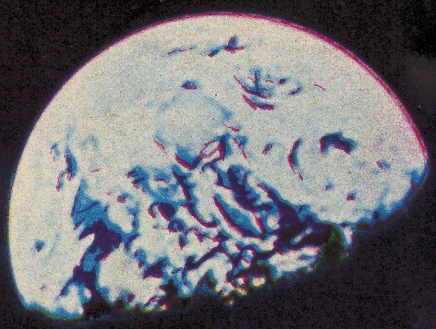
SCIENCE REPORTER

JULY 1978



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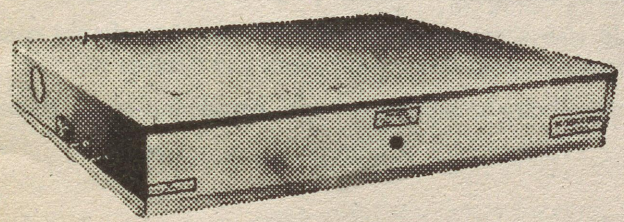

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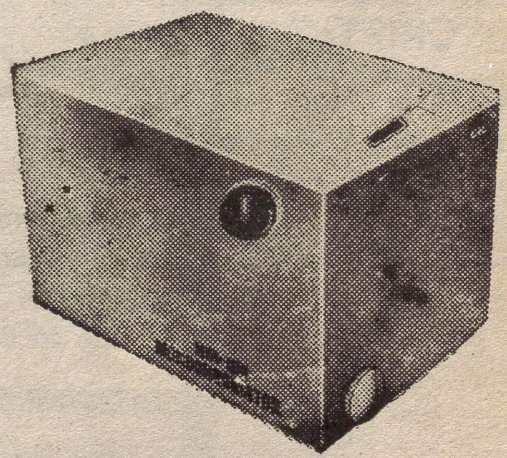

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Cover : Earth-rise as seen from moon (*Courtesy :* USIS)

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Noise menace

Sir, In **Science oddities** (*S. R.*, March 1978), many adverse effects of noise have been highlighted. Noise is defined as undesirable sound and is recognised as a slow and insidious killer. It is now causing considerable concern to environmentalists. We are beginning to realise the gravity of prolonged exposure to noise. In foreign countries, noise abatement groups are active and are trying to educate and convince the government, industry and the public about the magnitude and complexity of the problem.

The decibel level in most of our cities is perhaps not so high as in foreign cities. Unfortunately, we are confronted with ubiquitous loudspeakers blaring out film and devotional songs at odd hours. It is a social crime to expose unwilling people to loudspeaker menace.

The mad race for urbanisation and material comforts compels us to accumulate articles that invariably generate noise and the concrete and steel monstrosities constructed by us show scant regard to the acoustics problem.

S. K. GURTU
Defence Science Laboratory
Metcalfe House
Delhi-110054

And so cometh man (*S. R., Sept.* 1977)

Sir, Could you give me some information on the "Solo-man" ?

SUNIL ANAND
Dehra Dun-248001

The scientific name of "Solo-man" or Ngandong man is *Homo soloensis*. Fossil of this species of man was discovered in ancient lime-cemented graves of the Solo river, near Ngandong in Java in 1933. Ngandong man is somewhat similar to the Neanderthal man, *Homo neanderthalensis*, and lived some 1,000,000 years ago.

B. K. BEHURA
Professor of Zoology
Utkal University, Vani Vihar
Bhubaneswar-751004

Odour

Sir, To **Chemical nature of odour** (*S. R.*, April 1978) by S. K. Zutshi, I would like to add the following.

Human beings normally have the capacity to detect and identify an enormous range of smells, at least 10,000 distinct odours, in varying degrees of intensity. The primary human organs of smell are the two lobes called glomeruli, one in each nostril and each consisting of about 2,000 bundles of smell-detecting neurons hooked upto the brain in various intricate ways.

BHARAT BHUSHAN BINDROO
Genetics Section
Regional Research Laboratory
Sanat Nagar, Srinagar-190005

The fascinating flamingo

Sir, **The fascinating, fabulous flamingo** (*S. R.*, March 1978) is a regular winter visitor to the natural lagoon, the Chilka Lake, Orissa. Days are gone when they came in flocks of hundreds and thousands. Legend has it that once an enemy army reached the shores of Chilka with a view to invading Parikud on the other side of the lake. To its horror, the army saw hundreds and thousands of soldiers in battle array on the Parikud side ready for the fray. The enemy retreated in sheer panic. But the 'army' of Parikud was nothing but a flock of flamingoes (*Phoenicopterus roseus*, locally known as *Era* and *Marala*), which with their red legs and rosy-pink-black-white colouration of the plumage and 1 to 1½ metres height, appeared like an army of uniformed soldiers from the other side of the lake, about eight kilometers across.

B. K. BEHURA
Professor of Zoology
Utkal University, Vani Vihar
Bhubaneswar-751004

Climbing perch

Sir, Re: **Mud-skipper climbing perch** (*S. R.*, March 1978) by G. M. Natarajan.

Obviously, a fish that spends more than half its time out of water possesses a specialised breathing technique. Submerged in water, the mud-skipper respires in the usual manner devouring in water through the mouth and passing it across gill filaments that extract dissolved oxygen. The mud-skipper fills its gill chamber with a mixture of air and water when it emerges out. This portable life support system "Aqua lung", in reverse, moistens the gills during the mud-skipper's hours of long journey in the world of air. Success in hunting its prey in air however brings complications in breathing. As the fish swallows its prey, the vital water and air in the gill chambers escape with a gush. The mud-skipper must then hasten to water to recharge its supply.

Is there any other special mechanism of respiration?

Though the climbing habit of *Anabas* was strongly criticised by F. A. Day (1877) and S. L. Horal (1933), a well known ichthyologist H.M.Smith (1945) has supported the earlier view. According to his statement, *Anabas* is exposed in Thailand for sale in large wicker baskets. The

fish is often seen climbing up the sides of the wicker baskets and jumping out. He asserts that "A Palmyra palm, with its rough bark and its fronds beginning near the ground, would be no more formidable for an *Anabas* to ascend than would be the vertical side of a wicker basket". Further, even today, native fishermen narrate stories of having seen *Anabas* climbing wild date palm (Ref. *S. R.*, Feb. 1971. p. 63)

S. THIAGARAJAN
Asstt. Prof. of Zoology
Rajah Serfoji Govt. College
Thanjavur-613005

pH

Sir, **What is pH ?** by Nomita Sen (*S. R.*, Feb. 1978) would have been useful if the concept was introduced correctly. The concept of pH was introduced by S. P. L. Sorensen (1909) as "the hydrogen ion concentration" but this was modified, and it now means "the negative logarithm of hydrogen ion activity (not concentration) expressed in moles per litre". The term 'pH' is of German origin where *p* is for 'potenz' meaning "power of" and *H* stands for hydrogen ion (H^+) activity. For convenience, the pH was and is expressed as the negative logarithm of the "active hydrogen ion concentration". Also, the constant, Kw, is no doubt the dissociation constant. But while referring to pH constant, Kw is specifically called the "ionic product of water". To avoid confusion between activity and concentration, the following relationship will be useful:–

$$a = c \times f$$

where *a* stands for activity, *c* denotes concentration and *f* is the activity coefficient whose value is usually less than one. This is because all the charged ions present in dissociated form in a solution are not free to take active part in chemical reaction. Their movement is affected by the oppositely charged ions present close to them.

S. K. GHABRU
IARI, New Delhi-110012

Crop mutants

Sir, This is with reference to the article **Mutation and its usefulness in agriculture** by S. P. Chatterjee (*S. R.*, April 1978). On page 261, last para, he says "no spontaneous mutant has been identified in the case of wheat and rice". This is not correct. The famous GEB-24 strain arose as a spontaneous mutant in the rice variety "*Konamani*". It is a well-known mutant in South India.

A spontaneous mutant with dwarf habit and other desirable characteristics was discovered some years ago by Chinese scientists in "Dee-gee-woo-gen", an *Indica* variety in Chinese rice. The wonder rice IR8 developed at International Rice Research Institute, Philippines, is a cross between peta, a tall *Indica* variety and Dee-gee-woo-gen. It yields 8 to 10 tonnes per hectare.

The genes which confer dwarfness in wheat arose as spontaneous mutation in the "Norin" Japanese wheat. Norin 10 is a strain with the desired combination of short plant height, lodging resistance and ear characters.

The author has not mentioned about the somatic mutation. If a mutation occurs in the meristematic tissue in very early stage of bud development, all the cells of the bud will be mutant in nature. This is called 'bud mutation or bud sport'. Robertson navel orange is an example. If a mutation occurs in the later stages of bud development, only some of the cells of the bud will be mutant.

P. VINDHIYA VARMAN
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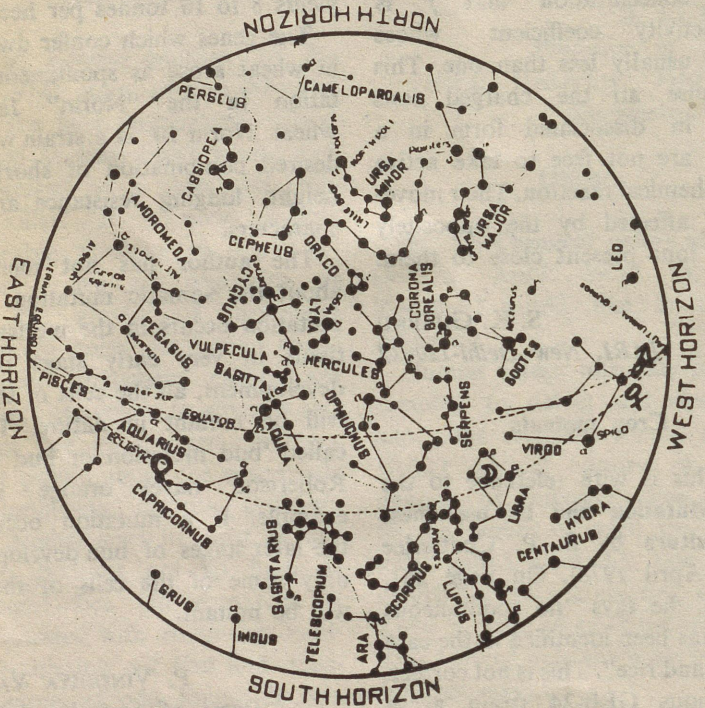
Coimbatore-3

Planets and their positions

August 1978



MAGNITUDES

-1 0 1 2 3 4 5

PLANETS

♀ VENUS

♂ MARS

MOON

☽ FIRST QUARTER 12TH

○ FULL MOON 18TH

NEW moon occurs on 4th at 6-31 a.m. and full moon on 18th at 3.44 p.m. I.S.T. It passes about five degrees south of Jupiter on 2nd, two degrees north of Mercury and about four degrees south of Saturn on 6th, also passes very close to Venus and Mars on 8th and again about five degrees south of Jupiter on 30th.

The lunar crescent becomes first visible after the new moon day in the evening of 5th.

The moon is at apogee or farthest from the earth on 2nd and again on 29th, and is at perigee or nearest to it on 17th.

The planets

Mercury (Budha), visible in the evening sky, sets about an hour after sunset during the first quarter of the month. Thereafter, it is too near the sun to be visible. It is in inferior conjunction with the sun on 19th. It becomes retrograde on 5th. Towards the end of the month, it reappears as a morning star and rises about an hour before sunrise. It passes about five and a half degrees south of Saturn on 4th. It passes 5 degrees south of the star Regulas (*Magha*) in the early hours of 11th. It becomes direct on 28th. It moves from Leo (*Simha*) to Cancer (*Karkata*) by retrograde motion. Its visual magnitude varies from + 1.0 to + 1.8.

Venus (Sukra), an evening star, sets about two hours after sunset during the month. It passes about a degree south of Mars in the night of 14th. It is at the greatest eastern elongation of about 46 degrees from the sun on 30th. It passes very close to the star Spica (*Citra*) on 31st. It moves from Leo (*Simha*) to Virgo (*Kanya*). Its visual magnitude is about—3.9.

Mars (Mangala), visible in the evening sky, sets about two hours after sunset during the month. It is in Virgo (*Kanya*). Its visual magnitude is about + 1.8.

Jupiter (Brihaspati), visible in the morning sky, rises about one and a half hours before sunrise during the first half of the month and about two and a half hours before it during the second half. It passes seven degrees south of the star Pollux (*Punarvasu*) in the evening of 7th. It moves from Gemini (*Mithuna*) to Cancer (*Karkata*). Its visual magnitude is about —1.4.

Saturn (Sani), visible in the evening sky, sets about an hour after sunset during the first quarter of the month. Thereafter, it is too near the sun to be visible. It is in conjunction with the sun on 27th. It is in Leo (*Simha*). Its magnitude is about + 0.9.

(*Source:* Nautical Almanac Unit of the Meteorological Office, P-546, Block 'N' (1st floor), New Alipore, Calcutta-700053.)



Aerial photography and its

Aerial photography is a technique of remote sensing, which means study of objects from a distance

C. SRIKANTAPPA

AERIAL photography means photographing the surface of the earth from an aircraft or spacecraft. In recent years, this technique has become an indispensable tool in many scientific fields, particularly in environmental studies. In earlier days, long before the advent of the aeroplane, photography from the air was done by means of hot-air balloons. Flex Nadar, a French photographer, was the first to take photographs from the air in 1855. But it was only after the invention of roll film by George Eastman in 1885 and the aeroplane by the Wright brothers in 1903, that aerial photography was put to use on a large scale. The Second World War saw a rapid development in the various techniques and today aerial photography is a science by itself. The term aerial photography has now been largely replaced by "remote sensing", which means study of objects from a great distance.

In principle, the field of remote sensing is restricted to electromagnetic radiant energy from the visible to the microwave region of the spectrum. There are different types of remote sensing techniques used in relation to spectral wavelength and its characteristics are shown in Table 1.

In the visible and near infrared region of the electromagnetic spectrum, the energy response is due to reflection of solar illumination, while in the thermal infrared part, it is the radiant energy emitted by the object that is detected. These systems are called passive direct systems. In microwave region (radar), however, solar energy plays hardly any role and so an 'active' system is needed. An active system uses an artificial source of electromagnetic radiation to illuminate the object and its reflections are detected and analysed. As photographic emulsions are not sensitive to wavelengths greater than 1 μm (micrometer), for infrared and radar bands of electromagnetic spectrum, special detectors are employed in which observed variations in radiation intensity are transformed into electrical signals. These signals are amplified and recorded on magnetic tape or can be transformed through a cathode ray tube into photographic images.

Aerial photography is not as simple as many may think. It involves delicate operation of the aircraft and demands painstaking preparation and professional execution. There are many problems and

Shri Srikantappa is Lecturer in Geology, Manas Gangotri, Mysore University, Mysore-6.

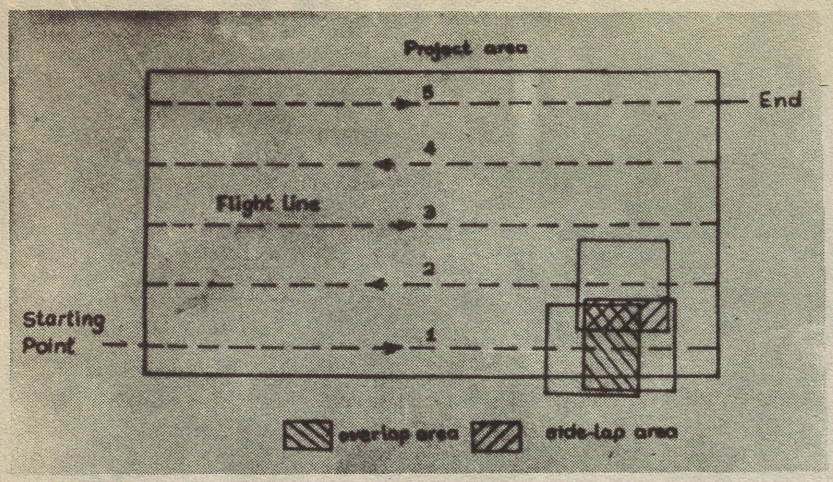


Fig. 1. Planned flight procedure to photograph a project area

factors that need to be considered before the photographic plane takes off the ground.

For photographing an area, the aircraft moves back and forth across it, following predetermined flight lines which are equally spaced. Photographs are taken from a camera mounted in the belly of the aircraft flying at a constant altitude. Each photograph is a series of overlaps of at least 60% such that each point on the ground is photographed twice from slightly different angles as shown in Fig. 1, and there will be 30% sidelap. This overlap is essential as it supplies different angles in the vertical photographs necessary to achieve a three dimensional effect in stereoscopic photo-interpretation.

Types of aerial photograph

There are mainly two types of aerial photographs, viz., vertical and oblique. Vertical aerial photographs (Fig. 2) are taken with the optic axis of the camera in a vertical position, whereas obliques are taken with the optic axis of the camera considerably inclined from the vertical. Vertical aerial photographs are better for photo-interpretation because they can be taken with overlappings for constructing photomosaics and for the mesurement of elevations using the principles of stereoscopic vision.

Much more information can be derived from aerial photographs if they are viewed in pairs in a stereoscope. All of us are familiar with the necessity of using both the eyes to perceive relative distance of objects, while with one eye they appear to lie in a common plane. In the same way, two photographs of the same object taken at different camera stations (Fig. 3) give a sensation of depth when viewed in a stereoscope.

Table 1

Wavelength	*Characteristics*	*Main remote sensing techniques*
0.3 to 0.7 μm.	Visible light	Panchromatic and true colour photography
0.7 to 0.9 μm.	Near infrared (reflective infrared)	False colour and panchromatic
0.5 and 8—14 μm.	Middle infrared (thermal infrared)	IR line scan imagery
5 μm. —20μm.	Radar bands	Sideways-looking airborne radar

Types of film used

In general, there are four main types of film used in aerial photography, viz., (1) black and white (panchromatic), (2) infrared monochrome (IR), (3) true colour, and (4) false colour. Each of these has a definite range of uses. Black and white panchromatic film is widely used because of its relative cheapness and availability. It is mainly used for topographic survey and for reconnaissance studies.

Infrared monochrome film is very useful in discriminating between land and water, in delineating shorelines, the depth of shallow water features and detecting presence of water on land surface. Of late, use of true colour photography has been increasing because of its advantage over panchromatic photography. True colour photography displays variation in hue, value and chroma rather than tone only. The use of true colour photography is more valuable in interpretation procedure as the human eye can detect as many as 7.5 million different colour combinations as against only 200 tones of grey.

False colour photography is the most versatile and potentially valuable technique used for terrain interpretation.

Airphoto interpretation

Aerial photographs contain more detailed record of the features of the earth surface than is available in the largest scale map of the area. We observe many features in aerial photographs which are unfamiliar to us. In normal vision on the ground, we distinguish an object on the basis of its size, shape, colour and the associated features. The same factors help us in identifying objects seen in aerial photographs.

In black and white photographs, tone plays an important role in identifying different features. The tone depends much on the amount of light reflected back to the camera from an object. Hence smooth objects appear generally darker in aerial photographs. Different textural appearances such as smooth, mottled, striped, etc., often help in differentiating certain features from others.

Identification of associated features is extremely important in airphoto interpretation. For instance, many college campuses consist of large buildings with attached playgrounds. Likewise, many modern factories have extensive car parking facilities; industrial areas or mining areas can be detected by the presence of features like waste heaps, large quarries, etc.

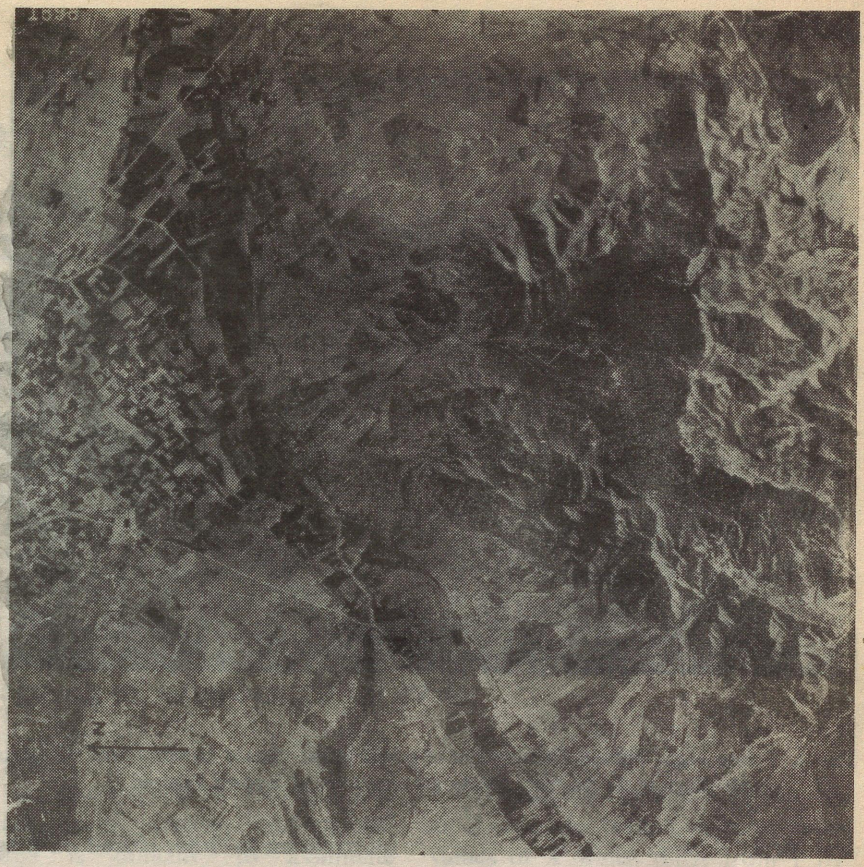


Fig. 2

Use of aerial photographs

Aerial photographs find wide use in many scientific fields. They are extensively used for mapping purposes and accurate maps can be produced with minimum field checks. Maps are usually produced with the help of mosaics of air photos, an assembly of individual aerial photographs fitted together systematically to form a composite view of an area by the photographs. Aerial photography is also widely used in geology and geography for determining terrain types, climatic conditions and to unearth mineral deposits. Agriculturists make use of aerial photographs for the detection of plant diseases, to know crop coverage, crop yield, to classify soil types and to monitor land use. With the help of infrared photographs, plant diseases (Fig. 4) can be detected with great accuracy.

