. The first is concerned with measurement. We know that time passes but we need some instrument to measure it. We know that something is hot but we need some instrument to measure it. The second group deals with amplification. There are many things we cannot see with our ordinary senses: we need instruments to convert them into a form which we can see. It may be a matter of amplification as in a microscope or of transformation as on a galvanometer. Amplification instruments can often be measuring instruments as well but the amplification function is the more important one.

Clocks would not be necessary if people did not have to do things at fixed time. Often this necessity is self-imposed. There is probably only one situation in which a clock is absolutely necessary: when it is used to measure not time but position, as in the

use of a marine clironometer to detennine longitude. Sundials, hour-glasses, water clocks, candle clocks gave way to the pendulum clock as soon as the time-keeping effect of the pendulum was discovered. There was one situation, however, in which the pendulum would not work - at sea, where the rolling of a ship made the pendulum unreliable. Unfortunately this was an area where clocks were really vital. In 1714 the British Admiralty offered a prize of no less than £20,000 (a huge sum in those days) for the development of a marine chronometer, but they were rather reluctant to pay out the money when a superb chronometer was actually made for them. It was the work of John Harrison, a self-educated Yorkshire carpenter, and it was so good that after its first voyage of 81 days it was only 5 minutes slow.

There are a variety of things we want to measure. The simple foot-rule for measuring distances does not seem to have been in use before 1683. In addition to distances we need to measure angles, and various early methods of doing this culminated in the theodolite. For temperature there was the thermometer and for atmospheric pressure the barometer developed by Torricelli, a pupil of Galileo. For measuring electricity there was the galvanometer.

Instruments for application have rather more intrinsic interest than those which measure. In the case of the galvanometer the two functions go together. It is easy to forget that without a detection instrument discovery becomes impossible. For instance, electricity would have been difficult to develop, without a galvanometer. Similarly, nuclear physicians would not have got very far without cloud chambers, bubble chambers and photographic detection layers. Once you have some measurement device, you can experiment and see what affects what and what happens when you do something specific. Using the recently developed spectroscope as an analytical device, Kirchhoff in 1861 discovered two new metals: caesium and ribidium.

The story of the development of the cloud chamber is fascinating because the inventor, C.T.R. Wilson, started off in meteorology, and it was his determined pursuit of cloud phenomena that led him straight to nuclear physics. The interesting thing is that he himself followed the idea right along - it was not a matter of someone else taking it over. With a cloud chamber or bubble chamber we can actually see tracks made by the most minute particles possible. A Geiger counter, which is a very simple device indeed, allows us to detect and measure radioactivity.

Lenses had been in use for three hundred years before a Dutchman, Hans Lippershey, thought of putting one in front of the other and discovered the telescope effect, which was taken up and developed by Galileo. The microscope is attributed to an individual (Leeuwenhock) who was not only superb at grinding the lenses and making the instrument but also at using it. Where instruments differ from most other inventions is that one single device is enough. You can invent a motor-car, sewing-machine or threshing-mashine but if no one else wants to use it the invention is lost because it depends for its effectiveness on use by others - on having a market. An instrument, on the other hand, does not necessarily require market value: it is enough that one person uses it to discover things which no one else can discover.

As usual, war technology has had its influence on the development of instruments. Sonar was developed to detect enemy submarines but is now used extensively for locating fish (much as the dolphin uses it). Radar was developed to locate enemy aircraft.

The chromatography technique for the detection and isolation of organic chemicals is an incredibly simple technique which has completely changed the nature of biochemistry. Simplicity is a feature of many instruments which have changed the course of science and technology, as witness the telescope, galvanometer, Geiger counter, clinical thermometer, and stethoscope.

Mental Aids

Man uses his senses and his instruments to gain knowledge about the world around him. What does he do with his knowledge? How does he sort it out and organize it in order to produce more knowledge and solve his problems? To do this, man has invented and developed a number of devices. Although they are not mechanical, like spinning-wheels or jet-engines, they are just as real.

The basic way man organizes is to 'externalize it'. This means putting it out again into the external world. Language is a communicating device: though talking to other people may be the primary purpose, it is also an important thinking device. In order to use language a person has to identify things in the external world. Sometimes he has to chop up a complex piece of the world into separate concepts. At other times he has to group different things together to give a single concept. This method of procedure creates what might be called 'units' of thought. So although language is a communication system it is also a display system: having put out his thoughts as language, man can then react to them as if they were part of the external world.

Most of the mental aids developed by man are ways of translating thought into an external form which can then be reacted to and manipulated in order to produce more thought. Written language is an obvious example. The different lines of development of language (ideographic, phonetic, alphabetic) each have their advantages and disadvantages for thinking and for communicating. For instance, a Chinese typewriter is vastly more cumbersome than an English one - on the other hand, the use of ideograms may provide a greater conceptual flexibility.

A calendar is a way of externalizing time so that it can be looked at. It is a sort of map of time. The history of the development of calendars shows how different cultures adopted different approaches, and also how much political influence was involved. A map is a display device for distance and position. A person can build up a map and then use it. The map typifies all the mental aids, in so far as it is something constructed by man and then used by man to give him an advantage. For instance, the Mercator projection has the advantage for navigators that there is a constant compass bearing between any two points joined by a straight line on the map.

Musical notation is a display device and a communicating device. Its communicating function is more important than the display function, but notation itself is not merely a communicating device, for it can expert a huge influence on the development of other ideas. For example, mathematics is almost impossible with Greek numerals and not much better with Roman numerals, which are suitable only for tallying. But the Arabic numerals (originally devised in India) open up whole new areas. The invention of the zero was also a great step forward in mathematics; so, from a point of view of convenience, was the decimal notation device.

In addition to display devices, man has also developed concept systems for helping him to organize his knowledge. Binary arithmetic is both a concept system and a display device. Algebra, geometry, trigonometry, calculus and topology are pre-worked systems with their own rules. They are packages of knowledge and procedure which can be used as tools. The brilliant invention of the logarithm served to pre-cook numbers so that they were easier to deal with - multiplication could be treated as addition, and division as subtraction.

The development of the slide-rule, a remarkably effective calculating device, followed directly from the invention of logarithms. The abacus was a way of displaying numbers so that they could be used more easily in calculations. With the invention of the calculating machine man could actually delegate some of the calculations themselves. The first such machine was devised in 1642 by Blaise Pascal at the age of 19.As so often happens, there was a particular reason for his invention: his father was a clerk who had to carry out a large amount of calculating work. The next stage was the computer, which can carry out any conceivable mathematical function (and some inconceivable ones).The basic principles of the computer were laid out in 1823 by Charles Babbage, but for their implementation they had to await electronic technology. The first operating computer was built in

1946 and contained over 18,000 triode valves. Within two decades the power of the computer and the speed of its calculations had increased colossally. The invention of the transistor made the machines very much smaller and more reliable. The development of micro-circuits made them even smaller.

A. Comprehension

1. Is there difference between tools and instruments? Explain.
2. What groups do instruments fall into? Give examples.
3. What does 'the life' of invention depend on?
4. What influenced the development of instruments?
5. Speak on the main feature of instruments.

B. Discussion and Criticism (Reasoning)

1. Do you agree that invention of new devices depends on the market only?
2. Discuss the importance of language as a device of thinking.
3. Do you think that new instruments are intensively developed?
4. Name instruments that are widely used in the field of science or technology you deal with.
5. Interpret the text in the light of your own experience and ideas.

VII. Humanity. Scientist.

Human Communication

With the recent dramatic discoveries of fossils and footprints in Ethiopia, we now know that our ancestors walked erect some 4 million years ago. Hands, no longer required for locomotion, took on some of the tasks that the mouth had performed, such as carrying and fighting. In turn, it became possible for the mouth to form increasingly complex signals for communicative purposes, leading ultimately to the sounds of speech.

Stone tools date back more than 2 million years. Since that time, the human brain has more than doubled in size and has evolved into the most complicated and powerful piece of machinery known. The mental life and social structure of early humans elaborated symbiotically with the development of the brain, stimulating its growth and drawing on its increasing powers.