Urban planners use aerial photographs to delineate densely populated areas and to plan for the development of cities, to select suitable areas for recreation purposes, to install new industries and to locate suitable sites for waste disposal. The forester uses them to demarcate forest boundaries, to find accessability, to know tree types, to locate fire affected areas and to maintain wild life habitats.

Infrared sensors can detect thermal emissions and can be used to monitor volcanic activity, water pollution and oceanic currents. In many advanced countries like Britain, Holland and Germany, infrared colour photographs are widely used to locate seepage points along shore lines and to measure the amount of water pollution along the shores due to chemical waste disposal by

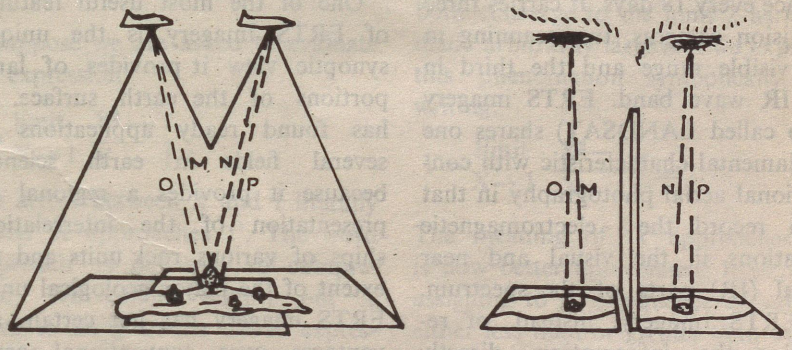


Fig. 3. Stereoscopic vision. The tree on the top of the hillock has been photographed by aircraft from two angles represented by M and N. The consecutive photographs of the area taken (with 60 per cent overlap) are viewed in a stereoscope which creates an exaggerated sense of depth. The tree top appears higher than its surroundings

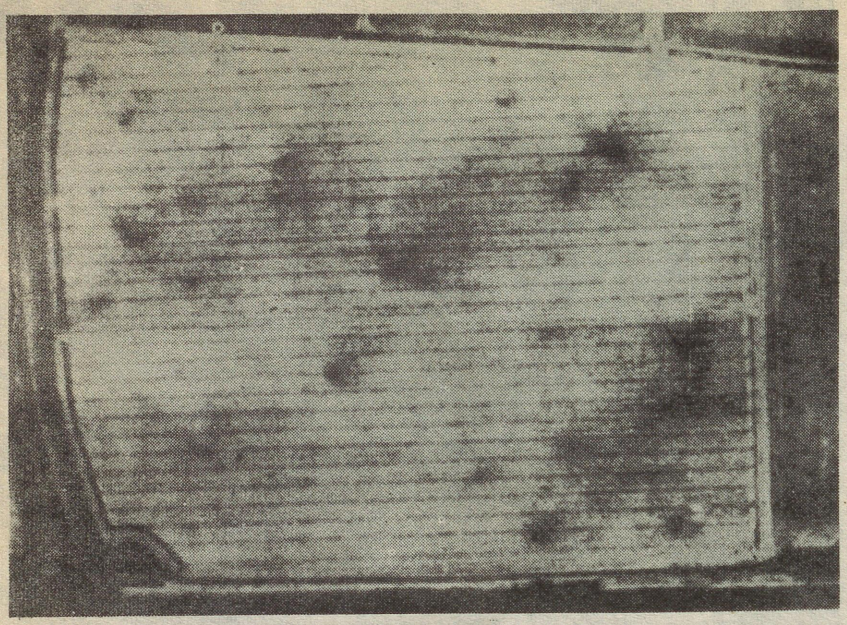


Fig. 4. Potato blight disease. Development of potato blight disease detected with IR photograph taken in the intensive potato growing area of eastern England

industries.

Satellite photography

Nowadays satellites are widely used in remote sensing. The first Earth Resource Technology Satellite (ERTS-1) was launched by NASA on July 23, 1972. ERTS-1 goes round the earth at an altitude of about 900 kilometers in a circular, sun-synchronous, near polar orbit, systematically covering the earth surface every 18 days. It carries three television cameras, two scanning in the visible range and the third in the IR wave band. ERTS imagery (also called LANDSAT) shares one fundamental characteristic with conventional aerial photography in that both record the electromagnetic radiations in the visual and near visual (IR) parts of the spectrum. In ERTS imagery, instead of recording the information directly onto photographic material, the information is recorded by a four channel multi-spectral scanner in four spectral bands separately. The information is either stored on magnetic tapes on board the satellite and relayed later, or is transmitted direct to ground stations, provided the ground stations are located within the range. After transmission to earth, the ERTS information is processed and made available either in the form of computer magnetic tapes or as 70 mm photographic transparencies. The transparencies can be used to make 1 : 1,000,000 scale photographic prints.

One of the most useful features of ERTS imagery is the unique synoptic view it provides of large portions of the earth surface. It has found ready applications in several fields in earth sciences because it provides a regional representation of the interrelationships of various rock units and the extent of the major geological units. ERTS imagery has got certain advantages over conventional aerial photography in that the photographs have uniform illumination and tonal quality. The most important of all is its ready availability and the low cost involved, but it gives a lower resolution (appx. 120 km) when compared to aerial photographs.

Imagery in India

Large scale multi-spectral photography of large parts of India have been obtained during the ERTS-1 programme. Based on ERTS imagery, detailed geological investigations including delineation of faults, folds and identification of major lineament patterns of parts of the Himalayas have been carried out by the Geological Survey of India. The studies have revealed the presence of numerous high angle wrench faults more or less in agreement with the hypothesis based on the plate tectonic theory.

Using remote sensing techniques, lineament studies representing faults, fractures and dykes have been carried out in the west coast region of India by S. R. Das and A. K. Roy (1974) of Geological Survey of India. The studies have shown that the present shape of the west coast of India is mainly controlled by the NNW-SSE oriented lineament which are fractures of great length extending both inland and seaward. Presence of numerous hot springs in Bombay region has been interpreted by such studies.

Further reading

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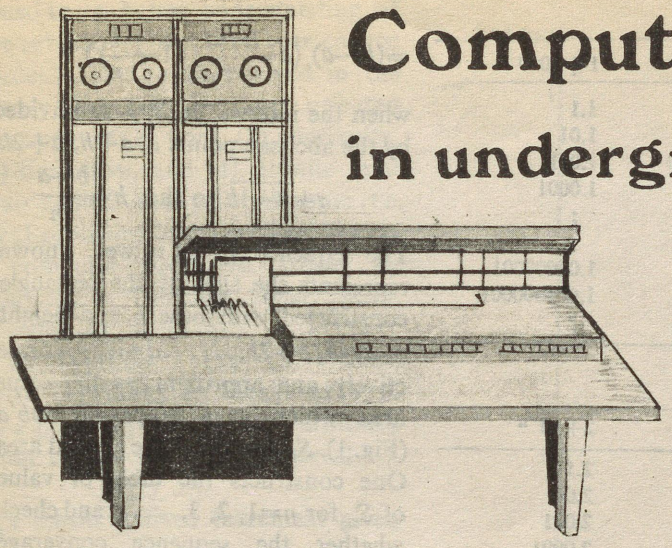

Computer Calculus in undergraduate course

SHYAMAL MAJUMDAR

Use of computer at the undergraduate level can make learning of calculus much easier

A number of universities in India have already installed fairly large-sized computers. It will perhaps be not long when almost every university in the country will have acquired a computer. It may however take quite some time before we can think of a computer terminal facility available for college students. Presuming that such facility can be provided in not too distant future, let us examine how a computer can help improve the mathematics instruction in calculus at the undergraduate level.

A major portion of what the students learn in mathematics upto class X stage at schools can aptly be called 'discrete mathematics' in the sense that every school problem in arithmetic and algebra (except graphs) has either a unique answer or a set of discrete well defined answers. The students first encounter the concept of continuous solutions while drawing graphs and studying locii in geometry and conic sections (e. g., the construction of conics from their definitions). Nevertheless, the concept of continuity (i. e., gaplessness) of the real line made up of integers, fractions and surds is difficult to assimilate even at the school-leaving stage. It is, therefore, natural that the main difficulty for a student at the beginning (in college) is to grasp the idea of continuity and limit in the calculus course.

What concept does bridge the gap between the 'discrete' and the 'continuous' ? The concept of sequence is a convenient means to connect the two ideas. This can be illustrated by an elementary example.

Suppose we are asked to evaluate the expression

$$Y = \lim_{X \to 1} \frac{X^2 - 1}{X - 1}$$

The arrow between X and 1 literally means 'X approaches 1'. The word 'approach' is not easy to comprehend. We cannot simply put X equal to unity in the above expression because that would lead to the undefined expression $\frac{0}{0}$. On the other hand, when $X \neq 1$, the expression has a well-defined value, namely, 2. To evaluate the above expression as $X \to 1$, we take a set of discrete values of X which differ from 1 by as small an amount as we please without making X exactly equal to unity. For example, we can take the set of discrete values from the sequence $\{X_n\}$ defined by

$$X_n = 1 \pm 10^{-n} \quad (n = 1, 2, 3, \ldots\ldots)$$

as shown in Table 1 below. The corresponding values of the sequence $\{Y_n\}$ defined by $Y_n = 1 + X_n = 2 \pm 10^{-n}$ are shown in Table 2. Note that as long as $X \neq 1$, $Y = X + 1$, the sequence $\{2 - 10^{-n}\}$ and $\{2 + 10^{-n}\}$ both converge to the limit 2 as n is made arbitrarily large and we express this phenomenon symbolically by writing:

$$Y = \lim_{X \to 1} \frac{X^2 - 1}{X - 1} = 2.$$

The meaning of 'X approaches 1' is now better appreciated. It implies assigning to X a sequence of values either less than or greater than unity respectively as shown in the Tables 1 and 2. Also, for n very large, any two consecutive numbers in a given column of the above Table differ

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Table 1

n	$1-10^{-n}$	$1+10^{-n}$
1	.9	1.1
2	.99	1.01
3	.999	1.001
4	.9999	1.0001
⋮	⋮	⋮
⋮	⋮	⋮
8	.99999999	1.00000001
9	.999999999	1.000000001
⋮	⋮	⋮

Table 2

n	$2-10^{-n}$	$2+10^{-n}$
1	1.9	2.1
2	1.99	2.01
3	1.999	2.001
4	1.9999	2.0001
⋮	⋮	⋮
⋮	⋮	⋮
8	1.99999999	2.00000001
9	1.999999999	2.000000001
⋮	⋮	⋮

from each other by an arbitrarily small amount. This implies in turn that X can be made to take up 'any value' arbitrarily close to unity. The expression 'any value' is synonymous with the expression 'continuous set of values' and we realise the 'continuous' through the discrete sequence $\{X_n\}$. (Students get to know of sequences when they learn how to sum a series in arithmetical and geometrical progressions.)

Consider next the idea of the derivative of a function $f(x)$ at $x=x_0$. We define the derivative at $x=x_0$ as

$$f^1(x_0) = \lim_{h\to 0} \frac{f(x_0+h) - f(x_0)}{h}$$

Once again we try to realise the continuous set of values of h arbitrarily close to zero (i. e., $h \to 0$) by constructing an appropriate sequence $\{h_n\}$ whose n-th member is, for example,

$h_n = 10^{-n}$ $(n=1,2,3.....)$

We thereby obtain a sequence of quotients $\left\{\frac{f(x_0 \pm h_n) - f(x_0)}{h_n}\right\}$.

The function is derivable (i. e., has a derivative) at x_0 if the sequences of quotients (one from left, another from right) converge to a unique and finite value.

A definite integral $\int_a^b f(x)dx$, when it exists, is the unique limit of a sequence of upper and lower Riemann sums. For example, when $f(x)=x$, a typical member S_n of the lower sums $(b>a)$ has the form

$$S_n = h\{a+(a+h)+(a+2h)+ \ldots\ldots + (a+\overline{n-1}h\}$$
$$= h\{na+h(1+2+3+\ldots\ldots+n-1)\}$$
$$= (b-a)\left(a+\frac{b-a}{2}\left(1-\frac{1}{n}\right)\right)$$

when the interval $[a, b]$ is subdivided by the abcissae points $a, a+h, a+2h, \ldots\ldots a+\overline{n-1}h$ so that $h=\frac{b-a}{n}$.

The sequence S_n, as is well known, represents the sum of the rectangles constructed with base h and heights $a, a+h, a+2h, \ldots\ldots a+\overline{n-1}h$ respectively and approximates the actual area which is a trapezoid $abb'a'$ (Fig. 1). S_n computes the shaded area. One constructs the table of values of S_n for $n=1, 2, 3, \ldots\ldots$ and checks whether the sequence converages to the actual area $\frac{1}{2}(b^2-a^2)$ as n is made larger and larger.

It is seen from these illustrations that the concepts of limits and continuity can be explained through the notion of sequences. A sequence is a set of discrete numbers and as such is easily generated on a digital computing machine. A student would be required to write computer programs to calculate appropriate sequences for each of the problems discussed above to see for himself the implications of the ideas involved. Numbers make a concept concrete and help the learner in visualising it.

Experiments and projects carried out recently in the U. S. A. confirm that 'Computer calculus' has contri-

Table 3. Examples of typical programs

Program investigates	*Student chooses*	*Terminal computes*
$\lim_{x\to 0} \frac{\sin x}{x}$	x	$\sin x$, $\frac{1}{x}$, $\frac{\sin x}{x}$
Estimating $f(x_0+h)$ by the tangent at x_0 for $f(x)=x^2, \sqrt{x}$, $\sin x$	x_0+h	$f(x_0)$; $f'(x_0)$; $f(x_0+h)$; $f(x_0)+hf'(x_0)$ $\mathrm{Err}(h)=f(x_0+h)-f(x_0)-hf'(x_0)$ $\frac{\mathrm{Err}(h)}{h}$
Riemann sums	f(x), a, b, n $c_1 \in [x_{1-1}, x_1]$	$x(i-1)$, $x(i)=a+\frac{i(b-a)}{n}$ $f(c_1)$, $f(c)\Delta x$ $\Sigma f(ci)\Delta x$

buted to a better understanding of the subject for the first year college students. The topics covered in the survey included computer oriented treatment of (1) limit, (2) continuity, (3) derivative, and (4) definite integral. Table 3 gives a list of some typical problems tested by students on a computer (from an article by Margaret S. Menzin, *Amer. Math. Monthly* **83**, 5, 1976).

Explanations : Err (h) means Error depending on the choice of h. $C_i \in [x_{i-1}, x_i]$ means an arbitrary point chosen in the subinterval.

$[x_{i-1}, x_i]$.

$\triangle x$ means a fixed increment given to x.

The main conclusions drawn from the computer-based calculus course introduced in American colleges can be summarised as follows:

(1) The course is more concrete and understandable to the student. After testing many examples on the computer the students believed that the sequences did converge and that the calculus was not too abstract to grasp.

(2) The concept of 'approaching a limit' without actually arriving at it is better understood.

(3) The students can link the abstract with the reality, i.e., the exact value and its approximation.

(4) The students enjoy doing calculus on a computer.

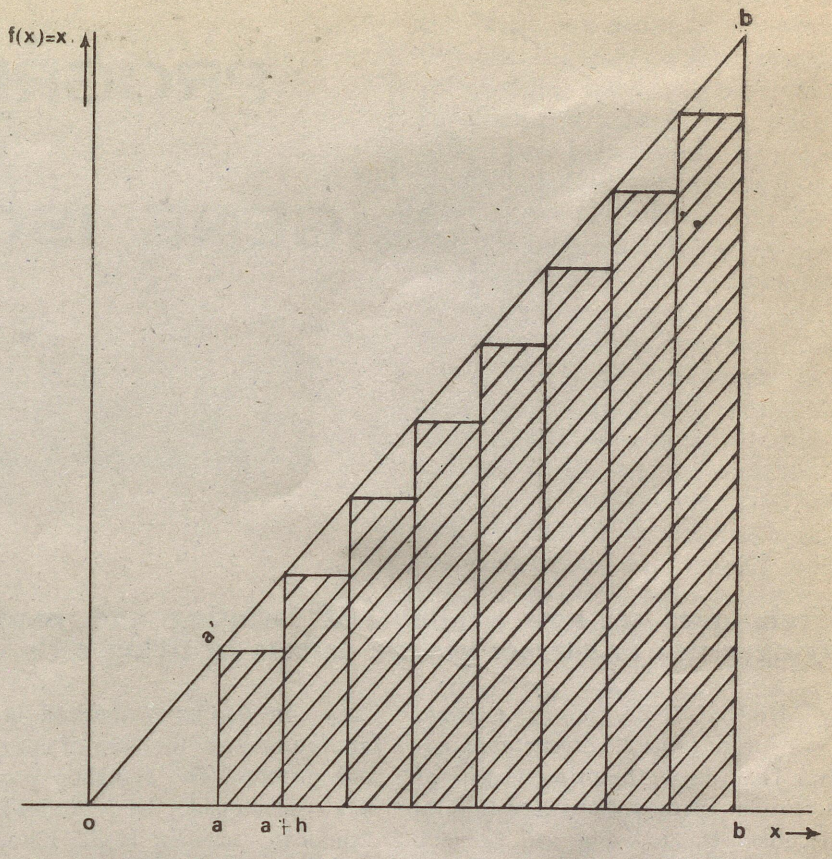

Fig. 1. Sn computes the shaded area

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PROGRESS IN GENE ISOLATION

Techniques are now available of isolating and modifying genes to correct genetic defects in living cells

R.K. CHOUDHURI

CHARACTERS are an expression of genes, and genetic activities have been the prime targets of scientific investigations for several decades. In a living cell, genetic material or DNA (deoxyribonucleic acid) is localised mostly in nuclear organelles called chromosomes. Under light microscope, chromosomes are visible as rods and are composed of nucleoproteins. Deoxyribonucleic acid is a double-stranded helical structure with paired purine and pyrimidine bases. Base adenine always pairs with the base thymine and base guanine pairs with base cytosine and *vice versa*. During transcription, DNA transcribes its messages on RNA (ribonucleic acid) molecules which move to the cytoplasm. Proteins are synthesised on RNA templates with the help of amino acids, enzymes, various cofactors and ribosomes. In short, the pathway from DNA to enzymes (proteins) is gene expression.

Genes or segments of DNA molecule can be isolated and purified by a number of biochemical methods. They can also be synthesised in the laboratory with the help of enzymes and primers. The synthetic process was developed by India-born American scientist H.G. Khorana and his associates at the University of Wisconsin in U.S.A. in 1970. Khorana's work has opened up tremendous possibilities for tampering with the genes and their messages for the benefit of mankind.

The first step for this synthetic process is the isolation and purification of genes. The next step is to read a message correctly. The synthetic process then starts from an end on the sequence of message. One base after another is hooked up in the chain. This is a laborious and very expensive method and requires a modern sophisticated laboratory. Another method, which is less expensive, is being developed in many countries including ours. It involves isolation of total DNA constituents and a particular message separately. The nucleic acids are then purified. Analysis and isolation of that particular gene is carried out by molecular hybridization.