Fire was brought under control some 500,000 years ago; organized hunting probably took place much earlier. Microscopic analysis of stone implements 200,000 years old suggests that their makers were right-handed; this observation may link up with the fact that language too is significantly lateralized to the left brain. The first evidence we have of the transition into a distinctly human type of consciousness dates from 50,000 years ago: cave paintings, primitive sculpture, and flower burials.

We may never be able to determine exactly where along this corridor of time language emerged. In all likelihood, its development was a long and gradual process, and the rate must have been importantly influenced by cultural advances as well as by population density. Certainly by 10,000 years ago, language must have evolved close to the rich and subtle system that we have today.

In human life today language is everywhere. We communicate with computer through languages designed anew each day. Society is maintained, for better or worse, largely by means of language. Our inner selves are clearly dominated by language as well, as it helps us remember, plan, and carry out the day's activities. We experience language even during sleep, occasionally talking out loud.

Language means different things to different people. It has been likened to a symphony to be played, a cipher to be analyzed, a weapon to control others, a bond to be shared. And a window to the mind or perhaps a large part of the mind itself. As in the parable of the blind men who tried to understand the elephant simply by touching only one of its various parts, language is not any of these things singly. Rather, it must be seen from a composite of all these different perspectives.

It is not possible to say exactly how many languages there are in the world today with the degree of precision, say, that a biologist can count species. An estimate that is widely accepted by linguists is between 5,000 and 10,000.

A substantial number of these languages has been described over the last century by linguists, essentially with two objects in mind: a typological one, i.e., to determine the ways in which human languages resemble and differ from one another; and a historical one, i.e., to establish genetic relationships among them.

The type of structure a language has or its degree of complexity is little influenced by the kind of society its speakers live in, except at the very superficial level of vocabulary richness.

That modern languages are related to each other via ancestors that no longer exist is a historical concept that was found in linguistics quite a bit before it was argued for the specification of organisms in biology. This principle , more than any other, was responsible for the consolidation of linguistics into a discipline in the last century. The single greatest achievement of scholarship in this area is the reconstruction of the ancestor of the far-flung family of Indo-European languages.

Although the study of language change has developed along lines quite parallel to biological thinking, it is important to emphasize a fundamental difference between the two. In biology, the transmission of genetic material is virtually all 'vertical', i.e., from parents to offspring. The transmission of linguistic traits is by no means constrained this way; our linguistic behavior is significantly influenced by our peers ('horizontal') and by speakers of other generations ('oblique'). Consequently, no language is pure in the sense that a biological species can be said to be.

Non-vertical transmission is most obvious when different populations abruptly brought into contact have to solve the problem of communicating with each other.

Whereas all humans learn to speak effortlessly and naturally, indicating that here must be a significant influence from genetic facilitation, the situation is very different with writing. Many societies still do not have written languages; and in most literate societies, there are people who cannot read or write, either for social or organic reasons. Evolutionarily, writing was invented no more than a few thousand years ago, at several independent sites at different times.

With the invention of writing, language at last overcame the limitations of time and space, enabling human communication to become truly cumulative.

Although the Phoenician alphabet, which emerged over 3,000 years ago, has had a decisive influence on many important languages, there are three major methods of putting speech down. In an alphabet each graph corresponds to a sound segment, i.e., a consonant or a vowel. In a syllabary, on the other hand, such as the Japanese kana, each graph corresponds to an entire syllable. The Chinese method may best be called morphosyllabic; that is, each graph gives information about both the morpheme it represents and the syllable for its pronunciation. The research that is necessary to determine the merits of each method largely remains to be done. Obviously, one important parameter that must be taken into account is the structure of the spoken language that is being written down.

Language in Theories

Research on how language is served by the brain confronts a supreme intellectual challenge that poses a double dilemma in epistemology: What are the limits in a quest in which brain is studying brain and language is probing language? Nonetheless, as this section documents, some progress has been made toward understanding the intricate relations between brain and language and toward stimulation of linguistic behavior by computer.

Recognition of the role of the brain came quite late in various world cultures. The Aristotelians attributed the seat of the soul and the center of all sensations to the heart. This view has left its traces in many phases of our language, so we speak of a kind heart, a cold heart, and so on. In English, courage is stoutheartedness; but in Chinese, it is attributed to the size of the gallbladder, and in Arabic, it is the liver that holds love.

A good deal of what we know about language and the brain came in the last century or so. When the impairment of a linguistic function is highly correlated with damage to a particular region of the brain, the possibility arises that the function is served by that region. Research on such correlations was difficult because the brain could not be directly accessed for in-depth examination while the patient was exhibiting the dysfunction. However, with the advent of new techniques such as electroencephalography, blood-flow studies, and especially the recent methods of computerized axial tomography, new horizons are opening up.

In Norman Geschwind's work, we find some of the most lucid statements on how language is organized in the brain and how such organization may have evolved in the cortex. The evidence is abundant that not all brain tissues are equally evolved in every mental behavior. Geschwind suggests that there exist brain tissues which are exclusively specialized for language - a hypothesis that is being intensively examined at present.

An adequate theory of the psychobiology of language must eventually knit together all these observations into an integrated fabric.

While speech comes naturally, reading and writing are independent skills that require concentrated effort. For a variety of reasons, some biological and some social, many people never acquire one or both of these skills adequately and are severely handicapped in a society where much power lies with the written word.

In many parts of the world, people typically use two or more languages in their day-to-day activities. One might be the language of the region, for example, and the other language officially sponsored by the government. In a pluralistic city like San Fransisco, the language of the neighborhood may be Spanish, Japanese, Chinese, Russian, Tagalog, or a wealth of others. The question naturally follows: How does the brain accommodate a second language, or a third?

Cultures value differently the ability to speak well. 'Fluent', 'eloquent', 'articulate', 'glib', and 'tongue-tied', are some of the adjectives used in this society, where often enough it is the fast talker who wins the political office or the business contract. To Confucius, however, a superior person was someone of few words. Indeed, there are communities in various parts of the world in which social visits involve long periods of shared silence - a situation that would produce discomfort and embarrassment in our culture.

There has always been work in a variety of areas, including machine translation, text comprehension, and information retrieval, connected with the powerful methods of electronics and signal processing that have developed rapidly in recent years.

With the explosive growth of microcomputers recently, speech synthesis and language processing are becoming increasingly available to secondary schools and to private homes. Such developments are found to broaden the base of interest in, and deepen out knowledge of, the nature of human communication.

Interaction Activities

We often speak of language as a vehicle of expression - a metaphor that can illumine many aspects of our foreign-language teaching situation. Language is a vehicle of meaning that we do not even realize we are using; in other words, a vehicle that is transporting a person's message somewhere but is not itself the object of the trip. Before students can use such vehicle for their purposes it must be constructed, and this construction requires a blueprint and various stages of production, with tryouts as the various sections and combinations are assembled - tryouts during which what has been assembled to date is used, if only momentarily, for its ultimate purpose. With our language vehicle this ultimate purpose is expression: people revealing themselves to, or disguising or hiding themselves from, other people. Expression involves all the problems of impersonal relations.For this reason it is frequently less painful for teachers and students to continue working on the construction of the vehicle than to try it out for level of performance.

In a model of foreign-language teaching and learning processes that is now quite well known, we have distinguished skill-getting, represented by both cognition and production (or pseudo-communication), from skill-using in interaction, which involves both reception and expression and is dependent on motivation to communicate.

The construction of our vehicle presupposes a design. Some particularly talented individuals can put the design into effect without the help of the blueprint; they appear to move directly from the prototype to production, which means that they develop then-own internal representation from acquaintance with the prototype. These are the exceptions, however. Most need help in developing a series of blueprints of increasing complexity as a basis for production. Some prefer lessons in drafting blueprints, whereas others can draw them up from experience with a prototype of the vehicle. These blueprints represent the system underlying both reception and expression. Our students depend on their blueprints as they put the parts together in production so that the vehicle will function. Sometimes students try merely to copy someone else's assembly. Tins may work for a time but leaves the student bewildered as the assembly becomes more complicated. At this stage only those with comprehensive blueprints, or internal representations, are able to make the mechanism operate as they would like. Construction is not, however, the use of the vehicle: This is represented by the trying out that continually takes place as the assembly takes form. It is only through such tryouts that the operation of the vehicle can be smoothly integrated , the faults corrected, and the user gain confidence in handling it.