RNA, carrying messages of genes, can be identified by a number of methods, but the one commonly used today by biochemists and workers in other sciences is the study of nucleic acid hybridization. Such an analysis shows that during development, different segments of a DNA molecule are engaged in RNA transcription. It is now an agreed opinion that during transcription some specialised DNA sequences act as a switch which controls nearby structural genes called cistrons containing about 1000 base pair sequences. To understand the production of messanger RNA (mRNA) on these sequences, one should be familiar with DNA molecule (Fig. 1). During RNA. synthesis complementary purine and pyrimidine bases, viz., thymine and adenine/adenine and thymine/ guanine and uracil/ cytosine and guanine, are attracted to one another and pair. As a result, a molecule of RNA, the mirrorimage of a DNA segment, is synthesised on a DNA message

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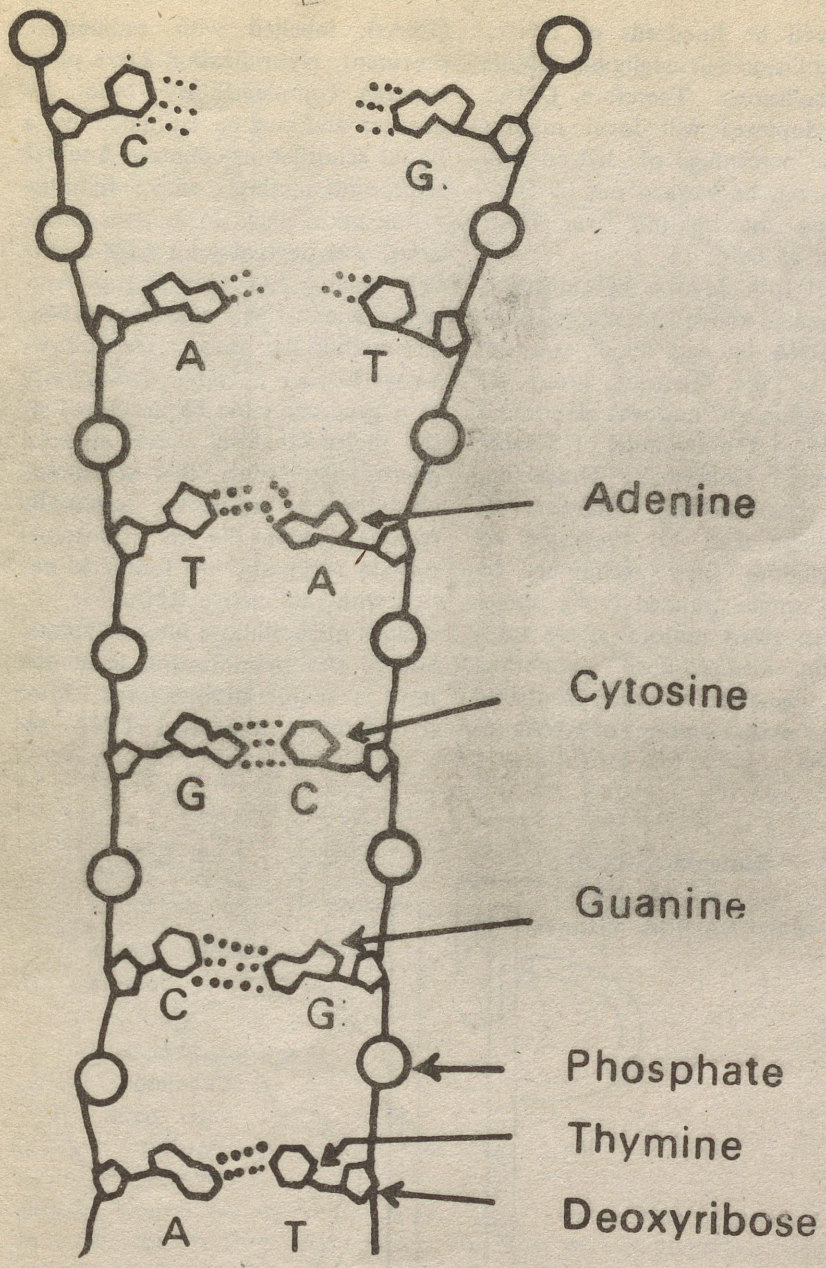

Fig. 1

or cistron. It is therefore possible to get an estimate of total active genes in a particular organism or in a particular developmental stage by calculating the percentage of DNA segments which find partners in DNA-RNA reannealing experiments. It is important to note here that of the two strands of a DNA molecule only one strand is active in transcription. Therefore, theoretically, one cannot get more than 50% DNA segments transcribed.

The subject of nucleic acid hybridization develops with the idea of identifying the force which holds a purine base with a pyrimidine base in a double-stranded DNA molecule (Fig. 1). The force is so strong that even when hydrogen bonds between two opposite bases are artificially broken, bases reassociate rapidly after the removal of external stimuli, heat or alkali, in appropriate conditions. The prime requirement for such a reassociation depends on collision factor of bases. Therefore, two nucleic acid molecules pair when they meet in a common environment, provided they are in single-stranded condition and eager to pair. Scientists took advantage of this unique situation and applied heat, alkali or low salt solutions to dissociate hydrogen bonds and let the molecules in a mixture to reassociate by putting them in appropriate buffer salt solution and temperature. The purity of reacting molecules and critical incubation conditions are the main criteria for successful experimentation with nucleic acids.

In gene expression studies, DNA and mRNAs are extracted by standard procedures, e.g., shaking with phenol-chloroform mixture, caesium chloride centrifugation or hydroxyapatite chromatography. After extraction and purification of DNAs, they are chopped into smaller pieces by passing the solution through a narrow orifice under high pressure or by exposing the solution to ultrasonic waves. To record reannealing reactions, it is essential that one of the reacting molecules, preferably DNA, should be labelled with a radioactive element (P^{32}, H^3, or $3C^{14}$). Labelling is generally done *in vitro*, but *in vivo* labelling with radioactive iodine (I^{125}) is also now in practice. Estimation of reannealed molecules is done with liquid scintillation counter.

Until recently, the estimate of gene expression was based on the whole unfractionated DNA. As a result, a low percentage of DNA sequences was obtained as transcribed sequences. The reason was the presence of some fast reassociating fractions in DNA of higher organisms known as repeated DNA segment. During hybridization experiments, these segments find their counterparts easily as compared to other sequences and form duplexes; mRNAs are therefore barred from reannealing with complementary DNA sequences. To eliminate fast reassociating frac-

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tions, Roy Britten and D.E. Kohne of Carnegie Institute, Washington, DC (USA), used hydroxyapatite chromatography in 1968. With non-repeated DNA sequences, per cent of DNA transcription was recorded as high as 30% by J. Bonner and associates in USA, D. E. Kohne in Carnegie and the author (while working at Howard University, USA) in different organisms including human tissue.

Since Carnegie group's successful experimentation with hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_3$ crystal is becoming popular as chromatographic material for separating single (non-reassociated) strands from double (reassociating stranded DNA segments. Hydroxyapatite crystals are loaded in a double jacketed glass column in the presence of phosphate buffer at pH 6.8. The column is kept at 60°C and nucleic acid is loaded in the column at a capacity of 0.5 mg per ml of hydroxyapatite (HAP) suspension. When the column is washed with 0.12 M pb, single-stranded molecules come out leaving double-stranded hetroduplexes absorbed to the HAP crystals. Duplexes can be washed by raising the salt molarity to 0.4 M or by raising the column temperature to 95°C (Fig. 2). Detailed procedure is as follows. Purified and sheared non-repeated DNA sequences are mixed with RNAs in buffered salt solution (mono-cation), boiled at 100°C for a few minutes and incubated at 60°C to 70°C for the desired period. Two nucleic acids reassociate depending on the similarities of base sequence arrangement, i.e., a DNA molecule with a base sequence A.A.T.G.C. T.A... will reassociate with a RNA molecule having T.T.A.U.G.A.T... base sequence. A microamount of labelled non-repeated DNA and an excess amount of RNA from a particular source are mixed in such a way that for each DNA segment there should be a thousand fold RNA counterparts. As a consequence, there will be hundreds of DNA: RNA collision but negligible DNA: DNA collisions. Therefore, DNA: RNA duplexes will form rapidly and the percentage of hybrid formation can be worked out by fractionating the mixture over HAP column at 60°C.

Apart from *in vitro* hybridization as described above, a method of trapping DNA on agar block was devised by the Carnegie group of Washington DC and was elaborated in 1965 at the Institute of Cancer Research, Columbia University, USA, by American scientists S. Spiegelman and D. Gellespie as nitrocellulose filter technique, by which single-stranded DNA molecules (or RNA molecules) are trapped on nitrocellulose membrane filters. The filters are then incubated with an excess amount of RNAs (or DNAs), labelled with radioactive precursor. Hybridization takes place between complementary base sequences and can be estimated by a liquid scintillation counter. Another important method, where hybridization takes place in *in vivo* conditions, was devised jointly by a British scientist J.G. Gall and an American scientist M.L. Pardue in 1968. The method has been perfected now-a-days to such a degree that activity of a gene can now be visualised at the molecular level under electron microscope. With this technique, chromosome segments, especially regions responsible for ribosomal protein synthesis, are found to enrich with radioactive RNAs.

Both nitrocellulose filter technique and *in situ* hybridization technique have a major disadvantage. After hybridization, expressed DNA se-

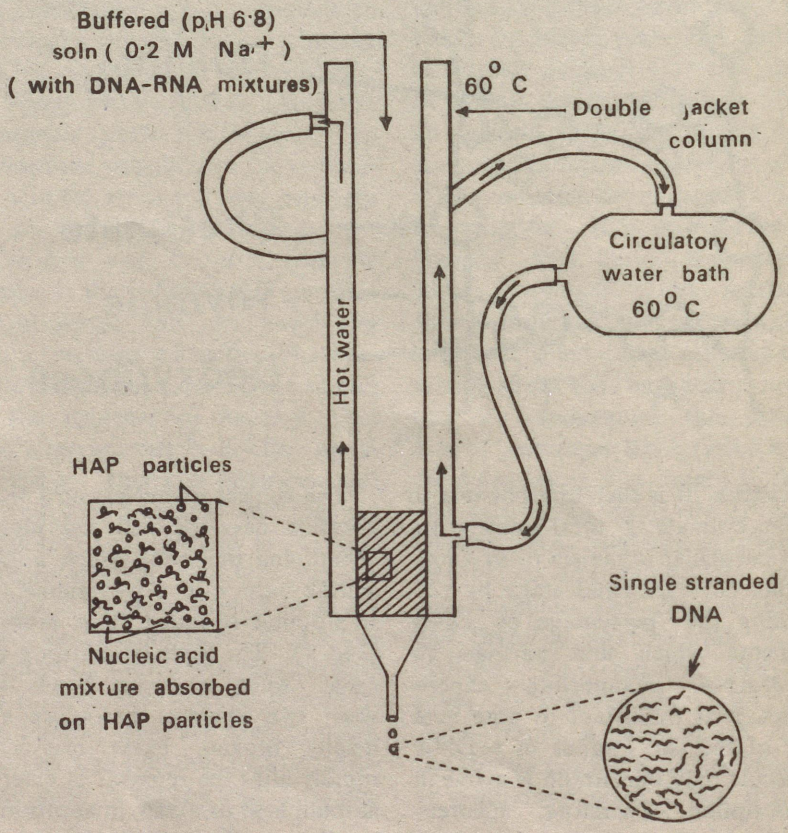

Fig. 2

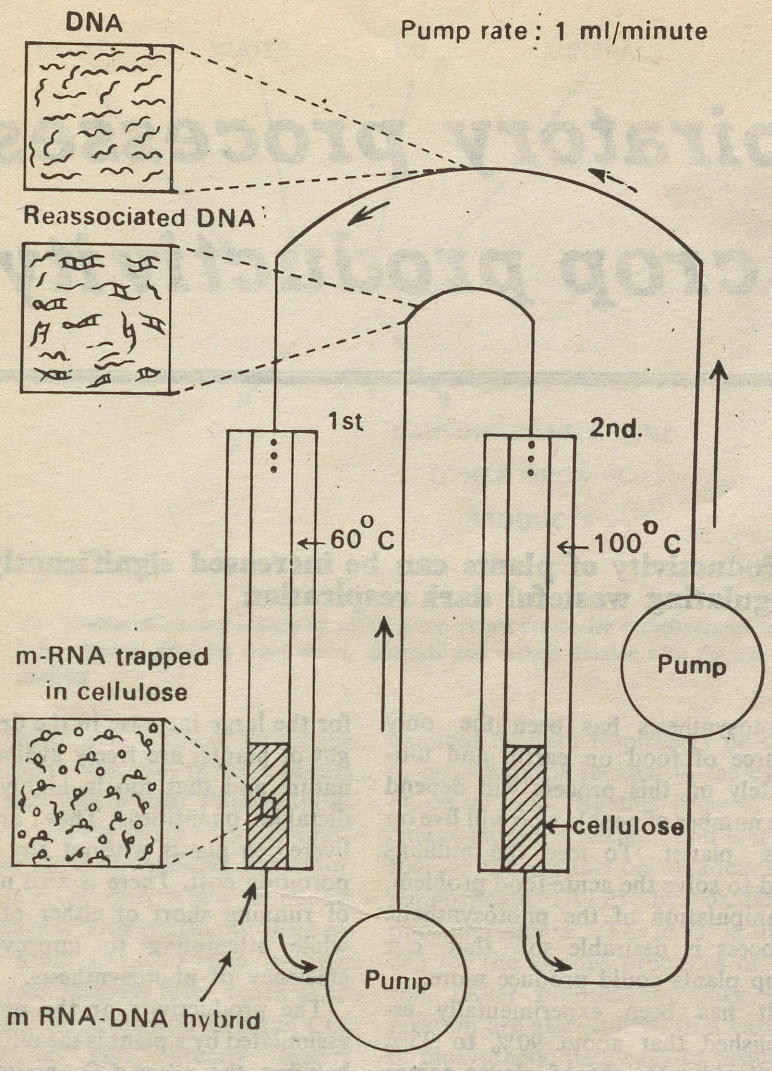

Fig. 3

quences cannot be recovered and analysed for further characterisations. Hydroxyapatite chromatography technique, on the other hand, eliminates this disadvantage and by this process a particular RNA message can be extracted as hybridized form, hydrolysed to recover the original DNA strand and can be analysed. After the success of HAP technique, resins, cellulose particles, etc., were tried as a chromatographic material for separating hybridised molecules (genes) from the non-hybridized molecules. Stimulated with the findings, a cellulose column, double jacketed, was designed where mRNAs were found to bind with cellulose particles. The bound material is loaded in the column at 60°C and single-stranded (dissociated) radioactive DNA pieces are passed through the column where complementary base sequences pair and stick to the column. The non-hybridized material comes out and goes through a pump to a second cellulose column, free from any nucleic acid molecule, and is kept at 100°C. On entering this column, DNA pieces become single-stranded and come out. These pieces are again recycled through the first column where again some more hybridizations take place. The whole process goes on continuously until all the available mRNAs find their DNA counterparts (Fig. 3). This is the extraction procedure of a gene, developed on the knowledge of hydroxyapatite chromatography by Carnegie group.

The results obtained so far with molecular hybridization are encouraging and scientists are now in a position to play with the gene. Genes can be isolated, purified and analysed. The knowledge is valuable if we think of the metabolic defects which are nothing but errors in enzyme synthesis. If the message of a gene can be read correctly, the next step of genetic engineering becomes a reality. Attempts are being made throughout the world to rectify metabolic disorders in human systems through genetic engineering. The isolation of a gene by chromatographic procedure is a right step in that direction and large scale isolation of a gene has opened up a frontier of bio-engineering to detect and to rectify the defective genes in living cells.

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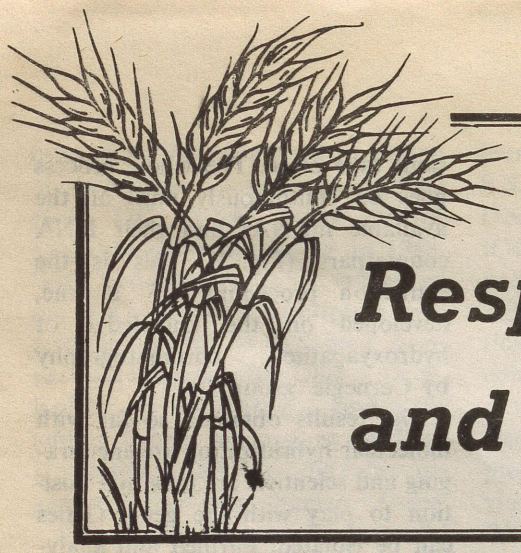

Respiratory processes and crop productivity

MANORANJAN KAR
DINABANDHU MISHRA

Productivity of plants can be increased significantly by regulating wasteful dark respiration

GREEN plants, in the presence of light, are capable of synthesizing carbohydrates (or sugars) from simple inorganic materials like water, minerals and carbon dioxide (Fig. 1). This process, which is unique to green plants, is known as photosynthesis. The carbohydrates initially formed during photosynthesis are subsequently utilized for the synthesis of starch, fats, proteins, vitamins and hormones, etc., inside the plant. These organic molecules are used by animals and human beings as food. We all depend either directly or indirectly upon the plants for our food. In future too, most of man's food will continue to be produced, either directly or indirectly, by the photosynthetic activity of green plants. At present, there are more than 4 billion people on this planet. This number may double before the year 2000, but will it continue to increase indefinitely? How many people can our planet support?

Food is the most important factor limiting population. So far, photosynthesis has been the only source of food on earth, and ultimately on this process will depend the number of people who will live on this planet. To feed the millions and to solve the acute food problem, manipulation of the photosynthetic process is desirable so that our crop plants could produce more.

It has been experimentally established that about 90% to 95% of the dry weight of plants comes from the assimilation of carbon dioxide (CO_2) during photosynthesis, and the rest of 5% to 10% comes from the nutrients absorbed by the root system from soil. These findings immediately suggest that the current agricultural practices of using dwarf varieties and application of fertilizers to increase crop productivity are of little value. On the other hand, it is logical to think that a far greater increase in productivity could be achieved by increasing the efficiency of photosynthetic CO_2 assimilation. Moreover, sunlight and CO_2, the two most important ingredients responsible for the large increase in the dry weight of plants, are freely available in nature and that too in highly predictable quantities. They are delivered to plants without any transportation cost. There is also no fear of running short of either of these while attempting to improve the efficiency of photosynthesis.

The productivity or the net CO_2 assimilated by a plant is the difference between the gross CO_2 assimilated during photosynthesis and the CO_2 released during respiration. There are two types of respiratory CO_2 production in plants. The first is the conventional respiration which is biochemically similar to that found in animal tissues and many microorganisms—a process essential for the growth and maintenance of plant cells. This respiration occurs at an equal rate in light and in darkness and is designated as dark respiration. Some portion of the dark respiration process is wasteful. When this wasteful portion occurs in plants, it may diminish productivity. The other type of respiration is known as

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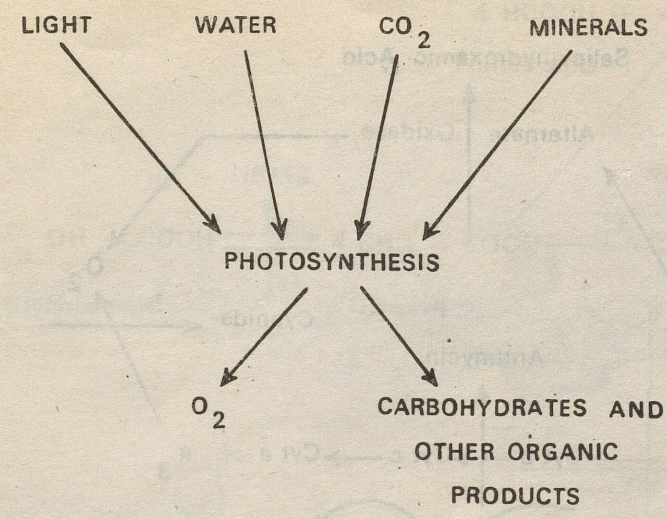

Fig. 1. The process of photosynthesis by which green plants synthesize carbohydrates and other organic products from water, minerals and carbon dioxide with the aid of sunlight

photorespiration, because, unlike the dark respiration, this process occurs only in response to light. Photorespiration involves pathways entirely different from those of the dark respiration. Many plant species, when illuminated, release a large portion of their recently fixed CO_2 by this process. Photo-respiration is often much faster than dark respiration in terms of CO_2 production. This greatly lowers plant productivity. The net photosynthetic assimilation of CO_2 can be increased by decreasing the loss of CO_2 by respiration. The net CO_2 assimilation can also be increased by increasing the rate of CO_2 fixation. Of the two, the first alternative seems more plausible because the magnitude of CO_2 loss by these processes is quite large, and if these losses are checked, productivity can be increased significantly.

Wasteful dark respiration and its regulation

In higher plants, a large quantity of solar energy is stored as chemical energy in the photosynthetic organic products. The organic products are oxidized by dark respiratory process in mitochondria located in the cytoplasm of cells. By this process, the energy stored is released and is utilized in the production of adenosine triphosphate (ATP) by oxidative phosphorylation. The ATP is utilized for the various processes of the cell. Other products of dark respiration are also utilized in a variety of biosynthetic pathways to produce carbon compounds that make up cell constituents.

The rate of dark respiration, measured by the CO_2 loss in the photosynthetic tissues in darkness, is usually 5% to 10% of the CO_2 assimilation in bright light. Loss of respiratory CO_2 occurs equally in light and darkness. Other parts of the plant like stem, roots, shaded old leaves, flowers and fruits which can fix little or no CO_2 by photosynthesis, respire out large amounts of CO_2 in light and in darkness. In all, about 29% to 71% of the gross CO_2 fixed during photosynthesis may be lost by dark respiration. Because such large quantities of carbon (as CO_2) are lost by the process of dark respiration, it is important to establish how much of this respiration is coupled to useful synthetic and growth processes of plants and what portion of it is wasteful—only liberating CO_2. If part of the dark respiration is wasteful, elimination of it could bring about a large increase in the net CO_2 assimilation and crop productivity.