In every lesson it must be regarded as preliminary to actually trying out what is being learned so that from the earliest stages all learning activities lead to some form of real communication rather than remaining at the level of pseudo-real communication through imposed utterances.

Interaction has always been the most neglected part of the language activities in which we engage in the classroom. This situation will not improve unless definite steps are taken to include substantial interaction activities in each lesson. Because 'real' communication for our students takes place in the native language, it is not surprising that they need some stimulus to use the foreign language for natural purposes. Interaction does not take place in avoid. It is not enough to put several people together; there must also be some situational element that naturally elicits an inter-change. Interaction is a purposeful person-to-person affair in speech and in most kinds in writing. This interpersonal character of interaction explains why so much of foreign-language teaching and learning remains at the production or pseudo-communication level.

In most classrooms there is very little reason or opportunity for students or teachers to reveal themselves to each other. The relationship is a formal and formalized one for which conventionalities suffice. The teacher is there to teach; the students are there to learn what the teacher or the administration thinks they should learn. The usual greetings are exchanged, conventional questions are asked about material presented aurally or graphically, and conventional answers arising from the material are expected.

Spontaneous communication and free interaction are possible in any language only when teachers and their students have built up a warm, uninhibited, confident, sympathetic relationship and when such a relationship also exists among the students themselves. In the first lessons no such state of affairs exists as yet. The teacher's efforts from the beginning should be devoted to building up such relationships through enjoyable, successful experiences in using interesting and amusing segments of language in a multiplicity of ways so that students begin to feel that they can express real concerns through this new medium and that it is exhilarating to do so. This confident attitude, so essential to development of future speaking skills, is very fragile and can be stifled quite early by a situation where a teacher has the advantage of fluency and is inevitably tight while the student is uncertain , groping , and for the most part wrong. Early interaction practice calls for self-restraint and tact on the part of the teacher. Once the students understand the rules of the game - that you do the most you can with the little you have in some meaningful activity shared with others in the group , and that the teacher is there not to condemn but to give a helping hand, a gentle reminder, and much encouragement - confident self-expression is possible even at a very early stage.

A. Comprehension

1. What dramatic discoveries leading ultimately to the sounds of speech are mentioned in the passage?
2. What does language mean to different people? Explain and give examples.
3. So, do we know the exact number of languages in the world?
4. What is the difference between the study of language and that of biological thinking?

B. Discussion and Criticism (Reasoning)

1. Can we say that humankind has determined exactly the time language emerged? If so, comment and explain.
2. 'Society is maintained largely by means of language'. Why did the author, insert 'for better or worse' in the sentence?
3. Summarize the theories mentioned in the extract.
4. Share your ideas on trying the language out for level of performance.

A Personal Assessment

A great scientist and a great man - a genius?

Again and again, in the years that have followed the Oxford work on penicillin, Fleming has been hailed as a genius, a great scientist and a great man. Can we now, unbiased by the dazzling brilliance of the antibiotic revolution, assess the validity of these judgements?

The word 'genius' is overworked and ill-defined. 'What does it take to be a genius' asked W.H. Hughes of Fleming, showing him the double-page article in the Daily Mirror that placed him firmly in that category. 'You've got to be lucky', said Fleming, laconic as ever. 'You've got to be lucky twice', said Chain when asked the same question. They were hardly serious answers. Luck may favour the fulfillment of genius, but it is no part of the quality itself.

One of the least satisfactory definitions is also the most widely quoted: 'Genius is the infinite capacity for taking pains 'seems to be a rewording of de Buffon's 'Le genie n'estqu'une grande aptitude a la patience'. Again this capacity may be an important factor in the successful expression of genius - it may be necessary but it is certainly not sufficient.