That wasteful dark respiration results in the actual reduction in the dry weight has been shown in an experiment using two maize varieties. The two varieties had similar rates of net CO_2 assimilation. But one variety showed about 50% faster gain in dry weight than the other variety. It was observed that during dark respiration, the faster growing variety lost about 26% of its gross CO_2 assimilation while the slow growing variety lost 33%. This showed that in the slow growing variety an appreciable portion of the dark respiration was clearly wasteful and was not coupled to useful synthe-

Table 1. Energy score for dark respiration in the normal and alternate pathway of electron transport as shown in Fig. 2

Molecules generated per glucose molecule oxidized	*ATP equivalence*	
	Normal pathway	*Alternate pathway*
Glycolysis		
2 molecules ATP	2 molecules ATP	2 molecules ATP
2 molecules $NADH_2$	6 molecules ATP	6 molecules ATP
Krebs cycle		
2 molecules ATP	2 molecules ATP	2 molecules ATP
2 molecules FPH_2	4 molecules ATP	0 molecule ATP
8 molecules $NADH_2$	24 molecules ATP	8 molecules ATP
Total ATP generated per 6 molecules of CO_2 released	38 molecules ATP	18 molecules ATP

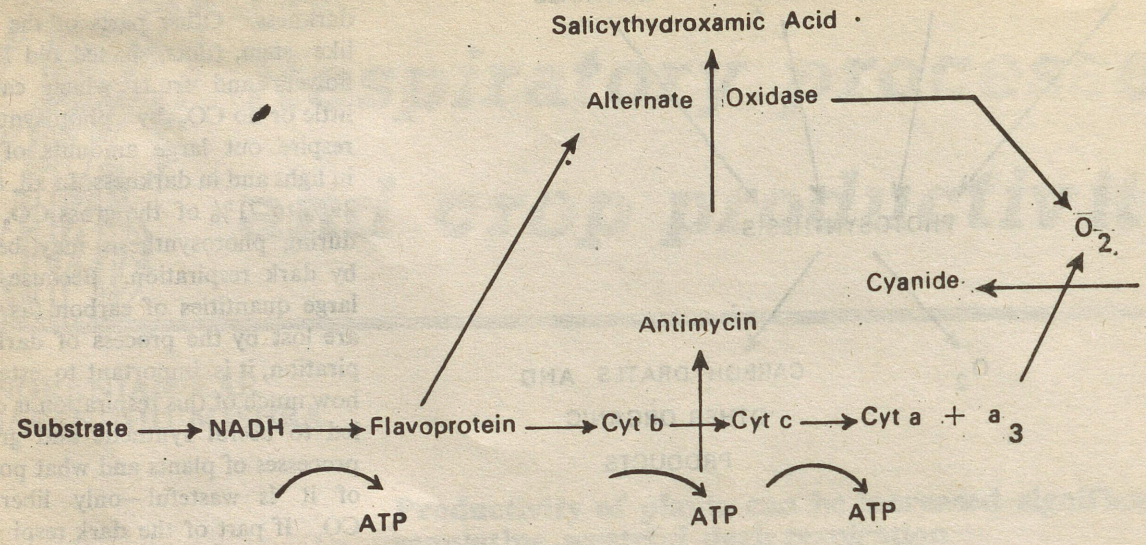

Fig. 2. Normal (antimycin and cyanide sensitive) and alternate (salicythydroxamic acid sensitive) pathways of electron flow and ATP formation in plant mitochondria

tic and growth processes. During the wasteful dark respiration, electron transport may occur without being coupled to as much ATP synthesis as should be expected in the normal dark respiration process. It seems likely that this electron transport occurs by the alternate pathway as shown in Fig. 2. In this pathway, only one third as much ATP is produced for each pair of hydrogen atoms oxidized as in the conventional pathway. About 50% of the dark respiration in leaves occurs through the alternate pathway. On calculation (Table 1), it cna be derived that in dark respiration through the conventional pathway about 38 molecules of ATP are produced per molecule of glucose oxidized releasing 6 molecules of CO_2. In wasteful dark respiration through alternate pathway, only 18 molecules of ATP are produced with the release of the same 6 molecules of CO_2. This shows that the latter process in plants is very much expensive so far as conservation of carbon is concerned. This means that from the view point of energy production more carbon compounds are used up in wasteful dark respiration than in conventional dark respiration.

The alternate (wasteful) pathway of dark respiration is sensitive to salicylhydroxamic acid which inhibits it. So this acid may be used to decrease the wasteful dark respiration and thus increase the dry weight of plants. Eliminating the alternate pathway, perhaps by the genetic regulation, would also result in greater productivity.

Photorespiration and its regulation

As mentioned earlier, photorespiration is a wasteful process in plants. It is often 3 to 5 times faster than dark respiration and diminishes greatly the net photosynthetic CO_2 uptake and crop productivity. However, not all plant species can photorespire. Leaves of crop plants like maize, sorghum and sugarcane have rapid rates of net CO_2 assimilation and low photorespiration. In these species, the first product of photosynthesis is a 4-carbon compound (oxaloacetic acid) and hence this group of plants is known as C_4 plants. Leaves of most other species like tobacco, rice and wheat, etc., have the net CO_2 assimilation rates about one-half or less than those of the C_4 plants. In these species the first product of photosynthesis is a 3-carbon compound (3-phosphoglyceric acid) and hence these plants are known as C_3 plants. The maximal growth rates are about 50 for C_4 plants and 17 to 36 for C_3 plants. The C_3 plants are characterized by rapid rate of photorespiration whereby a large proportion of CO_2 fixed during photosynthesis is released from the plants. Thus photorespiration accounts for the low dry weight production in these plants. Controlling photorespiration can therefore increase productivity in C_3 plants.

Glycolic acid is produced in leaves as an early product of photosyn-

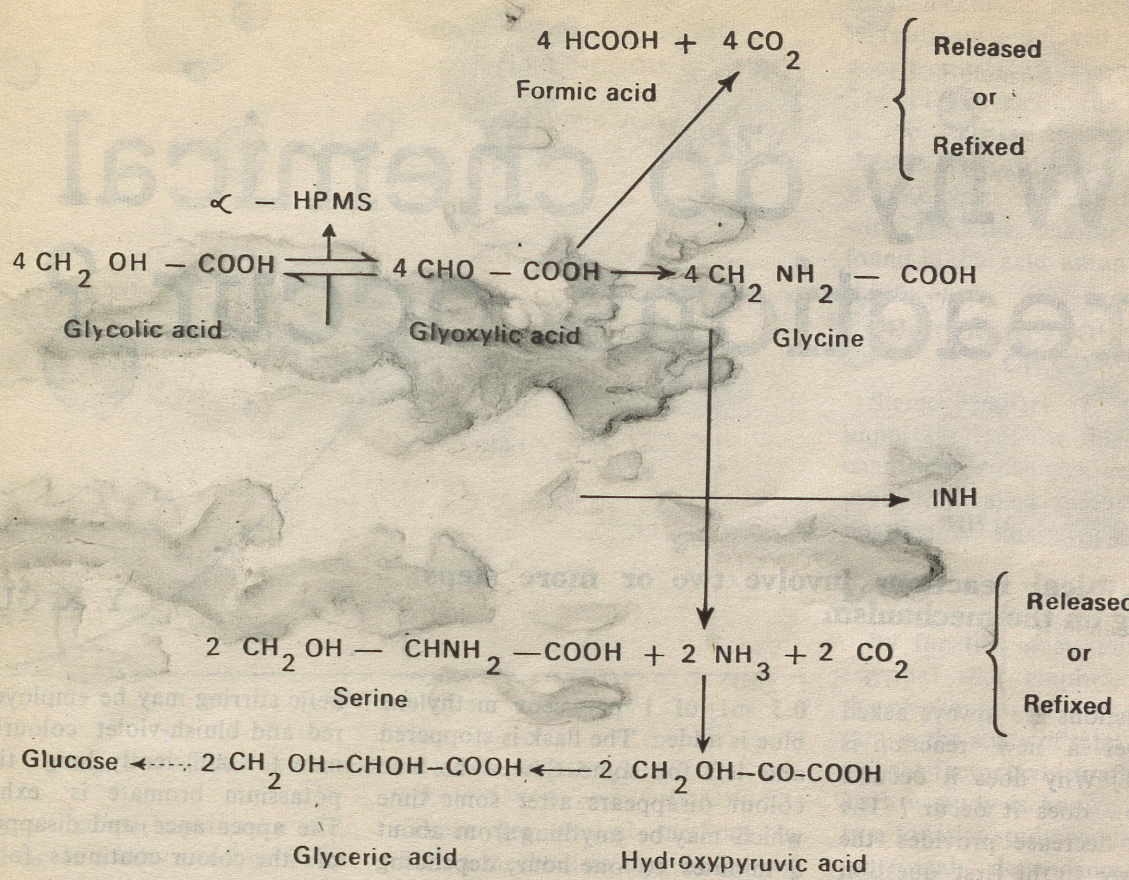

Fig. 3. **Glycolate pathway of carbohydrate synthesis in plants showing the probable source of photorespiratory CO_2. α-Hydroxy-2-pyridinemethanesulfonic acid (α-HPMS) and isonicotinic acid hydrazide (INH) are the inhibitors of the pathway as shown in the figure**

thetic CO_2 assimilation. The oxidation of glycolic acid produces the bulk of CO_2 released in photorespiration. The biochemical sequence of this process is shown in Fig 3. The released CO_2 diminishes the net CO_2 fixation. Glycolic acid is further metabolized only after its oxidation to glyoxylic acid by an enzyme glycolic acid oxidase. α-Hydroxy-2-pyridine methane sulfonic acid is a potential inhibitor of glycolic acid oxidase. So it can effectively inhibit photorespiration. But inhibiting glycolic acid oxidation is not a proper approach to control photorespiration because, by doing so, glycolic acid will continue to accumulate. Therefore, productivity can be increased either by controlling glycolic acid synthesis or by enhancing the utilization of the intermediates of glycolate pathway so that les ssubstrate will be available for decarboxylation during photorespiration. Israel Zelitch (1973) of the Connecticut Agricultural Experimental Station, Connecticut, U.S.A, has shown that glycidic acid can inhibit glycolic acid biosynthesis in C_3 plants. He discovered that a slowing down of the glycolic acid biosynthesis by biochemical or genetic methods decreases photorespiration and increases net photosynthesis and crop productivity in less efficient species.

If proper genetic control for photorespiration and wasteful dark respiration can be found, we can change our present day cereal crops to ''super plants" which will give very high yields. Apart from controlling the wasteful respiratory processes, one can also increase productivity by planting varieties that have rapid rates of expansion of leaf area by the use of closer plant spacings to capture more sunlight, and by breeding plants with leaves having more erect angles of elevation to absorb sunlight more effectively.

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(Continued on page 481)

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Why do chemical reactions occur ?

Most chemical reactions involve two or more steps depending on the mechanism

Y. K. GUPTA

TWO questions are always asked whenever a new reaction is reported: (1) Why does it occur ? and (2) How does it occur ? The free energy decrease provides the precise answer to the first question and the answer to the second question would be found in this article.

Consider the reaction of potassium permanganate with oxalic acid in acid medium. Mix 10 ml of 1.0 M H_2SO_4, 30 ml of 0.2 M $H_2C_2O_4$ and 10 ml of 0.01 M $KMnO_4$. The reaction does not occur visibly for about 5-10 minutes, and then there is a series of colour changes from purple to red, orange and possibly yellow (depending on the strength of H_2SO_4) and finally the mixture is colourless. How does this happen ? Why is the reaction static for about 5-10 minutes ? How are there so many colour changes ? In other words, what is the mechanism of the reaction ?

In a second experiment, commonly known as Blue Bottle Experiment, 2 gm of NaOH, 2 gm of glucose and 100 ml of water are mixed in an Erlenmeyer flask (400 ml), and about 0.5 ml of 1 per cent methylene blue is added. The flask is stoppered and left for some time. The blue colour disappears after some time which may be anything from about 5 minutes to one hour, depending upon the concentrations of the reactants. Give a shake to the flask and the blue colour returns but disappears again, this time rather quickly. The colour can be restored by futher shaking and just reshaking. It is delightful to do this experiment and to show it to others. The disappearance of the blue colour might be due to some sort of reactions between the reactants, but how a mere shake brings back the colour is an absorbing question. Briefly what is the mechanism of debluing and bluing in this reaction?

Still more interesting is a third reaction, which is typical of oscillating reactions. Mix 40 ml of 1.0 M malonic acid, 5 ml of 5.0 M H_2SO_4, 14 ml of 0.01 M cerous sulphate, 1 ml of 0.02 M ferroin indicator and 40 ml of 0.25M $KBrO_3$. Continue stirring the mixture with a glass rod or preferably, magnetic stirring may be employed. The red and bluish-violet colours alternate for sufficiently long time till potassium bromate is exhausted. The appearance and disappearance of the colour continues for quite sometime.

What is the mechanism ?

Before attempting to give the mechanism of these reactions, let us first see what constitutes mechanism. A reaction seldom occurs is one step. Even the simplest reactions may occur in two steps. The reaction of permanganate with oxalate :

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

is one in which, in all, twenty three molecules react. There must be collisions amongst the molecules; but it is highly unlikely, rather impossible, that all the twenty three molecules will collide simultaneously. However, two or three molecules may collide at a time and react, and then more molecules may collide in several such steps. An

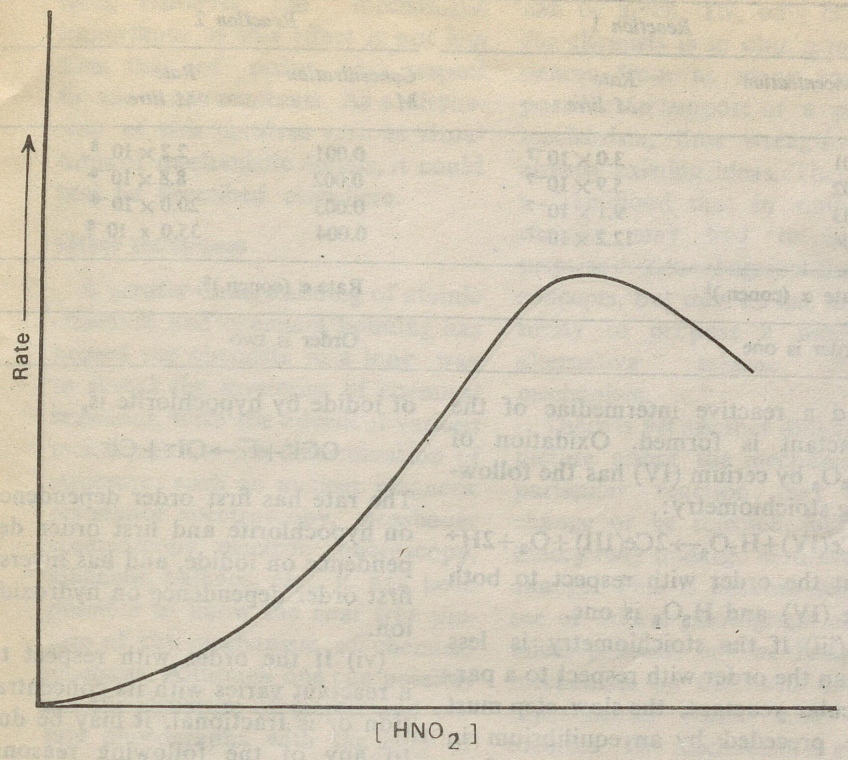

Fig. 1. Variation of rate with the increase of $[HNO_2]$

analogy would perhaps make this point clear. In a busy street of a city there are cars, scooters, trucks, bicycles and what not. Howsoever great a rush there may be, it is highly unlikely that two scooters, three cars and two bicycles collide simultaneously. It is likely that first, two bicycles or scooters or cars may collide and then one after another, or two at a time, other vehicles may come and collide. Thus a reaction occurs in a number of steps and each step involves a bimolecular or at best termolecular collisions. If we know these various steps of a reaction, we know the mechanism. Further, what types of species are reacting is another aspect of the mechanism—Are the reactive species neutral molecules or charged ions ? A third aspect of the mechanism is whether any detectable intermediates are formed. All this information about a chemical reaction helps us chalk out and propose a picture of the mechanism of a chemical reaction.

There are several methods by which a mechanism may be known. Some of the more important ones are : stoichiometry, intermediate products, use of isotopes, stereochemistry, and kinetics. The very first thing which must be known to propose a mechanism is its stoichiometry. In other words, we must know what products are being formed and what their amounts are. Stoichiometry does not give the mechanism but it helps us write the complete mechansim if other details are known.

Identification of the intermediate products is another method by which the mechanism is known. Sometimes it is possible to isolate these products but often it is not, since they are highly reactive. If the reactive intermediate products can be detected by any physical property and their identity established, it is of great help for suggesting the mechanism. Radioactive isotopes are often helpful in tracing the course of a reaction and thus in establishing the mechanism. Radioactive iodine is routinely employed to trace the course of its assimilation in the body. The breakage of the C-O bond in the alkaline hydrolysis of ethyl acetate is provided by the fact that if the oxygen of the OH is enriched with O^{18}, the heavier isotope is found in the acid anion and not in the alcohol,

$$CH_3COOC_2H_5 + {}^{18}OH^- \rightarrow CH_3CO^{18}O^- + C_2H_5OH$$

Stereochemistry is yet another important tool for finding the mechanism of a chemical rection. However, a detailed discussion is not possible in this article.

Kinetics

By far the most important and essential tool employed to know the mechanism of a chemical reaction is the study of rates of reactions and the factors which affect the rate. Such a study is known as kinetics. In a kinetics study we determine the functional dependence of rate on concentration of the reactants and other factors like temperature, pressure, catalyst, different electrolytes, etc. It has been mentioned earlier that a reaction may occur in a number of steps. A simple reaction is one in which one step is slower than the other steps. It is the rate of this step which governs the rate of the overall reaction. In other words, kinetics provides information about the slow step. Then with the help of other studies such as the effect of electrolytes (salt effect), different solvents, rates at different temperatures and pressures, information is obtained about the nature of the species participating in the slow step. The whole kinetics study can be divided into the following heads.

1. Effect of concentration (order with respect to a reactant);
2. Effect of indifferent electrolytes (salt effect);

3. Effect of dielectric constant of the medium;
4. Effect of temperature (entropy change);
5. Effect of pressure;
6. Existence of induced reactions (reactive intermediates);
7. Catalytic effects; and
8. Kinetic isotope effect.

The first in the list is the most important one and forms the primary basis for understanding the mechanism. The remaining kinetic effects may or may not support a particular mechanism. They have limited applicability. Nevertheless, their importance as supporting kinetic evidences should not be ignored. The effect of concentration is described in detail here.

Order of reaction

Before describing the correlation of the effect of concentration on the rate and mechanism, it would be better to define the term 'order' which will occur too often later. The order is a measure of how the rate varies with the concentration of a reactant. It also indicates what function the rate is of the concentration of a reactant. Precisely, the order of a reaction is given by the power of concentration of a reactant according to which the rate varies. Table 1 illustrates this point for two imaginary reactions.

Table 1

Reaction 1		*Reaction 2*	
Concentration M	*Rate M litre*	*Concentration M*	*Rate M litre*
0.01	3.0×10^{-7}	0.001	2.2×10^{-6}
0.02	5.9×10^{-7}	0.002	8.8×10^{-6}
0.03	9.1×10^{-7}	0.003	20.0×10^{-6}
0.04	12.2×10^{-7}	0.004	35.0×10^{-6}
Rate α (concn.)^1		Rate α (concn.)^2	
Order is one		Order is two	

There are rules based on the functional dependence of rate on concentration.

(i) If the rate is independent of the concentration of a particular reactant, the latter is not involved in the slow step, but is involved in subsequent fast steps.

Silver (I) catalyzed oxidation of manganese (II) by peroxydisulphate is independent of the concentration of manganese (II) and has first order dependence on the concentrations of Ag (I) and peroxydisulphate.

$$S_2O_8^{2-} + 2Mn^{2+} + Ag(I) \rightarrow 2SO_4^{2-} + 2Mn(III) + Ag(I)$$

(ii) If stoichiometry is more than the order with respect to a particular reactant, the latter is involved in a slow as well as subsequent fast steps and a reactive intermediae of the reactant is formed. Oxidation of H_2O_2 by cerium (IV) has the following stoichiometry:

$$2Ce(IV) + H_2O_2 \rightarrow 2Ce(III) + O_2 + 2H^+$$

but the order with respect to both Ce (IV) and H_2O_2 is one.

(iii) If the stoichiometry is less than the order with respect to a particular reactant, the slow step must be preceded by an equilibrium in which more than one mole of a particular reactant are involved and some moles of the reactant are obtained back unreacted in the slow step. Oxidation of H_2O_2 by Tl(III) in acid solution shows that the order with respect to H_22O_2 and Tl(III) are two and one respectively, but the stoichiometry is :

$$Tl(III) + H_2O_2 \rightarrow Tl(I) + 2H^+ + O_2$$

(iv) If the rate is inhibited by one of the products, the slow step must be preceded by an equilibrium in which the product species is formed.

Chromium (III) is oxidized by cerium (IV) in sulphuric acid solution according to the following equation:

$$3Ce(IV) + Cr(III) \rightarrow 3Ce(III) + Cr(VI)$$

The order with respect to cerium(IV) and chromium (III) are two and one respectively. The reaction has inverse first order dependence on cerium(III).

(v) If negative order is found with respect to a species which does not appear in the stoichiometric equation, the species must be formed in an equilibrium preceding the slow step and must be consumed in the following fast step. The stoichiometric equation for the oxidation of iodide by hypochlorite is,

$$OCl^- + I^- \rightarrow OI^- + Cl^-$$

The rate has first order dependence on hypochlorite and first order dependence on iodide, and has inverse first order dependence on hydroxide ion.

(vi) If the order with respect to a reactant varies with its concentration or is fractional, it may be due to any of the following reasons. It may be a chain reaction; there may be complex formation between reactants; the reaction might be taking place by more than one path; or a reactant may be existing in more than one reactive form.

Sometimes the rate decreases with increase in concentration of a reactant. This is the most peculiar situation because at first sight this seems to contradict the well known Law of Mass Action, according to which, the rate must be proportional to some positive power of concentration of the reactant. This would happen when the reactant forms complexes, one or more of which are reactive and others are not reactive. The oxidation of nitrite with Ti (III) in perchloric acid solution is an example of such a case. If the rates are measured at various nitrite concentrations and plotted, a characteristic curve of Fig. 2 would be obtained. The rate increases, becomes maximum and then finally decreases with the increase of nitrite.

The effect of hydrogen ion concentration on rate, which could be regarded as the effect of concentration on the rate, is not discussed

here. However, the mechanistic importance of this effect is not less than that of order with respect to the main reactants. As a discussion of this involves various situations of mechanistic details, it could best be described elsewhere.

Other techniques

A greater understanding of atomic structure and chemical bonding has helped the chemists in a long way to reveal the mysteries of chemical reactions. With the advent of various techniques for the determination of structure such as nuclear magnetic resonance spectroscopy, mossbauer spectroscopy, electron , microscopy, magnetic balance, etc., it has been possible to know the near true picture of the mechanism of chemical reactions. Although one can possibly see the structure of matter and obtain photographs with the help of present day techniques, it is not possible to see the course of a chemical reaction and one has to rely on indirect evidences in support of the mechanism. The question is, how much should we depend on indirect evidences ? No clear cut answer to this question can be given. The only course left for chemists is to obtain more evidences from as many sources as possible in support of a particular mechanism, thus strengthing the already existing ideas. There is also a likelihood that in doing so, a chemist may find to his utter surprise evidences against the current concepts, but then he has an opportunity to propose a modified or alternative scheme for the mechanism.

There is yet another difficulty. The picture about the mechanism of a particular reaction may undergo change or be rejected, just as any theory may undergo modification or change. This is because we cannot see or take a photograph of a chemical process, but we imagine the mechanism on the basis of certain experimental results and current theories. The mechanism is a mental model devised to explain the observed facts. The mechanism may have to be given up if the concerned theories on which it rests undergo change. Similarly, a mechanism would no more be tenable if the future experimental results cannot be explained on its basis.

A final word about the mechanism of a particular reaction can never be given. All that we can say is that one is the most probable mechanism based on the latest facts known about the reaction.

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also account for the scarcity of oxygen atoms or oxygen gas (O_2) in the lunar atmosphere. Unlike earth, surface temperatures on the moon fluctuate over a much wider range, from +110°C at lunar noon to −180°C just before dawn.

Age determination studies have indicated moon to be as old as earth. Abundance of certain radioactive elements in rocks, and studies of meteorites indicate that the sun and all other bodies in the solar system formed about 4.6 billion years ago from a collapsing cloud of hot gas and dust. Chemical evidences in lunar and terrestrial rocks suggest that the earth and moon formed at the same time. Although the oldest known rocks on earth are only 3.7 billion years old, scientists think that still older rocks have been destroyed by earth's continuing volcanism, mountain-building and erosion. Lavas from the dark maria are the moon's youngest rocks, but they are as old as the oldest rocks found on earth. Rocks from the lunar highlands are even older, with ages in the range of 4.0 billion to 4.3 billion years. This suggests that a substantial fraction of the mare basins was excavated around 4.0 billion years ago and filled with basaltic lavas during the following one billion years.

Like earthquakes, moonquakes also occur, about 3000 of them every year. The moonquakes originate about 600 kilometers to 800 kilometers deep inside the moon; they are much deeper than those on earth. Moreover, the moon is not uniform from inside. Like earth, the lunar inside is divided into a series of layers. But the layers of earth and moon are different. The outermost part of moon is a crust about 60 kilometers thick. It is possibly composed of calcium and aluminium rich rocks like those found in highlands (Fig. 1). Beneath this crust is a thick layer of denser rock, called mantle, which extends down to more than 800 kilometers. The deep interior of moon is still unknown. It may contain a small iron core at its centre which may be hot and even partly molten. There are, however, no conclusive evidences to this effect. The moon does not have any magnetic field like that of earth, though some older lunar rocks do exhibit magnetism. It has been suggested that the moon had an ancient magnetic field. It somehow disappeared at a later stage. A comparative study of some basic properties of the moon, earth and mars is presented in Table 2.

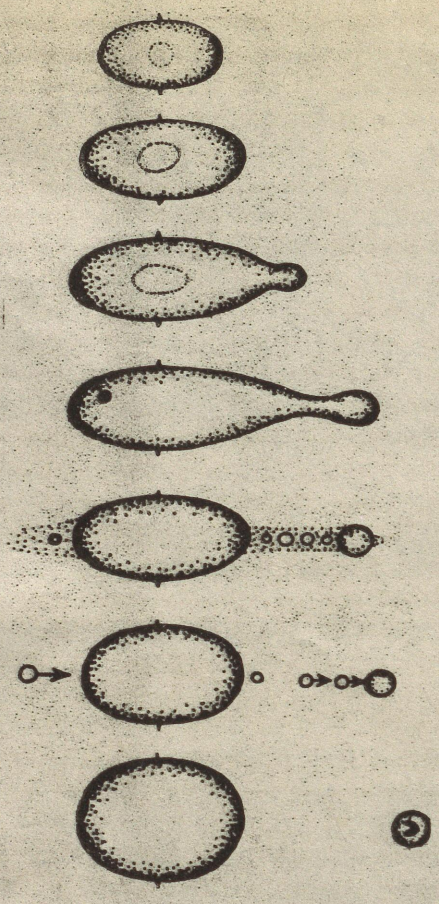

Fig. 3. Moon separated from earth by fission in several stages

One of the chief objectives of man's quest of space and the whole of Apollo programme was to find out if there is any life outside earth. Despite careful searches, neither living organisms nor fossil life have been found in any lunar samples. The lunar rocks are so barren of life that quarantine period for returned astronauts was dropped after the third Apollo landing.

There are three main theories to explain the origin of moon : (i) It was formed alongwith the earth. According to this theory, known as twin planet theory, the solar system formed from a primordial dust cloud where two planets condensed instead of one; (ii) It was orighally a part of earth. When the dust cloud began to spin rapidly, it changed into a disc shape, then into a sausage shape, and finally separated into two parts as shown in Fig. 2. The larger part became earth and the smaller part moon. This is called fission or daughter theory ; (iii) It was formed somewhere else and was captured by earth as shown in Fig.

Table 2. A comparison of some basic properties of the Earth, Moon and Mars

Property	*Earth*	*Moon*	*Mars*
1. Mean radius (Km)	6731	1738	3388
2. Mass ($\times 10^{25}$g)	599	7.353	64.4
3. Mass 9 (relative to earth)	1.0	0.0123	0.11
4. Density (g/cm^3)	5.517	3.34	3.94
5. Surface area ($\times 10^6$Km^2)	510.1	37.9	144.2
6. Surface gravity (cm/sec^2)	980.7	162	373
7. Surface gravity (relative to earth)	1.0	0.165	0.38
8. Mean distance of Moon to earth (Km)	—	384402	—

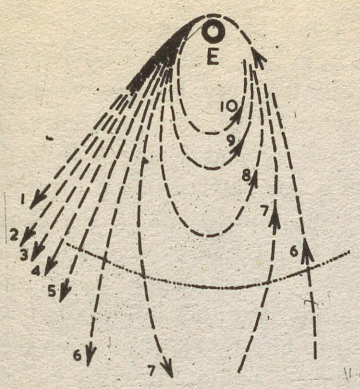

Fig. 4. Moon was captured by earth into its orbit after it had been formed somewhere else

3. On the basis of information gained from the Apollo missions and the study of lunar samples, none of these theories can be ruled out. However, scientists agree that the moon formed as a part of our solar system and also that it had existed as an individual body for 4.6 billion years. More data are needed before the question of moon's origin could be settled.

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Tapping ocean heat by nitric acid cycle

ENORMOUS amounts of solar energy are stored in the tropical oceans which can be harnessed for power generation. One of the earliest attempts to tap this heat was made in 1930 when a small (10-20 kw) power plant was set up in the sea off the Cuban coast. The plant was based on what is known as the Rankine Cycle which made use of the temperature difference between the warm surface waters and cold deep waters of the sea to run a water vapour driven turbine generator. The efficiency of the process was however rather low. Later developments envisaged the use of a low-boiling working fluid such as ammonia or propane. The warm surface water could vapourise the working fluid to drive a turbine, and the spent vapours condensed using cold deep sea water.

Now two Japanese scientists N. Wakao and K. Nojo of Yokohama National University, have come up with a new concept of up-grading the low-level heat of ocean waters to generate power. Here the temperature of water is actually raised to much above the surface temperature by utilising the heat of dilution of nitric acid (*Nature*, **273**, 25, 1978).

The process is based on the heat liberated when concentrated nitric acid is mixed with water. For instance, when 1 Kg of 65% nitric acid is diluted with 0.5 l to 0.8 l of water, a temperature rise of the order of 20°C is observed. The liberated heat can be recovered for use in a heat exchanger.

After mixing and heat recovery, if the dilute solution is fed (through pumps) into a chamber (distillation column) at a low pressure (~9 mm Hg) and heated to about 25°C (by warm surface water), the solution separates into water vapour which is distilled off, and a constant boiling mixture of 65% nitric acid (as the bottom liquid). The water vapour is condensed using the cold sea water. The mixture is therefore separated back into 65% nitric acid and water. The distillate (water) and the bottom liquid from the distillation column are pressurised to about 50 mm Hg by pumps before recycling them to the mixing chamber.

If, before mixing, the nitric acid and water are heated to about 26°C by warm surface water, mixture temperatures as high as 45°C-46°C can be obtained. In practice, according to Wakao and Nojo, several such stages could be hooked up in series to increase the final temperature attained. In a four-stage unit, for example, a temperature of over 100°C is theoretically feasible.

The overall heat recovery efficiency of the nitric acid cycle is estimated by the authors at about 4% as against 2.5%, to 3% for systems using ammonia or propane. Although its economic feasibility is not yet established, the two scientists are hopeful that the new process of extracting pollution-free thermal energy of a higher temperature from the sea will become a "promising candidate as a new energy source."

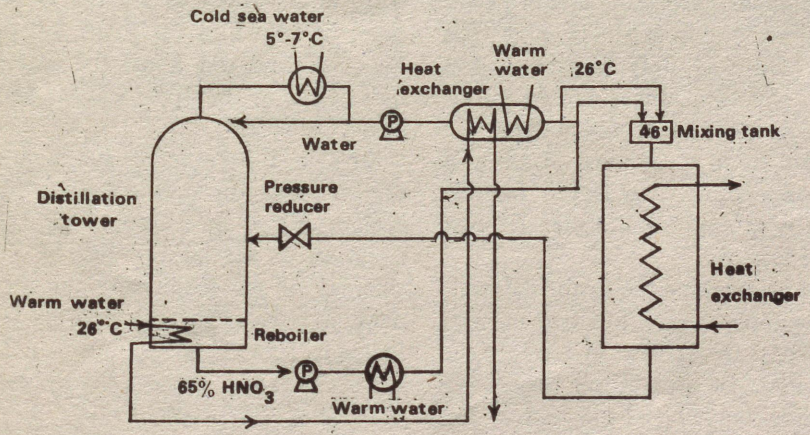

Fig. 1 Heat recovery system using nitric acid cycle

BIMAN BASU

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Optical bistability

THE bistable circuit also known as the flip-flop, which can either remain in an 'off' state or in an 'on' state, is the building block of all electronic counting and computing systems. An electrical signal (voltage) would cause the circuit to change from one state to another. A similar bistability has been discovered in optics. A medium opaque to light becomes suddenly transparent to the same light when the intensity of the beam is increased above a certain high level. Such intense beams of light can be obtained from lasers. The same medium returns to its normal opaque state when the light intensity is decreased. This property 'promises to contribute significantly to the growing technology of light wave communication' (*Physics Today*, Dec 1977). The binary action can be used in counting and also in performing switching and logic operations as in electronics. If such a device is exposed to light of right intensity just below the transition level (i.e., the element is biased suitably) and if an additional alternating (varying in intensity) light signal is superposed on the input one will get a large output every time the superposed signal takes the input above the transition level and amplification (triode action) is achieved. Such devices could form active components for integrated optical circuits similar to the integrated electronic circuits (the ICs).

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Newton and the apple

WHEN I was young, I remember the science teacher explaining to us how an apple fell before the brooding eyes of Newton and gave him the idea for the theory of gravitation. Later, another teacher graphically described that the apple had in fact landed on the nose of the unsuspecting philosopher and had been the cause of that celebrated discovery! It was difficult for us to argue out the matter at that time, because any attempt to question the omniscient knowledge of the teacher more often than not attracted some punishment—it was one of those schools where the cane was just about the only teaching aid available. But we harboured our doubts. We knew about the story of another celebrated inventor James Watt getting the idea for his steam engine by idly watching a tea kettle boil. The story was not true. For engines harnessing steam power had been long in existence, and what Watt did was only improve upon them. Such instances can be multiplied because it is fancy that the human mind loves most of all, and any opportunity to link a famous name with any fanciful idea is most appealing.

Let us examine the historical basis of the apple theory. Pemberton, who received from Newton himself the first ideas of gravitation, does not mention anywhere the apple but speaks simply of the idea having occurred to the philosopher as he sat alone in the garden.

It is, in fact, Voltaire who is credited with the story. He says, "One day, in the year 1666 Newton went to the the country and seeing a fruit fall from a tree entered into a profound train of thoughts as to the causes which could lead to such a drawing together or attraction". Voltaire mentions that this information was given to him by Newton's step niece Madame Conduit. It must be observed that Voltaire does not speak of the fruit being an apple. It is Martin Folkes, the President of the Royal Society, who speaks of its being an apple.

The great philosopher Hegel rejected the apple hypothesis as ridiculous. In his view, the story of the apple was a modern version of the history of the tree of knowledge, with whose fruit the serpent beguiled Eve.

Carl F. Gauss, one of the greatest mathematicians says with characteristic Teutonic candour, "The history of the apple is too absurd. Whether the apple fell or not, how can anyone believe that such a discovery could in that way be accelerated or retarded? Undoubtedly the occurrence was something of this sort; there comes to Newton a stupid importunate man who asks him how he hit upon his great discovery. When Newton had convinced himself what a noodle he had to deal with, and wanted to get rid of the man, he told him the apple fell on his nose, and this made the matter quite clear to the man, and he went away satisfied".

Sir David Brewster in his biography of Newton does not expressly declare either his acceptance or rejection of the legend. But by the manner of his recounting the incident, it is clear that he favours the incident, though he would put it in the year 1665 rather than 1666. He writes, "The apple is said to have fallen from the tree at Woolsthorpe, and suggested to Newton the idea of

gravity. When sitting alone in the garden and speculating on the powers of gravity it occurred to him that as the same power by which the apple fell to the ground was not sensibly diminished at the greatest distance of the centre of the earth..." Then in a note, the biographer adverts to the fact that both Newton's niece and Martin Fokles had mentioned the story of the apple, but neither Whiston nor Pemberton had done so. However Sir David affectionately mentions that he saw the apple tree in 1814 and brought away a portion of one of its roots, as the tree was in an absolutely decayed condition. He further mentions that the tree was pulled down in 1820 and the wood — whatever of it was remaining — was carefully preserved by Mr. Turner of Stoke Rocheford. In his entire description, it must be noted, Brewster does not give his categorical opinion as to the correctness of the legend. He merely describes the legend and visits a particular tree involved in the legend, but does not bother to critically assess the evidence.

Professor De Morgan points out somewhat satirically that the fact of such a tree having stood in Newton's garden goes very little to prove that the fall of an apple from that tree suggested the theory to Newton! In fact, in his opinion, there is no evidence whatever to link these two. He believes that the current story must have grown out of a conversation between Newton and his niece, twisted by hundreds of mouths as it circulated. He suggests that Sir Isaac in a casual talk with his niece may have mentioned the fall of some fruit as having once struck his mind when he was pondering over moon's motion and she, in all innocence, must have related this incident in a way which Newton never intended.

As a matter of fact Kepler, Bouillard and Huygens had all made discoveries or put forth speculations regarding the probable law by which heavenly bodies are attracted to each other—the decks having been cleared by Galileo. It was a mass of available observations which Newton used to derive the laws of universal gravitation. It is doubtful that after Galileo's work Newton would have at all needed the help of an apple.

From the above discussion we are inclined to believe that the fall of the apple was perhaps a fancy in someone's mind which ultimately assumed the weight of a legend merrily carried on inspite of scanty evidence and pronouncements of men like Gauss, Hegel and De Morgan. No wonder then that in the museum at Oxford, the statue of Newton is sculptured with the renowned pippin at the philosopher's feet!

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Electrochemical polymerisation

POLYMER is a giant molecule built up by the repetition of a small chemical unit called monomer. Polymer is the general term for plastics, rubbers and resins. The process of conversion of small molecules into polymeric molecules is called polymerization. The formation of polyethylene (polymer) from ethylene (monomer) will serve as a good example :

$CH_2=CH_2 \longrightarrow$
Ethylene

$\sim CH_2-CH_2-CH_2-CH_2 \sim$
Polyethylene

Millions of molecules of ethylene can combine together to form polyethylene. Polymerization reaction is usually triggered off by an appropriate initiator which is either a free radical or an ionic or coordination compound (Ziegler-Natta catalyst). The basic differences among the various catalysts which cause polymerization, either by a free or ionic mechanism, lie in their electronic configurations. Therefore a relatively simple way to generate them may be by an electron transfer from an electrode. The cathode can serve as an electron donor and the anode as an electron acceptor. Electrochemical polymerization simply means the use of an electric current to initiate the polymerization of a monomer. It is essentially a combination of electrode process and chemical reaction.

A typical electrolytic polymerization system consists of an electrolytic cell equipped with two electrodes, supporting electrolyte and solvent. The cell is usually divided into anode and cathode compartments by fritted glass disc in order to avoid interaction between anodic and cathodic products. Supporting electrolyte is used to increase the electric conductivity of the reaction medium. When the reaction mixture containing monomer is subjected to electrolysis, active species generated *in situ* at electrode reacts with monomer molecule and initiates polymerization. If the reduction potential of a monomer is less negative than that of supporting electrolyte and solvent, the cathodic reduction of the monomer is the main electrochemical primary process leading to the formation of radical anions as shown in Fig. 1 in the case of styrene monomer. The radical anion is capable of simultaneous radical and anionic growth. The monomeric radical ions get

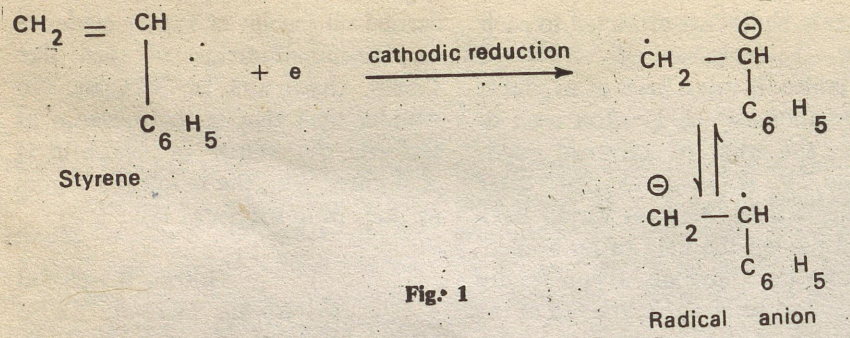

Fig. 1

dimerized to form dimeric di-carbanions which may continue their growth by an anionic mechanism. On the other hand, if the oxidation potential of a monomer is less positive than those of the anions of the background electrolyte or solvent, the polymerization occurs by a cationic radical which on subsequent coupling may give rise to di-cations that would result in cationic growth from both ends of the coupled product.

Alternatively, the polymerization is induced by a product of electrolysis not arising from the monomer molecule. Acetate ion, for example, is preferentially oxidised at platinum anode to yield $\overset{\odot}{CH_3}COO$ and/or $\overset{\odot}{CH_3}$ radicals which are capable of starting a radical polymerization. Na^+ ion is reduced at the cathode to metallic Na which initiates an anionic polymerization of styrene and other monomers. Perchlorate ions, ClO_4^-, is oxidised at the anode to produce perchlorate radicals, $\overset{\odot}{ClO_4}$, which abstract hydrogen atoms from the reaction medium to form $HClO_4$ acid—a powerful cationic initiator. It is also possible that some species, generated at the electrode, may complex with the monomer to bring about a coordination polymerization.

There are several distinct advantages of electrolytic polymerization over conventional polymerization. Some of them are described below :

(1) Electrolytic polymerization takes place at normal temperature and pressure and no expensive catalyst is needed. This technique eliminates handling of hazardous catalyst such as BF_3, R_3· Al, alkali metal, azo compounds. It lessens chemical pollutants to some extent, as the main consuming material is electricity.

(2) The polymerization rate can be easily controlled and programmed by merely proper adjustment of electric current and electrode potential. This situation is analogous to that of photoinitiated polymerization. In each instance, it is possible to control and determine the number of initiating species and their energy. In photolysis, this is determined by the number of photons absorbed by the system and by their energy. For electrolytic polymerization, it is correspondingly measured by the number of electrons transferred and by the electrode potential at which this transfer takes place.

(3) Some monomers which cannot be activated owing to lack of a sufficiently energetic initiator may be possibly activated by electrode reaction.

Although commercial utilization of electrochemical polymerization is limited at present, considerable amount of research in industrial and university laboratories is afoot. Outlook for industrial application of this technique is seemingly favourable.

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A micro-scissors for tailoring DNA

DEOXYRIBONUCLEIC acid or DNA (the material basis of heridity) is one of the most interesting and also the most complex of all biological macromolecules. Paradoxically, this complexity arises from the very simplicity of its basic subunit structures. Until recently, the isolation of specific fragments of this complex class of macromolecules was a big problem for geneticists and genetic engineers, as the methods available were non-specific in nature. But the discovery of a special type of nuclease enzyme—a restriction endonuclease—marked a revolution in the field of genetics and genetic engineering and has solved the problem.