Thomas Edison was nearer the mark when he defined genius as 'One percent inspiration and ninety-nine per cent perspiration', though it is hardly possible to plot these two components on the same scale. It is the application of inspiration that confirms genius. Inspiration 'in vacuo' is futile - it has to begin form in words, or art, or some practical endeavor, to become a reality. And it is this process of 'realization' that can be more or less arduous. No one can be in any doubt that Mozart and Brahms were both geniuses. Mozart wrote forty-one symphonies and twenty-seven piano concertos before he died at the age of thirty-five. Brahms worked for twenty years on his first symphony. For Mozart, music flowed with the effortless clarity of a spring of sparkling water; for Brahms a symphony had to be built with the monumental precision of the Roman architecture. They illustrate two kinds of musical inspiration but there can be geniuses in any medium: what is needed is the mysterious aptitude that sets one high above the common herd, and the determination to use it. The range can be quite narrow.

Some mathematical geniuses are mentally deficient in other ways.

If Fleming was a genius, then it was presumably as a scientist. He has been compared to Newton, Galileo and Pasteur, but the comparison reveals the confusion of thought. The discovery of penicillin may have been more important to suffering humanity than the discovery that the gravitational pull between two bodies varies directly as the product of their masses and universally as the square of the distance between them. But this does not imply that Fleming was the intellectual equal of the author of the Principia. The means by what Fleming achieved what he did are of a different order.

Fleming, when talking about the lessons to be learned from his success, always stressed the need to be on the look-out for the unusual. It was acute, unbiased observation that led to his discoveries. Alexander Haddow wrote, after Fleming's death, that his mind would pounce on the one odd happening that would prove to be significant. Most adults are unobservant because they tend to see only what they have been taught to expect. The totally unexpected is often disguised, by a sort of optical illusion, to conform the familiar. Fleming had retained the unblinkered observance of his Ayrshire childhood, when every natural event was interesting and had a hidden meaning to be discovered. So he had two great aptitudes - the power to see what was really there and the more mysterious flair for distinguishing between the important and the trivial -whether, in fact, what he was seeing was the tip of a vast, submerged iceberg or merely a passing ice-floe. But to compare him to Newton, Galileo and Pasteur is to enter another dimension of thought. For these men it was the usual - not the unusual - that was the source of wonder and inspiration.

The incident of Newton's apple may have been a myth, but the fact of gravitation which we all normally take for granted, was for Newton a mystery to be woven into the laws of motion expounded in the Principia. The familiar swinging of a pendulum and the daily passage of the sun across the sky were not beyond Galileo's questing spirit and literally heretical conclusions. The starting point for Pasteur's life-long exploration of the world of 'the infinitely small' was the mundane process of the fennentation, one that had been used with skill but without much thought for millennia. What emerged from his exploration was the whole concept of bacterial disease, and the foundation of immunology. When Georges Duhamel said in a public speech that Fleming had gone further than Pasteur, what did he mean? That Fleming had simply taken Pasteur's work on the therapeutic use of antibiosis a stage further? Or that Fleming was the greater scientist? Many people seemed to have accepted the latter meaning.

To rank Fleming with such towering scientific geniuses is the symptom of the mass hysteria that he had noted himself and surely did not take seriously. It is a comparison that is actually unfair to Fleming. It inevitably exposes the fact that he didn't possess the vision that sees familiar things in a new light and transforms the world, or the brilliant wide-ranging originality that transcends doctrine and dogma. To have to stress this is unfair because Fleming has his own position in science, and to put him in a false one is to invite criticism. No one would criticize a scientist because he is not a second Newton,
Pasteur or Einstein unless he is wrongly claimed to be so.

Within his own sphere, Fleming had a kind of genius. It must be said at once that this sphere was very limited - he had no great interest in the wider issues of science. Fleming's genius was essentially practical, and its expression was through technical inventions that were neat, extremely clever and beautifully executed. His germ paintings are a good example of this aptitude and also of his ability to take immense trouble when he wished to. Inevitably, writers who persist in regarding Fleming as an intellectual giant, have found in these miniature masterpieces an endearing descent from the stratosphere of higher thought to the level of human play. This attitude is quite wrong. Fleming's natural level was indeed play, and if he ever ascended into the stratosphere of higher thought there are no signs of it. 'I play with microbes' -his often repeated description of his work - was literally true. Most of his research was a game to him and indeed most of his enjoyment came from games of all kinds. His germ paintings involved bacteriological skills of the highest order. They depended on the isolation of bacteria that would produce a range of bright colors, the study of their cultural needs, and then the construction of a picture within a 4-inch circle in which all the colors would appear only after the period of incubation. The pictures themselves were marvelously executed. Fleming became, incidentally, quite an accomplished watercolor painter, though Pitchforth, the artist, wrote that he had little aesthetic feeling. But if anyone doubts the amount of skill, time, and effort needed to produce one of the germ paintings, let him try it for himself.