While some enzymes are involved in the construction of some bonds (for example DNA polymerase, promoting DNA polymer synthesis), certain enzymes are specific for a particular class of bonds, say a covalent bond. The latter phenomenon is best exemplified by the enzyme deoxyribonuclease (DNase) which catalyses hydrolysis of phosphodiester bonds (a covalent bond) in DNA molecule. Such enzyme is called a nuclease and is defined as an enzyme that acts to breakdown a polynucleotide chain into its component nucleotides. The breakdown is caused in two different ways by two different types of nuclease. An exonuclease begins its attack from a free end of a polynucleotide

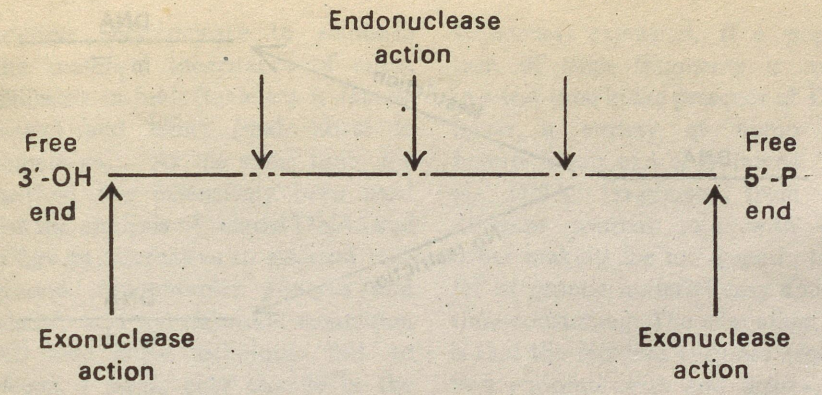

Fig. 1. Diagram shows the sites of the action of nucleases (solid lines—nucleotides and, dotted lines—sugar-phosphate bonds)

(either at a free 3'-OH end or at a free 5'-P end). An endonuclease too attacks one of the two sides of phosphodiester (3'-OH and 5'-P sides) and acts like exonuclease, but its activity is confined only to those bonds that occur within the interior of a polynucleotide chain—hence the prefix *endo* and *exo* (Fig. 1).

On the other hand, the word restriction implies that upon the uptake of a DNA molecule by a cell, the foreign DNA may survive in association with the recipient genome or it may enzymatically be degraded by a process known as restriction. So, a restriction enzyme or restriction endonuclease is an enzyme which restricts or degrades the interior phosphodiester bond (sugar-phosphate) of a foreign DNA molecule. This is the reason why a foreign DNA is not tolerated in a cell and is degraded by the restriction endonuclease of the recipient cell. The only difference between a DNase and a restriction endonuclease lies in the fact that the latter cleaves the DNA at specific sites as against the non-specific character of the former. Here, it is not out of place to describe a phenomenon known as modification, through which a DNA molecule is protected from enzymatic degradation by restriction endonuclease. The phenomenon of restriction-modification is defined as a change in the nature of the DNA mainly by methylation of its bases (purines and pyrimidines).

Occurrence

The discovery of this enzyme dates back to 1968 when Drs. Matthew Meselson and Robert Yuan of the Biological Laboratories, Harvard University, Massachusetts (USA) reported the isolation of the first restriction endonuclease from strains of *Escherichia coli*. Unfortunately, these enzymes (Class I) were not useful for geneticists and it was not until 1970 that a major breakthrough occurred when Dr. J. D. Smith and his coworkers of U.K. described the first genetically useful restriction enzyme (Class II) from *Haemophilus influenzae* serotype d. (Class I enzymes are those enzymes which recognise and cleave the DNA at two different sites, whereas Class II comprises of enzymes which recognise and cleave the DNA at the same site.)

In the intervening eight years, the number of known restriction enzymes has gone up to more than 85. Not only this, Dr. R. J. Roberts (1977) of Cold Spring Harbor Laboratory, New York, anticipates the existence of more than a thousand enzymes in different organisms. Each group of bacteria so far examined has produced at least one member from which a restriction enzyme has been isolated and of all strains so far examined, one in three contains a detectable restriction enzyme. The search for this enzyme in higher biological systems is in progress.

Nomenclature

Realizing the confusion which may arise due to the increasing number of restriction enzymes on record, Drs. H. O. Smith and D. Nathaans of Johns Hopkins University School of Medicine at Baltimore (USA) put forward a set of three rules for their nomenclature :

(1) Restriction endonuclease is identified by the first letter of the genus followed by first two letters of the source-species to form a 3-letter abbreviation written in italics. For instance, *Eco* from *E. coli*, *Hin* from *H. influenzae*, etc (see Table).

(2) Where necessary, a fourth letter is added to designate the strain or type in non-italics. For example, *Eco* B, *Eco* K, *Hin* a, *Hin* b, *Hin* c, etc. (see Table).

(3) When more than one enzyme are isolated from the same strain or type, Roman numerals follow the system name to express the plurality of enzymes, as for example, *Hin* aI, *Hin* aII, etc. (see Table).

Specificity and genetics of action

For its activity, each restriction endonuclease recognises a specific set of base sequences in DNA molecules and cleaves them at the same site or at a site a little further from the recognition site (see Table). The phenomenon of cleavage and the method to escape it (that is, restriction-modification system) is controlled by two alleles—restriction (r_i) and modification (m_i) alleles. A DNA molecule lacking an m_i allele (or m_i-) is always susceptible to degradation by a DNA moleucle

having the corresponding r_i allele (or r_i^+). On the other hand, the presence of an m_i allele (or m_i^+) modifies the chemical structure of the base sequences (within a recognition site) in such a way that the activity of the r_i^+ allele is overcome. That is, it is the modification allele which determines the fate of the DNA molecules in a recipient cell (Fig. 2). Both the alleles perform their activities by producing the respective enzymes.

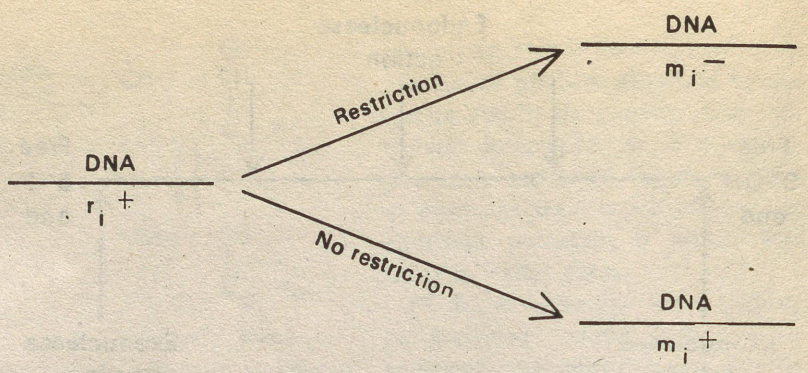

Fig. 2. Restriction modification system

Though restriction endonucleases are supposed to be efficient in cleaving the double-stranded DNA, several of them are capable of cleaving single-stranded DNA also as the secondary structure within a single-stranded DNA generates small duplex regions. The two strands of the double helix are cleaved at two different but adjacent sites, thus leaving an extension of a few base sequences in each which, on coming in contact with another strand having the same type of extension, combines to give rise to a novel genome (the so-called genetic engineering).

Uses

During the period of only eight years since the isolation of *Hin* dII, restriction enzymes have been successfully used in various genetic works, such as, preparation of physical maps of viral genomes, sequencing of DNA molecule, characterization of gene function, making new strains of micro-organisms through genetic engineering, etc. Of all these, the construction of the physical maps (to locate the position of genes on DNA) of viral and mitochondrial genomes is of prime importance for a geneticist. Mapping with the help of this class of enzyme is far easier than the conventional method. So far, twentyfour viral and plasmid genomes and four mitochondrial genomes from four different sources have been mapped. The maps of mitochondrial DNAs from yeasts, mice, monkeys and humans gave an interesting piece of result. All these DNAs are cleaved by the same enzymes (*Eco* RI and *Hin* dII), showing thereby the presence of the same set of base sequences in all cases. This study throws some light on the origin and evolution of the eukaryotic organelles (mitochondria and chloroplasts in higher forms of life) from the same prokaryotic system (lower form of life without membrane-bound nucleus and organelles).

If a search is made for a prokaryote whose DNA can be restricted by the same enzymes in the same manner, one can establish a possible progenitor of the chloroplasts and mitochondria of today. It has also been possible with the help of res-

Table 1. Sources of some restriction endonucleases, their nomenclature and recognition base sequences

Source	*Enzyme*	*Recognition sequence*
Anabaena variabilis	*Ava* I	CGA↓CCG
Arthrobacter luteus	*Alu* I	AG↓CT
Bacillus amyloliquefaciens H	*Bam* I+	G↓GATCC
B. subtilis strain N	*Bsu* NI+	GGATCC
B. subtilis strain R	*Bsu* RI	GG↓CC
Corynebacterium humiferum	*Chu* I*	AAGCTT
	Chu II×	GTP_yP_uAC
Diplococcus pneumoniae	*Dpn* I×	GATC
	Dpn II×	GATC
Escherichia coli RY13	*Eco* RI	G↓AATTC
E. coli R245	*Eco* RII	↓CCAGG
E. coli B	*Eco* B	?
E. coli K	*Eco* K	?
Haemophilus aegyptius	*Hae* I	AGG↓CCT
H. influenzae serotype b, 1076	*Hin* b III*	AAGCTT
H. influenzae serotype c, 1160	*Hin* c II×	GTP_yP_uAC
Klebsiella pneumoniae OK 8	*Kpn* I	?
Moraxella bovis	*Mbo* I	↓GATC
Streptomyces albus G	*Sal*	?
Xanthomonas malvacearum	*Xma* I	C↓CCGGG

Note: Recognition sequences are written from 5′—3′. Only one strand of the recognition sequence is given for convenience. Site of cleavage is indicated by an arrow. Enzymes marked with the same signs at the right hand top are *isoschizomers* (restriction enzymes recognizing the same recognition sequence—after R. J. Roberts, 1977).

triction endonuclease to establish the maternal inheritance of mitochondria in mule (male ass × female horse) and hinny (male horse × female ass). At the same time, the method has extensively been used for the analysis of related DNAs and offers an alternative to electron microscope heteroduplex analysis and nucleic acid hybridization technique. All these latter techniques fail to detect a single base change in the sequence, but is immediately detected by restriction endonucleases as they fail to recognise and cleave the altered sequence. It is these enzymes which have enabled geneticists to presume that one important reason for the evolution of repetitive sequences in DNA is the unequal crossing over.

Base sequencing has been made easy by making available small, well-defined pieces of DNA (less than ten nucleotides long). Sequencing with the help of restriction endonucleases is faster and easier than even RNA analysis.

Genetic engineering

By the end of the last decade, this exciting branch of biological research was set for advancement. The only tool yet to be discovered (just to give an impetus to the engineers) was a special type of micro-scissors which could cut the DNA molecule only at certain desired positions. The onset of the present decade appeared with this special class of cutter in the form of restriction endonuclease. Taking advantage of these enzymes, it is now possible to transfer DNA artificially even between the organisms which normally do not exchange their genetic materials in nature.

The speciality of these enzymes lies in the creation of fragments of DNA either with a 5'- or 3'-terminal oligonucleotide (a small fragment of DNA with a few base sequences) extension. If a population of such fragments is mixed in a test-tube in the presence of DNA ligase, a variety of homo- and hetero-dimers can be obtained. That is, DNA fragments from two different sources join with each other making the intergeneric transfer of genetic material easy and less time-consuming. The advantage here is that the required enzymes (restriction endonucleases and ligases) are commercially available and reactions are straightforward and easily monitored. This method has enabled scientists to transfer the DNA ligase and tryptophan genes of *Escherichia coli* (a human colon bacterium) to bacterial viruses and plasmid Col E1 respectively. Even rabbit β *globin* gene has been transferred by T. Maniatis and his co-workers (1976) of USA to Col E1 plasmid—a transfer between two considerably distant groups of genetic materials. Now it is possible for biological engineers to produce a wheat or a rice plant having the ability to fulfil their nitrogen demands of their own. However, this ability is supposed to be transferred from the nitrogen-fixing prokaryotes.

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Carcinogenic activity of polycyclic aromatic hydrocarbons

THOUGH the mechanism by which cancer cells form still remains unknown, the number of newly discovered carcinogens (i. e., agents which induce formation of cancer) continues to increase every day. Three general classes of carcinogens are recognised—radiations, chemicals and viruses. The history of cancer by chemical carcinogens dates back to 1915 when long term application of coaltar on the ears of rabbits was found to produce cancer. Cancer was first produced in the skin of mice by the application of a pure polycyclic aromatic hydrocarbon, 1, 2, 5, 6—dibenzanthracene (I) in 1930. Later, several hundred compounds were found to be carcinogenic, e.g., benzo(a)pyrene; 7, 12-dimethyl benz(a)anthracene; 1, 2, 5, 6-dibenz-(a)anthracene; 6-isopropyl-1, 2-benz (a) anthracene, etc. Other types of chemical carcinogens identified include various azocompounds, aromatic amines, aminostilbenes, nitrogen mustards, urethanes, various aliphatic compounds, epoxides and a few inorganic salts. A discussion on only a specific group of chemical compounds, i.e., polycyclic aromatic hydrocarbons (PAH) and their relation with carcinogenesis is presented here.

It has been suggested that a phenanthrene type bond (vi) of high order is one of the essential requirements for the carcinogenic activity of polycyclic aromatic hydrocarbons. Of course, many PAH of anthracene type (vii) have also been found to be potent carcinogenic agents.

In environment

PAH in environment is suggested to have its origin in the combustion of almost any organic material. The reaction involves carbon-hydrogen and carbon-carbon fission to yield primary radicals which further combine to produce a wide range of products. There are numerous reports about detection of PAH in air, water, soil, food and vegetation.

Aircraft and automobile exhausts are important sources of PAH. It has been reported that petrol-burning car engines produce about 330 mg of benzo(a)pyrene, a carcinogenic compound, per kg. of soot when idling. And diesel engines on full load produce 12 mg per kg. of soot.

A level of 0.2-12.2 μg of PAH has been found in the smoke of 100 cigarettes. Barbecued meat contains 2.5-11.2 μg of benzo (a)-pyrene per kg. Even the vegetarian cannot escape because similar values have been obtained for fruits and vegetables.

From these figures, we may conclude that we all are exposed to PAH, although the nature and extent of the contact is determined by where we are, what we eat, drink and smoke and in particular where we work.

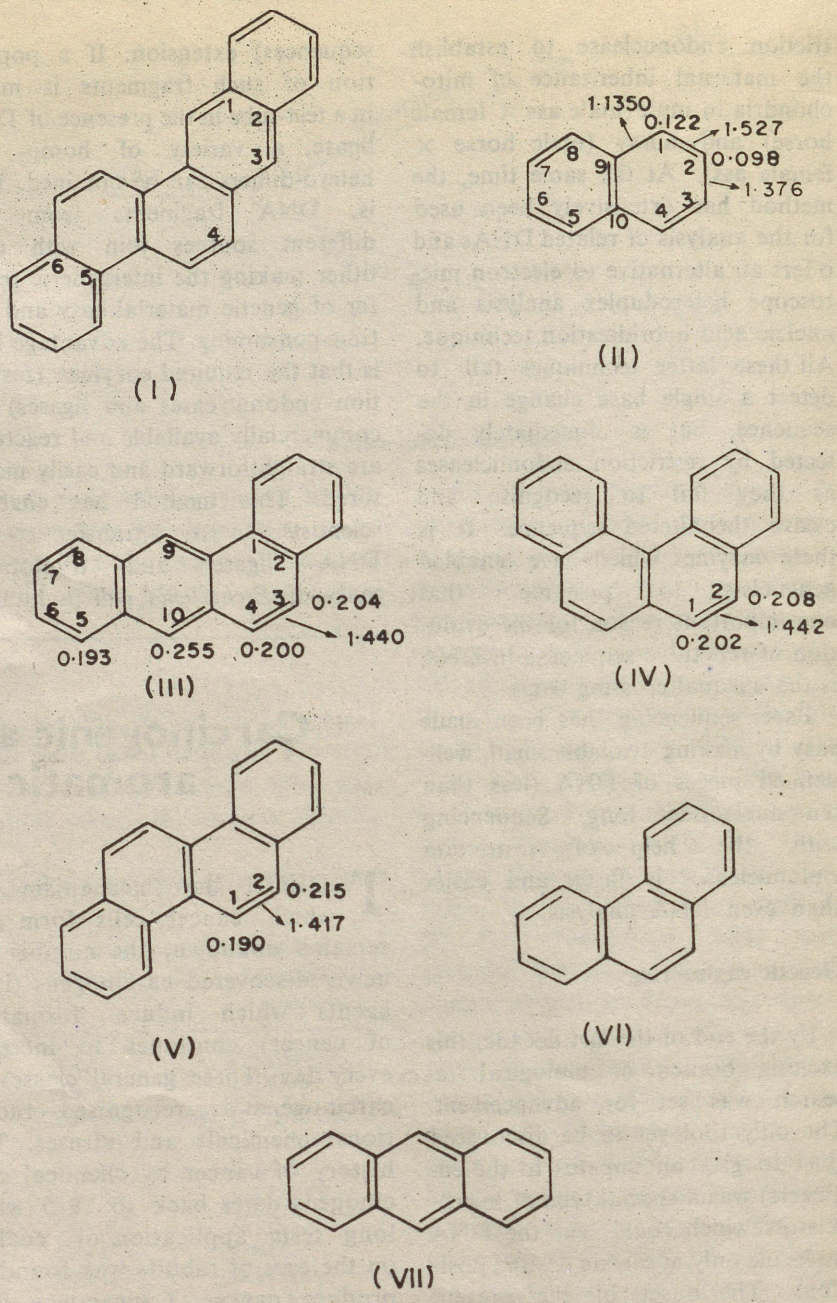

Fig. 1

Metabolic activation

It has been known for a long time that in target tissues chemical carcinogens are covalently linked with DNA, RNA and proteins of the cells. However, many chemical carcinogens, especially the PAH, do not covalently bind, when incubated in a test tube with DNA, RNA or proteins. Hence, it was suggested that these carcinogens must be activated during metabolism to a chemically reactive form which then reacts to form covalent complexes with the macromolecules (DNA, RNA and proteins).

A review of the research done so far leads to the following conclusions which are now generally accepted.
(i) Chemical carcinogens which are not chemically reactive themselves are converted into reactive forms after metabolism;
(ii) The chemically reactive form is electrophillic in nature; and
(iii) This reactive metabolite reacts with nucleophilic groups in the cellular macromolecules to initiate carcinogenesis.

These metabolic activations are performed mainly by the microsomal mixed function oxidases, which are, unfortunately, the same enzyme systems concerned with detoxification and drug metabolising functions.

Reactions with macromolecules

As mentioned earlier, PAH in tissues becomes covalently bound to DNA, RNA and proteins of cells as a result of prior metabolic activation. PAHs were also found to be bound covalently to a soluble protein fraction obtained on electrophoresis in direct proportion to their carcinogenic activity. But this protein, called h-protein, could not be detected in tumors induced by PAH. There are also other proteins found in skin and liver cells to which

PAHs are noncovalently bound. From this, it is assumed that there may be a specific cellular receptor protein which transports bound PAH to the nucleus of the cells.

The metabolic products of PAH are phenol, trans-dihydrodiol, sulphate and glutathione. The formation of a chemically reactive intermediate, expoxide, has also been proposed, but certain reactions suggest that epoxides are the metabolically activated forms of PAH. These epoxides covalently bind with DNA.

With gradual advance of civilization and consequent expansion of industry, a large number of new chemicals have been introduced into the market. They come in contact with human population either directly through use or indirectly as environmental pollutants. Undoubtedly a good number of these chemicals may have carcinogenic potentiality and hence in some advanced countries it has become customary on the part of industries to get a new chemical tested for its carcinogenic activity before introducing it into the market. These laboratory tests generally employ either bacterial system or experimental animals and the results are extrapolated to human system. But serious objections have been raised against the validity of these tests as it has been found that a carcinogen for experimental animals may be quite harmless to the human beings and *vice versa*. So except cases where a definite relationship has been established between a carcinogen and human cancer, other reports of carcinogenic activity of an agent only suggest the possibility of cancer.

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Bacterial fertilisers to increase crop yield

THE production of sufficient food for mankind is dependent upon the optimum availability of nitrogen to crops. The realisation of this fact and the steep rise in the cost of energy necessary for the production o fnitrogenous fertilisers have led scientists to intensify their research on the fixation of atmospheric nitrogen by bacteria living in special relationship with plant roots.

It is estimated that in India, about six million tonnes of nitrogen is removed from soil annually through orestry and agricultue,r but only 3.1 million tonnes of nitrogen is added—about 1.75 million tonnes as chemical fertilisers, 1.00 million tonnes through bacterial organisms present in the root nodules of leguminous plants, about 0.15 million tonnes through free-living micro-organisms present in the soil and about 0 .2 million tonnes as organic manure. Out of the total quantity of nitrogen thus reaching the soil, only an estimated 60 per cent is available for plant growth, the rest is lost through leaching and denitrification. We seem, therefore, to be all the time working with a deficient soil system, and a negative nitrogen balance. It is therefore important to find economic ways and means of bringing atmospheric nitrogen to cultivated land.

Atmospheric nitrogen gets fixed in the soil through rain water; through symbiotic bacterial organisms present in the root nodules of eguminous plants, and through free-living micro-organisms. The symbiotic and free-living micro-organisms fix nitrogen at the prevailing atmospheric temperature and pressure. Nitrogen is converted into ammonia which acts as a nutrient for a plant. This marvellous biochemical phenomenon is known as "nitrogen fixation."

The knowledge of nitrogen fixation by bacteria in association with economically important plants has been increasing rapidly. The role of about 12,000 species of legumes has been known, though not fully understood, for nearly a century. More recently, it has been observed that non-leguminous nodulating plants, of which about 150 species are known, have a similar symbiotic relationship with nitrogen fixing bacteria.

The best known nitrogen-fixing bacteria belong to the genus *Rhizobium*. They produce nodules on the roots of legumes such as peas, soyabeans, alfalfa and clover. *Rhizobium* strains, which are specific for each group of legume, invade root hairs and induce root nodules that become packed with modified forms of *Rhizobium* cells called bacteriods. In this mutualistic association, the bacteriods may add well over 500 kg. of atmospheric nitrogen to a hectare of soil annually. In the cropping pattern where a cereal crop succeeds a legume, the cereal requires 25-50 kg less nitrogenous fertiliser per hectare depending upon the richness of preceding legume crop. Since the residual effect is more pronounced in the early stages of cereal plant growth, the application of basal doses of nitrogen to the cereal can be easily avoided.

In addition to legumes, nitrogen is also fixed by a variety of free-living micro-organisms and associations. They include bacteria located in soils, in decaying wood and on the surface of plant roots; free-living blue green algae in terrestrial and marine environments; and associations of blue-green algae with

fungi, ferns, mosses, liverworts and higher plants. While nodulated legumes are the primary nitrogen-fixing plants in agriculture, most of the nitrogen for maintenance of our forests, woodlands and fresh-water and marine habitat is provided by non-leguminous nitrogen-fixing associations and free-living micro-organisms.

The non-leguminous free-living micro-organisms function either aerobically like *Azotobacter* or anaerobically like *Clostridium*. This group fixes much less nitrogen, the average in fertile soils being about 20 kg per acre annually. The use of *Azotobacter* has proved beneficial to all non-leguminous crops like wheat, jowar, bajra, maize, paddy, cotton, potato, fruit trees, tobacco, sugarcane, sunflower, sweet potato, onion, etc. Pre-treatment of seeds with strains of *Azotobacter* before sowing, soaking roots of seedlings in a suspension of this bacteria before transplanting have been found beneficial to rice, cotton and tomato crops.

Under certain conditions in tropical countries, blue green algae like *Nostoc anabaena* and *Calothrix* species contribute significant amounts of atmospheric nitrogen to the soil. These species utilize atmospheric nitrogen for their growth. When they die, the nitrogenous substance present in their cells becomes available for the growth of other micro-organisms and also higher plant species. Addition of blue green algae to rice fields has been found to enrich the soil by 40-50 kg nitrogen per hectare. A combination of blue green algae and nitrogenous fertiliser has been reported to yield significantly better results than higher doses of nitrogenous fertiliser alone.

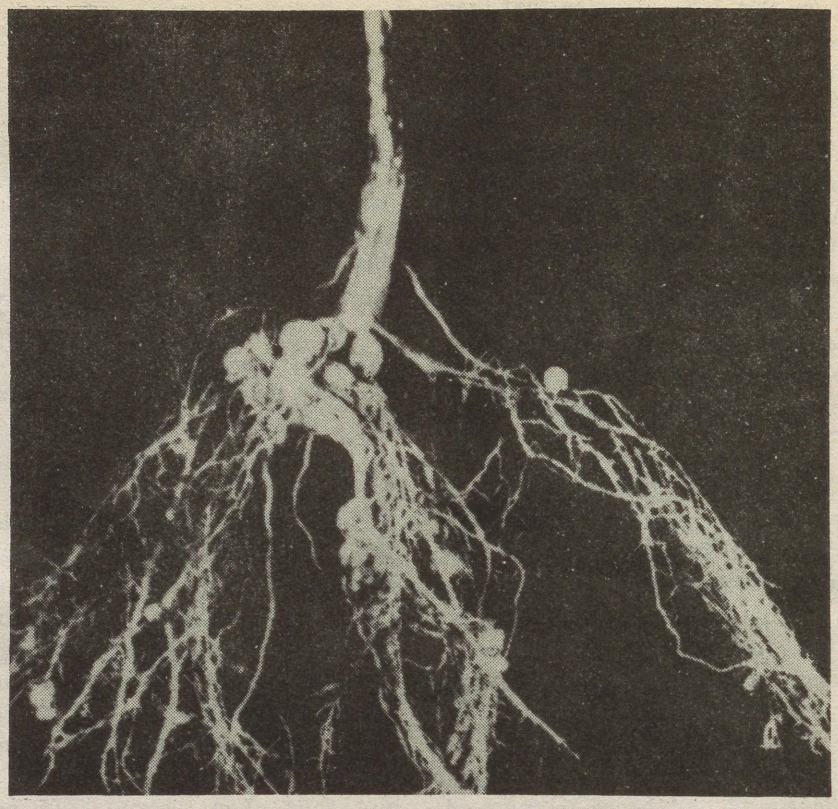

Fig. 1. Root of a leguminous plant showing nodules

UNDP project

In order to reduce a farmer's dependence on chemical fertilisers for increased crop production, a great deal of research on bacterial fertilisers is at present going on at national and international levels. Preliminary findings have revealed that rice plants and pulse varieties naturally produce about 3.5 crore tonnes of nitrogen per year—almost equivalent to the annual global output of nitrogenous fertilisers of about four crore tonnes. In certain experiments carried out at the International Rice Research Institute, Manila, rice plants were found to fix as much as 60 kg of nitrogen per hectare against the recommended dose ranging from 40kg to 60kg of nitrogen per hectare. It has also been shown that nitrogen fixation occurs best when rice fields are flooded with water. However, there is still much to know about the actual process. Scientists at IRRI are also trying to investigate the nature of these bacteria, the chemistry of the reaction they cause and whether different varieties of soils and strains of rice can increase the amount of nitrogen made available as nourishment to the plant.

Scientists are also trying to enhance nitrogen fixation in plants that have this ability and to transfer it to crops that lack it. This is done genetically. It has been recently observed that plants that do not fix nitrogen, such as corn, have a chemical regulator that can start nodules growing. Armed with this and other new insights into the mechanisms of biological nitrogen fixation, Soviet, British and American chemists have developed chemical catalysts that imitate the work of a bacterial enzyme, nitrogenase, in extracting nitrogen from the air at normal pressure and temperature.

So far, these devices have operated very inefficiently. But if they are perfected, an entirely new way of delivering cheap fertilisers to crop would emerge. The catalysts could be used right in the field, avoiding the costly manufacture and transportation of a nitrogen fertiliser.

Marketing

A landmark in the field of bacterial fertiliser research has been the production of packets of bacterial fertilisers by the Indian Agriculture Research Institute, New Delhi, and various farm universities. These organisations are mostly producing *Rhizobium* and selling it to farmers at the rate of Rs. 7.50 per hectare of land. Several small-scale producers of bacterial fertilisers have also entered this trade. There are many brands now in the market of varying qualities. In order to promote their quality and make them available to farmers at a reasonable price ,the Indian Standards Institution has set up a technical committee which is advisory in nature. It has brought out a standard specification for *Rhizobium*. The committee is now working on another specification for *Azotobacter*.

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Abscisic acid—the plant growth regulator

THE central position among the plant growth regulators must go to the hormone abscisic acid (ABA) which now ranks in importance with the auxins, gibberellins, cytokinins and ethylene as a controlling factor in physiological processes. The name "abscisin II" or "dormin" is now discarded as these compounds were later found to be structurally identical with ABA. The name abscisic acid has been accepted.

ABA—a sesquiterpene—was isolated and identified almost simultaneously by K. Ohkuma and his associates in U.S.A. (1965) and by J.W. Cornforth in England (1965). As a matter of fact three different research groups were directly concerned with ABA discovery. The first group led by H.R. Carns and F.T. Addicott with active collaboration of K. Ohkuma at the University of California, U.S.A., achieved the first isolation of ABA from cotton fruits (1963) and published the structure in 1965. The second group led by P.F. Wareing and J.W. Cornforth in England was concerned with dormancy-inducing substances in deciduous trees and isolated the active substance from *Acer* and determined that it was ABA (1965). A third research programme was initiated by the Australian scientist R.F.M. Van Stiveninck (1959) and later continued by two other Australians, K. Rothwell and R.L. Wain (1964). They investigated a fruit-abscission substance in lupins. In 1966, this substance was identified almost simultaneously in three independent laboratories by K. Koshimizu in Japan, J.W. Cornforth in England, and N.G. Porter and R.F.M. Van Stiveninck in Australia.

ABA can be obtained readily by alcoholic extraction of many plant materials. It was first isolated from young cotton fruit and the substance was found to be a $C_{15}H_{20}O_4$ acid, soluble in many organic solvents; it melts at 160°-161° C, and has an absorption maximum in methanol at 252 nm. Further research revealed that ABA is dextrorotatory (i.e., it rotates the plane of polarised light to the right) and has a (S) configuration (i.e., situated on the left side) around the asymmetric carbon atom. The naturally occurring enantiomer of abscisic acid has been shown to be (S)-(±)-ABA. Other naturally occurring substances related to ABA are (±)-2-*trans*-ABA, phaseic acid, 2-*trans*-phaseic acid, theaspirone and abscisyl glucoside. The synthetic ABA is a racemic (±) mixture (RS). Naturally occurring ABA has the *cis* configuration in the double bond nearest to the carboxyl group and *trans* configuration in the one nearest to the ring (Fig. 1).

ABA was isolated from cotton lupin, *Dioscorea*, pea, bean, cycamore, peach seed coats, *Phaseolus*, *Coleus*, walnuts, fern, grass, coconut, palm, potato, avocado, rice, apple, etc., and from plant parts like leaves, stems, buds, tubers, rhizomes, fruits of all ages, pollens, seed coats, endosperms and embryos.

Evidences suggest that ABA is synthesized through the isoprenoid pathway from mevalonic acid (also a precursor of gibberellins). Alternatively it could be formed through the oxidation of xanthophylls from violaxanthin forming xanthoxin, an epoxide derivative of ABA. The metabolism of ABA in plant gives rise to various derivatives as shown in Fig. 2.

Physiological response

The number and variety of plant responses to ABA is already so large and complex that even categorizing them is difficult. Broadly,

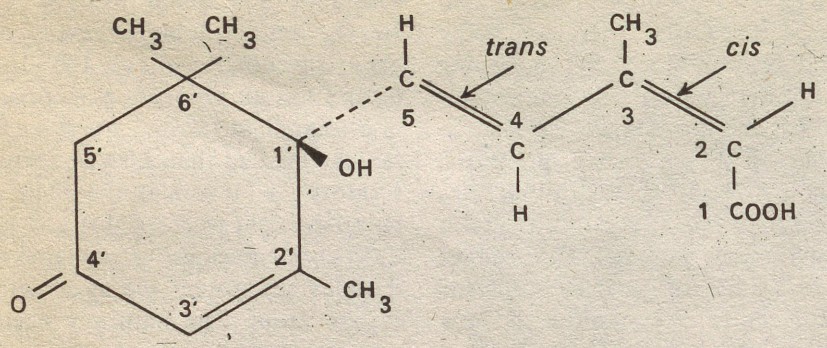

Fig. 1. Structure of (S)-ABA (3-methyl-5-(1'-hydroxy-4'-oxo-2', 6,' 6'-trimethyl-2'cyclohexane-1-yl) *cis*, *trans*-2, 4-pentadienoic acid)

their physiological responses may be divided into two groups : (i) promotion and (ii) inhibition. Experimental evidences suggest that ABA is widely distributed in plants and exerts numerous physiological effects, many of which are in opposition to the growth-promoting hormones, auxin, gibberellin, and cytokinin. Growth and developmental processes may be a resultant of a balance between growth-promoting hormones and growth-retarding hormones, such as ABA.

The abscission and senescence accelerating effect of ABA is well known. ABA accelerates loss of chlorophyll and turgour in abscising petiole stumps of explants. Senescence colour changes in leaves are a common response to foliage application of ABA. In isolated leaf discs also these responses are observed. Potato tubers treated with ABA soften and senescese. It increases carotenoids in orange, accelerates cotton fruit abscission and defruited pedicels as well as intact folliage abscission. ABA has been found to initiate and promote the growth and development of callus tissue at the abscission zone of apple and orange petiole explants. The endogenous content of ABA in cotton fruits reaches the highest levels during the period of abscission and dehiscence of fruits.

Inhibition of the growth of whole plants, excised organs, plant parts, or seeds is the most easily measured response to ABA. It inhibits growth of all parts of plants and counteracts the stimulatory effects of natural growth-promoting compounds when applied along with them. It also inhibits cultures of small aquatic plants such as *Lemna* and *Wolffia*.

In some cases ABA shows stimulatory effect too. It stimulates parthenocarpic seed development in rose, hypocotyl elongation in cucumber and promotes rooting of stem cuttings of mungbean, ivy, *Poinsettia*, and bean and lateral roots in tomato and mesocotyl growth in rice.

ABA induces seed and bud dormancy and is a potent inhibitor of seed germination. Dry storage of hazel nuts causes the development of a deeper state of dormancy (secondary dormancy) and this has been attributed to the blocking of gibberellin biosynthesis.

Inhibition of flowering of several long-day plants, following ABA sprays, has been reported. In short-day plants effects of ABA are varied. In some cases promotion of flowering during long days is observed. Short-day plants *Lemna* and *Wolffia* in induced short days showed strong inhibition of growth and flowering with ABA. Several effects of ABA on flowering of short-day plants may be explained on the basis of growth retardation responses. The concentration of ABA rises during fruit ripening and yet no role for ABA in fruit maturation other than abscission has been proposed. There is now considerable amount of evidence to suggest that ABA regulates fruit ripening, a role that is unrelated to its effect on seed dormancy.

There are many other effects of ABA on plant growth regulation. Application of ABA increases cold-hardiness in *Acer*. Chlorophyll synthesis in *Fraxinus* seedlings is inhibited by ABA. An interesting synergistic promotion of cucumber hypocotyls by ABA and $GA_4 + GA_7$ has been reported. ABA promotes the germination of spores of some pathogenic fungi. ABA treatment

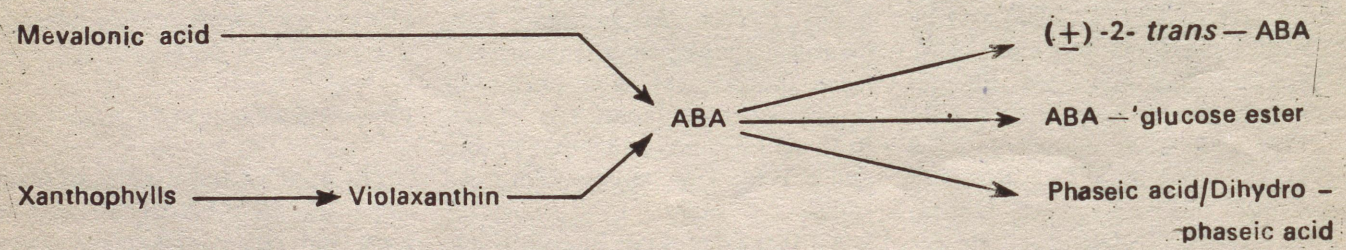

Fig. 2

inhibits nodulation in pea and runner formation in strawberry. It increases the permeability of tissue in some cases.

Biochemical response

Knowledge of the influence of ABA on the synthesis and activity of enzymes in plant is still incomplete. However, two broad roles are suggested by evidence now available. The first role involves ABA's ability to inhibit the GA-induced synthesis of hydrolyting enzymes thereby inhibiting germination of seeds. Possibly ABA's inhibitory effect on growth can also be ascribed to inhibition of hydrolytic enzymes. A second biochemcial role, whose relation to the first is as yet unclear, is the ability of ABA to promote the biochemical changes of senescence and abscission. However, the site at which ABA acts in order to bring about these biochemcial effects remains to be discovered.

Agricultural uses

The following agricultural uses of ABA can be cited : (a) induction of leaf senescence; (b) inhibition of shoot growth; (c) increased yield of plant tissue; (d) increased yield of tubers; (e) induction of flowering in short-day plants; (f) delay of flower opening; (g) stimulation of flower drop; (h) delay of sprouting of storage organs like potatoes; (i) stimulation of fruit ripening; and (j) delay of germination. Two factors make the agricultural value of ABA uncertain: (1) its rapid metabolism in plants, and (2) its high cost of synthesis.

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Why are most plants hermaphrodites?

AMONG flowering plants there are three well established and stable sex types: dioecious, monoecious and hermaphrodites. A species is dioecious when the male (staminate) and female (pistillate) flowers occur in separate individuals. When both male (stamen) and female (pistil) sex organs are present on the same plant the species is bisexual. Bisexual species may be monoecious when the male and the female sexes are separated into different flowers on the same plant, or, hermaphrodite when the two sexes (both stamen and pistil) are organized in a single flower. Therefore, in dioecious and monoecious plants flowers are either male or female (unisexual) while in hermaphroditic plants flowers are bisexual (Fig. 1).

In the plant kingdom, most higher plants are hermaphrodites, while a few plants are monoecious and only 2%—3% of flowering plants are distinctly male and female (dioecious) types. In the British flora, about 92% of all species of flowering plants are found to be completely hermaphrodite, while only 5.4% are entirely monoecious and only 2% are dioecious (Fig. 2). In the Indian flora, 79.42% of all species are completely hermaphrodite, 13.86% are completely monoecious and only 6.72% are completely dioecious (Fig. 2).

In contrast to the plant kingdom, separation of the two sexes in different individuals is almost a rule in the animal kingdom. Most higher animals are easily identified as male and female types. Only some of the lower animals are hermaphrodites. It appears from comparision between plants and animals that, unlike in animals, separation of sexes is relatively of minor importance in plants.

Why, then, most higher plants are hermaphrodite while most animals are dioecious? Nature must have played a hidden role during natural selection that led to the establishment of the dominance of hermaphroditism in higher plants and dioecism in higher animals. Dr. E.C. Charnov and Dr. J. J. Bull (1976) of the University of Utah, U.S.A. and Dr. J. M. Smith (1976) of the University of Sussex, U.K., have suggested that low mobility and low resource overlap are the main reasons why most higher plants are hermaphrodite.

In animals, hermaphroditism occurs in species with low adult mobility. Low mobility is associated with little sexual dimorphism (separation of sexes) because in that case union of male and female individuals for sexual reproduction is difficult for lack of locomotory structures. When an animal species is hermaphrodite, a single individual can effectively serve both the functions. Furthermore, low mobility limits the male reproductive success—the number of eggs that a male can competitively fertilize should rise at about a linear rate with the resource (nutrients and energy) input into male function. Dimorphism of sex is dominant in animals which are mobile and have locomotory structures for seeking out and holding females. Hermaphroditism in animals tends to occur in immobile species.

In higher plants, which are immobile and depend on natural agents for fertilization, hermaphorditism increases male reproductive success.

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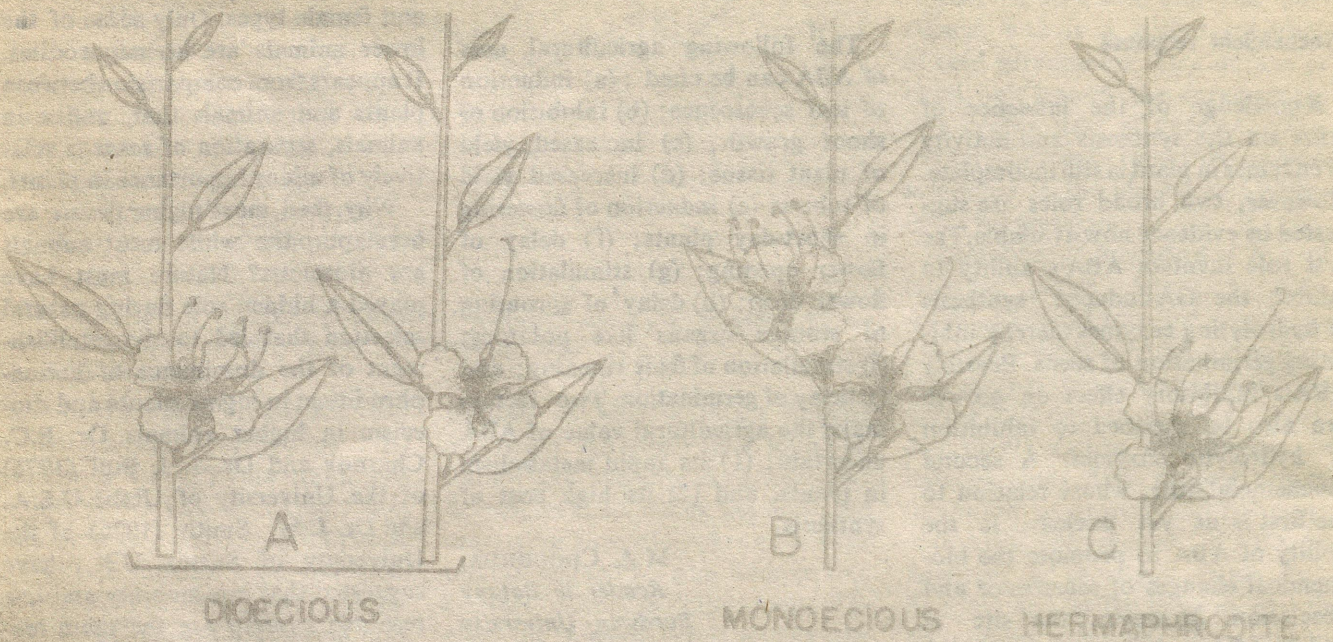

Fig. 1. Diagrammatic representation of the three stable sex forms among flowering plants

Reproductive success of a species increases when male and female reproductive structures are aggregated into a single flower rather than when they are wide apart.