Fleming's germ paintings were a by-product of his skill as a bacteriologist and his love of playing. One of his lines of research was the development of selective culture media that would favor the growth of one particular organism and discourage all others. Penicillin was a valuable addition to his range of such selective 'weed-killers', and he would demonstrate this range by setting up a series of plates, on each of which only one out of a mixture of organisms would grow.

It has often been said that it was Fleming's powers of observation that put Mm in a class of his own. The argument runs that hundreds of bacteriologists had to deal with mouldy plates and infected throat swabs every day of their working lives, but it was only Fleming who rightly interpreted the signs that must have been there for all to see. No one would deny that Fleming was very observant, or that some bacteriologists are less so, but to suppose that Fleming noticed two striking and important things that everyone else had repeatedly missed is quite wrong.

If we concede that Fleming had a certain technical genius, can we accept him as a great scientist? Popular opinion would certainly do so, and this is easy to understand. Einstein's greatness is universally acknowledged, even by people with no comprehension of the theory of relativity -they simply accept the verdict of experts. Fleming's greatness seems to be endorsed by a similar verdict, and penicillin is not an abstruse theory but a self-evident fact.

The recognition of greatness in a scientist comes first from professional colleagues who know the field in which he works. They would base their judgements on a number of points. The most obvious is the success of his research, as measured by the importance, of personal contributions to knowledge or of practical advances. But another consideration is the way in which these are achieved. Some discoveries follow patient exploration, others are made by pure accident. A scientist cannot expect much credit for an accident, but his recognition of its potential importance and the use to which he pats his discovery reveal the qualities.

The qualities that lead to success need definition. One is originality. Research moves at a variable pace. For a time it may be clogged by accumulated facts apparently without pattern. Then may come what is popularly called a 'breakthrough', the result of a flash of insight that gives meaning to the previous tumble, or the invention of some technique that throws new light and transforms the picture. Usually such innovations come from the imaginative originality of an individual - not from a team or a committee. But inventions and hypotheses begin as ideas which have to be given substance and rigorous testing by experiment. However brilliant and attractive, if they fail the test they must be scrapped or modified. Here there is a sometimes fatal temptation for the creator to keep his brainchild alive by misinterpreting or disregarding the brute facts that should lead him to dispatch it. So, among the qualities of a great scientist should be a ruthless objectivity, particularly to his own ideas, and with it the ability to design and carry out just those properly controlled experiments that will test those ideas and lead him on to new ones.

There is another gift that contributes to scientific success. This is a sense of direction in research. Lines of investigation often branch as they are followed, presenting enticing diversions. Which is the main and which is the most profitable route? Which are the blind alleys? Some scientists have a positive flair for choosing the paths that lead on and out into widening fields. And with this there should be a breadth of vision, the ability to recognize and exploit the new territories revealed.

Finally, there is the matter of dedication. There is no room for dilettante, however talented, in the top rank. Becoming a great scientist is a hard work. Exceptional energy is needed almost all to be channeled into the one absorbing subject of research. The energy is emotional in origin. For some, it comes from the irresistable urge to explore and to discover, to be the first to reveal some natural wonder. For others it is insatiable curiosity or the intense intellectual satisfaction of solving problems. Personal ambition can be a factor - fame and occasionally fortune are tangible rewards. A genuine desire to benefit humanity and its environment can be a powerful motive. But, whatever its sources dedication is essential for a scientist to achieve his greatness. It not only drives him, it inspires others. It attracts collaborators, followers and students. Whether he intends it or not, a great scientist will usually find himself the leader of a research school moulded by his own personality.

A. Comprehension

1. In what field of science did Fleming work?
2. What was the reason for the appearance of a number of judgements on the Fleming's works?
3. Why did the author compare two geniuses, those of Mozart and Brahms?
4. What feature retained by Fleming of his childhood led him to discoveries?
5. Where was Fleming born? How did his Motherland appreciate him as a Man and Scientist?

B. Discussion and Criticism (Reasoning)

1. How would you define genius? Give good evidence for your point of view.
2. What did the author mean saying 'Some mathematical geniuses are mentally deficient in other ways'?
3. Can we accept Fleming as a great scientist?
4. Define, in short, the qualities that lead a researcher to success.

On Scientists, Truth and Power

By Rodney W. Nichols President and CEO, the
New York Academy of Sciences

Scientific knowledge and technology are crucial means for pursuing economic, social, political and military aims. Scientists advise leaders on how to achieve those aims, and in so doing, they speak truth to power. That complex process is fraught with tangled motives, expectations and consequences. When ideas and action are amplified by levers of power, scientists must recognize, with Disraeli, 'that all power is a trust -that we are accountable for its exercise.'

Consider first the roles of scientists in the governance of the research enterprise itself. Specialists are the best referees of the intricate competitions for funds. Thus trust is delegated to specialists by people in power, and the crucial obligation of that trust is to be ruthlessly clear about what is excellent. Resources are too scarce for society to settle for the mediocre, much less to yield to fashion or to wink at patronage. The truth must out.

For technological projects, policy decisions often turn on analyses of the feasibility, cost and trade-offs among promising but competing options. As in judgements about basic research, individuals making assessments must be alert not only to the risks that are always run but also to the 'great tragedy of Science', in T. H. Huxley's lovely formulation 'the slaying of a beautiful hypothesis by an ugly fact.' However powerful the status of a technological program, decisions must be regularly rechecked against the facts: What works? What does not? And why? Sometimes, of course, even 'facts' are controversial.

Advisers to governments and firms frequently assess long-term trends that involve science and engineering in decisions with high stakes for the future. Take global warming. The public asks: Will it take place? If so,how much? If a great deal, when must society take action, at what cost and over what period? Similar queries abound. How can the safety of nuclear reactors and nuclear-waste disposal best be ensured? When will genetic therapy be effective, safe and affordable?

The evidence at such forward edges of knowledge is often thin. But scientists will be asked to help navigate even when the maps are inchoate. The only responsible approach is to be open about debating the data, frank about all the uncertainties. Science and technology show spectacular promise for serving humankind in the future, and it would be irresponsible to underestimate that promise. But overselling the promise is bound to boomerang. Unwarranted optimism or pessimism can be blinding.

Such reflections are not theoretical. Today's budget headlines show that scientists face rising intellectual and social demands. Surely there are no longer any guarantees about continuing support of research. Like it or not, scientists must accept that how much to spend on research, for what purposes and how to account for the results are urgent questions in every country of the world.

The new climate of heightened accountability is not confined to national decisions. In international programs - on energy, AIDS or synchrotrons - quarrelsome dilemmas often emerge. One cause is near-term economic competition, which seems to conflict with the cooperation needed for long-term research. Much of the future of science and engineering will be determined by how deep and resilient a balance is struck in resolving that conflict.

Respect for evidence impels us to recognize forthrightly, as John Locke said, that 'men may be as positive in error as in truth'. That recognition is absent too often when 'facts' or interests conflict, and views harden; then genuine progress is the casualty of declining morale and trust all around. As we at the New York Academy of Science make a vigorous case for science and technology, we shall muster independence toward speaking truth to the humane use of power.

A. Comprehension

1. What is the role of a scientist in society?
2. Can you explain in your own words what T.H. Huxley meant speaking of the 'great tragedy of science'?
3. Give other words and phrases meaning the same as: mediocre, trade-off(s), query(-ies), to abound, forward edges of knowledge, inchoate.

B. Discussion and Criticism (Reasoning)

1. Who (a scientist or the government) is to decide how much to spend on research and for what purposes?
2. It is said that the role of science and technology in society shouldn't be over - or underestimated. Why is it so important?
3. Discuss the importance for the scientist of being independent toward speaking the truth.

Методичні вказівки до самостійної роботи з дисципліни «Англійська мова» для здобувачів вищої освіти освітньо-наукової програми третього рівня (підготовка докторів філософії) для усіх спеціальностей

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