Low resource overlap and cost sharing

In flowering plants, production of pollen grains occurs much before ovule maturation. Therefore, utilization of plant's resources (photosynthates, inorganic nutrients and energy) for the production of pollen grains and maturation of ovules are different. As the utilization of resources for these processes do not overlap, hermaphroditism possesses some difficulty. Moreover, in insect-pollinated plants, some resources must be expended on production of organs of attraction (coloured petals, nectar, scented substances) to attract insects for pollination. In such cases, therefore, a plant's reproductive success will tend to be limited by its ability to attract pollinators but not by the input of resources into gametes. In dioecious and monoecious plants, number of male flowers should greatly exceed number of female flowers so that all eggs have a fair chance to be fertilized. In these cases the reproductive success of a species will be low in terms of total resource utilization for producing reproductive structures. In a hermaphroditic species, utilization of resources for the production or organs of attraction is minimized per egg, more of the resources is utilized in gamete formation. Reproductive success of the species is high in terms of the total resource utilization in reproductive structures and the number of eggs successfully fertilized. It suggests that dioecism should be rarer in insect-pollinated species than in wind and water-pollinated species.

P.C. Charnov and his group (1976) of the University of Utah, U.S.A., do not claim that the selective forces associated with resource allocation are the only ones relevant to the evolution of hermaphroditism. Self-fertilization results in weak offsprings and nature does not intend self-fertilization to occur. One may consider therefore that in plants dioecism has evolved as a mechanism to prevent self-fertilization. This, together with the fact that dioecious species are fewer in number and have had a fairly recent origin from hermaphroditic or monoecious forms, should not lead one to conclude that the present day evolutionary trend is towards dioecy. In fact, dioecism involves a large wastage of reproductive potential and this may be looked upon as a short-lived evolutionary outcome of outbreeding [illegible] of a plant to fertilize [illegible]

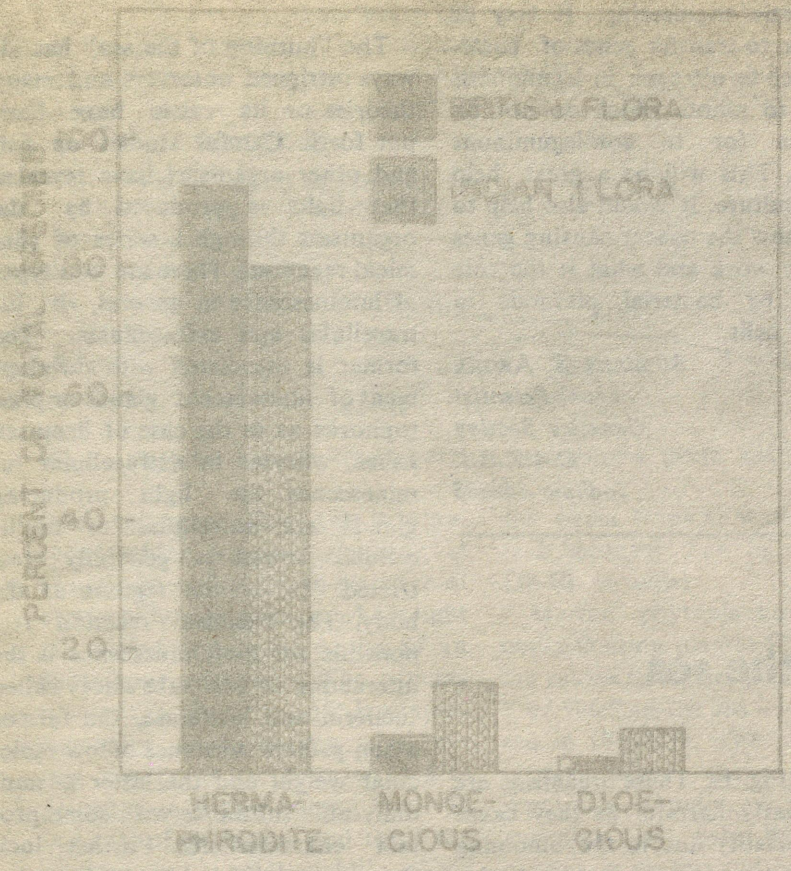

Fig. 2. Distribution of the three stable sex forms among British and Indian flora

egg of the same plant) are far more efficient in controlling the overall breeding behavior of flowering plants. Prof. R. P. Roy of Patna University (1974) suggested that hermaphroditism associated with occasional self-incompatibility has a far better chance of survival and success than dioecism.

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Cause of the crown gall

GALLS and tumours are outgrowths of plants. They often appear as irregularly rounded structures attached to the infected organs. Wounded plant parts are often found to be more susceptible to gall growth. It has been observed that susceptibility of the wounded plant parts is high in the first 2-3 days and reduces when the normal healing process of plant parts becomes active. Gall vary in size, from soft swelling outgrowth of only a few centimeters to large woody structure of several centimeters. Galls can be caused by fungi, viruses, bacteria and insects. When it is caused by a bacterium, specifically, *Agrobacterium tumefaciens* (a [illegible] simple, typically motile, [illegible] ed organism with [illegible] acid (DNA) as its genetic [illegible] on roots or stems, it is known as crown gall.

Crown gall was first noticed on grapes in Europe in 1853, and the organism was first isolated in 1904 in the United States from galls on a plant named Paris daisy. Crown gall has been studied extensively. *Agrobacterium tumefaciens* converts normal plant cells into tumour or gall cells which afterwards become more or less independent so far as their growth and multiplication are concerned. In other words, they become independent and uncontrolled. It has been suggested that the uncontrolled growth of the gall cells is due to the production of abnormally high concentration of a growth-promoting hormone, the auxin (indoleacetic acid, IAA) induced by the gall-causing bacteria.

It has now been proved by Mary-Dell Chilton and his colleagues at the University of Washington, USA, that *Agrobacterium tumefaciens* causes crown gall only when it has another small DNA or plasmid (very small, independently and self-reproducing bits of circular DNA) in it. This small DNA of plasmid is independent of the DNA of the host bacterium. If the bacterium is made free of its "cured" of its plasmids with the help of certain organic acridine dyes, such as acridine orange, it no longer causes gall in plants. It clearly shows that there is something in the tiny DNA of the plasmid, and not in the DNA of the bacteria, which transforms the normal plant cells into the autonomously growing gall cells.

This means that the bacterium acts only as a carrier of the potential gall-causing agent, the plasmid. Chilton and his associates have proved by a refined experiment that the part of plasmid DNA (also

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known as gene) that causes crown gall in the plants gets integrated into the DNA of the host cells. The facts now revealed are new in respect of plants but not in case of animals. The viruses which cause tumours in animals have already been proved to transform animal cells by integrating with them. It is called proto-virus theory of cancer—the cancer-causing gene of a virus inserts itself into the DNA of the host cell to direct that cell to multiply uncontrolled.

The findings of Chilton, if they could be supported further by more experiments, would have far reaching implications and would be a support to genetic engineering. It may be possible to transfer genes of bacteria which fix nitrogen in leguminous plants to plants which do not fix nitrogen (or to non-leguminous plants). This will be a great help in agriculture. It would also help to know how the cancer-causing genes actually work and what is the role played by bacterial plasmids in animal cells.

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Living lights in the sea

SOME marine animals display an outstanding characteristic in radiating light from their body, a phenomenon strictly connected with physiological activity. This interesting feature of these animals is called "cold light" or "living light" in the sea. There are about 600 known marine luminescent organisms, mainly distributed with groups such as protozoans, coelentrates, polychaetes, molluscs, crustaceans and fishes. Many marine bacteria also luminesce and an abundance of these may cause luminescence particularly on dead and the living bodies of other organisms, and at times luminesce other non-luminescent planktonic forms. The colour of different luminous organisms can be distinguished as reddish, yellow, green or violet.

Among protozoans, the marine dinoflagellates, *Noctiluca*, *Ceratium*, *Gonyaulax* and *Gymnodinium* are common luminescent organisms and are abundantly found in the plankton (drifting and floating organisms in the sea) collected during nights (Fig. 1). These organisms are particularly harmful as they cause fish mortality due to the blooming conditions and also due to the toxins which they liberate.

Physiology of luminescence

The "burning of the sea" has always intrigued observers and many theories on its cause have been put forth. Careful studies on fish and other organisms have revealed that light is produced by the organisms through a series of chemical reactions. There are two types of luminescence in general, *viz.*, intracellular and extracellular. The former is associated with development of luminescent glands or photophores as in the case of deep-sea fishes, whereas in extracellular luminescence the light producing glands are unicellular or multicellular structures generally restricted to definite regions of the body. The chemical reaction responsible for bioluminescence is the interaction of two substances called luciferin and luciferase, the former a non-protein substance of low molecular weight and the latter a non-dialysable substance with some protein characteristics. Further, luciferin is a relatively heat-stable substance, whereas luciferase is a heat

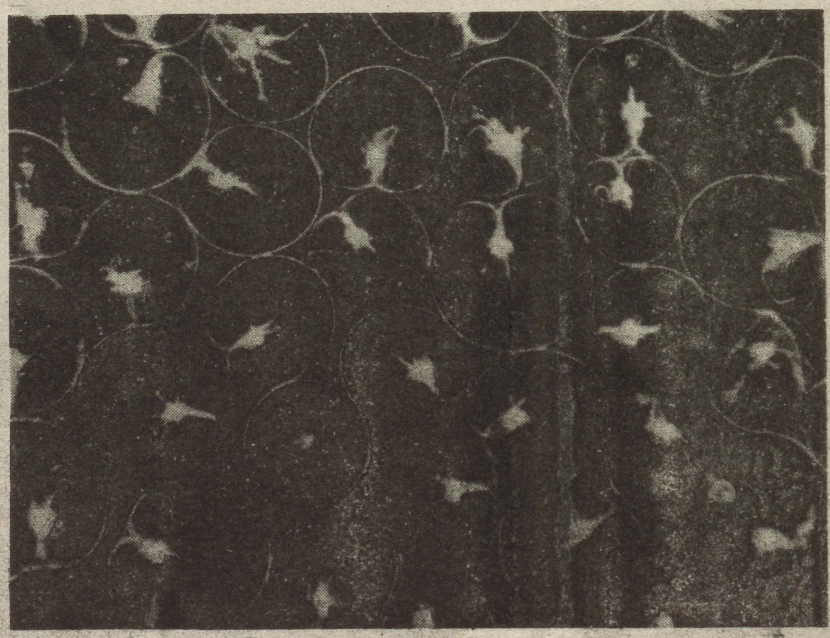

Fig. 1. *Noctiluca scintillans*, commonest source of luminescence in the sea (After Douglas P. Wilson)

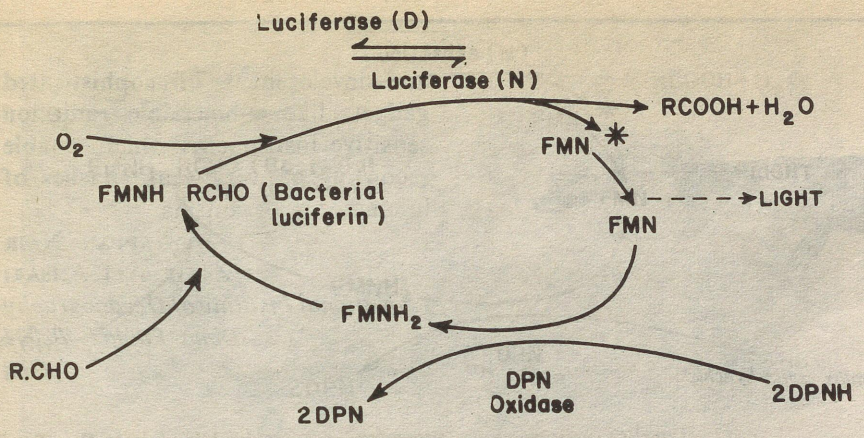

Fig. 2. Bacterial bioluminescence: schematic representation (Nicol, 1962)

labile substance. These two substances combine together resulting in luminiscence. This is an instance of chemical luminiscence in which light is emitted during the course of an exothermic reaction. The process involves a molecule of luminous substance, luciferin, acquiring excess energy as an electron is displaced to a higher energy level. It is a case of oxidation and the light emitted is "cold light" where the radiant energy is confined to the visible spectrum (400nm-700nm). Marine bacteria luminesce due to the presence of bacterial luciferase containing a florin group, and luciferin, an aldehyde complex of dihydroflorin mononucleotide. When this aldehyde in aqueous solution is mixed with an extract of bacterial luciferase in the presence of molecular oxygen, a flash of light is emitted (Fig 2).

Response due to stimulation

Light flashes of luminiscent organisms in the sea are under control of their nervous system and are emitted generally when the animal is disturbed. Intervals of intracellular flashes range in duration from a fraction of a second to prolonged glows lasting several minutes. The planktonic forms can be seen stimulated by breaking of waves, movement of boats and while operating fishing gear. Stimulation response in the warm tropical waters is faster (1-2 seconds) than in cold waters (30-60 seconds).

Marine phytoplankton (microscopic floating plants) like *Gonyaulax* causes red-water phenomenon or "red tide" in the sea and luminesce red in the dark. The phenomenon occurs when these organisms reproduce rapidly. It can cause mortality of fish by depleting oxygen in water and also by releasing toxins. A litre of sea water during the phenomenon may contain as much as 70 million cells.

Location of light organs

Light organs occur in a variety of locations such as (a) in the skin, (b) on the ventral musculature, (c) and within the abdomen. They are sometimes distributed all over the surface of the body as in *Idiacanthus* or in large numbers scattered over lower surfaces of the body as in *Etmopterus*. The photophores are arranged in rows on the lower surface of the head and trunk in *Cyclothone* and lies beneath the eyes in *Neoscopelus*. Luminous glands are found on the lower jaw of *Monocentris* and as a ring surrounding the oesophagus in *Gazza* (Fig. 3A, B, C).

Luminiscent clouds are ejected from the ventral photophores of the hatchet fish *Argyropelecus affinis* (Fig. 4) for countershading and blinding potential predators as in the case of squid *Heteroteuthis*. The photophores of *Argyropelecus* comprise a series of ventrally directed tubes which cause light generated in canals connected dorsally to tubes to shine downwards. Tissue pieces located in the tubes serve as colour filters to give a peak trans-

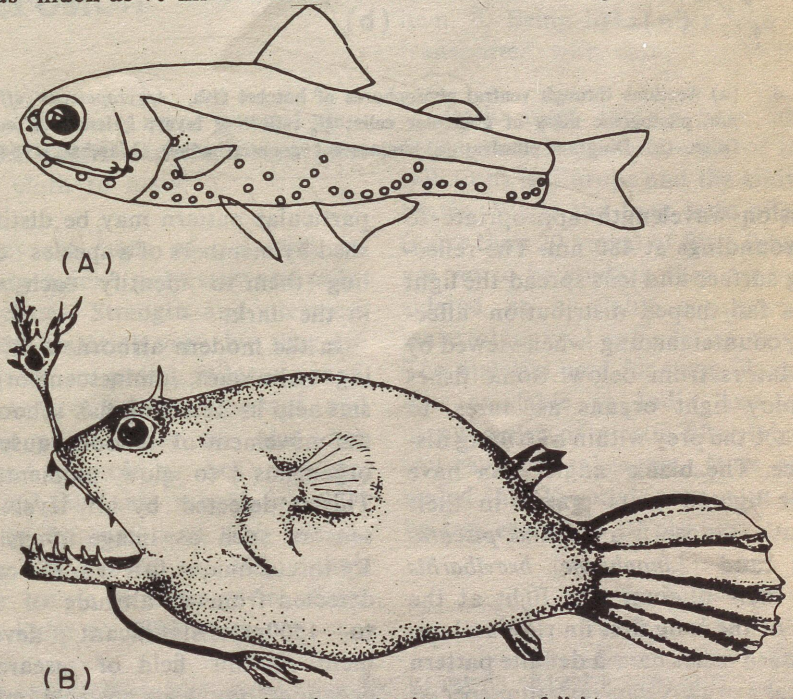

Fig. 3. (A) Lantern fish, *Diaphus theta*, showing pattern of light organs
(B) Angler fish, *Linophryne brevibarbis*, showing ilicium as lure

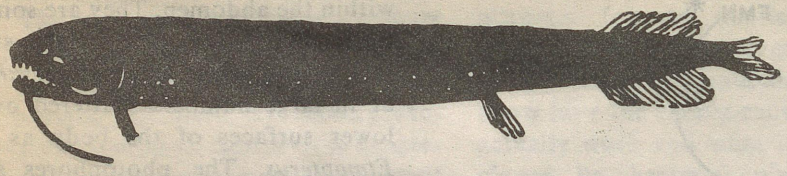

Fig. 3. (C) *Melanostomias spilorhynchus*

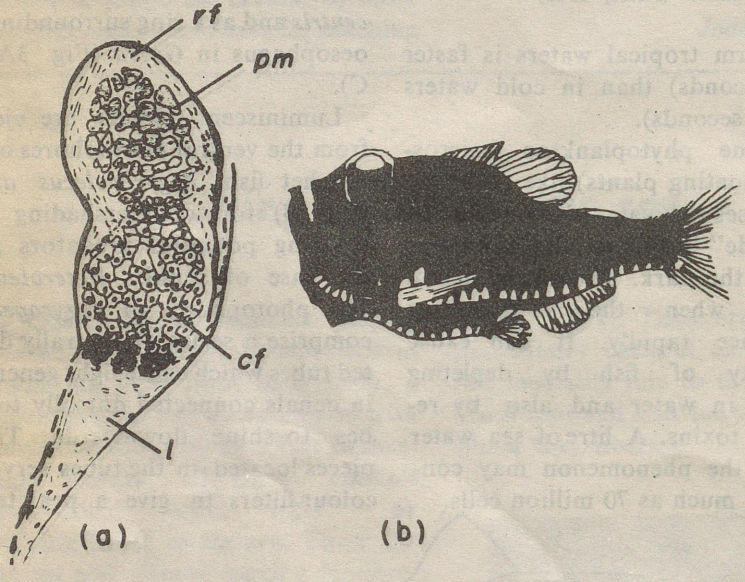

Fig. 4. (a) Sections through ventral photophores of hatchet fish, *Argyropelecus affinis; pm*, photogenic mass of glandular cells; *rf*, reflecting layer; *l*, lens; *cf*, colour filter. (b) Diagram illustrating luminescent countershading (Marshall 1954)

mission wavelength appropriate to surroundings at 480 nm. The reflecting surface and lens spread the light in a fan-shaped distribution affecting countershading when viewed by predators from below. Some fishes employ light organs as lures to attract the prey within a striking distance. The black angler fish have their lighted baits placed in their mouth. Goose fish *Lophius piscatorius* and *Linophryne brevibarbis* use their illicium (the light at the end of the long first fin ray) as lure. Lantern fishes have a definite pattern of light organs varying from species to species and it is possible that a particular pattern may be distinguished by members of a species enabling them to identify each other in the dark.

In the modern airborne fish finding techniques, luminescent organisms help in detecting fish schools as the movement of schools causes the organisms to glow momentarily. This is detected by low-level light sensors such as image intensifiers. By this technique fish schools can be detected from an altitude of 150m to 1500m. Significant development in this field of research in oceanography was possible only in the last two decades following use the and development of sophisticated gadgets like submersible radiation sensitive instruments which enable recording of very weak flashes of luminescent organisms.

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Abnormal genital papilla in fresh water snail *Pila globosa*

THE popularly known apples nail (*Pila*) is the largest known freshwater mollusc. It has a specialised pulmonary sac in addition to functional ctenidium (gill) making them amphibious in habit.

Pila is dioecious (unisexual, the male and female sexual reproductive organs are borne on different individuals) with a distinct secondary sexual character. Shells of male individuals are smaller than those of the females because the body whorl of the shell is less swollen. In additon, there is well developed copulatory organ in the male but it is rudimentary in the female. For routine practical classes, hundreds of pila were dissected and one was found with the abnormal presence of the genital papilla.

Baini Prashad (*The Ind. Zoo. Mem. IV*, page 73-78, 1932.) had mentioned the presence of a single penis (genital papilla) which is simple, slightly curved flagellar structure, as seen in the given photograph (A-straight arrow). This is a feature common to all individuals. The author found one pila with two

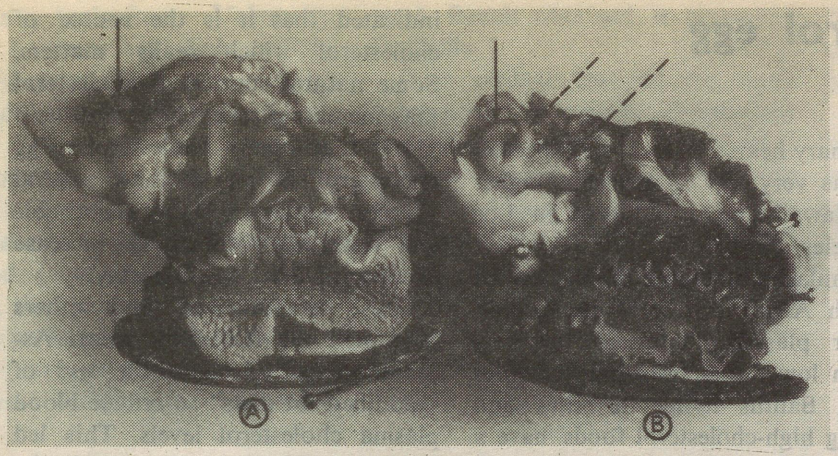

Fig. 1. *Pila globosa*

additional genital papilla (B-dotted arrow) alongwith the penis. Each was swollen at its point of attachment but gradually tapering off at the free end. A deep groove ran all along their inner margins.

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Plastic filter fabrics to prevent soil erosion

IN constructing a shore protection structure, engineers normally place rivetments in the form of large rocks called 'rip rap' on top of the eroding soil. Granular filters are usually put between the 'rip rap' and the soil to prevent the washing away of the soil. These filters allow water to pass in and out while retaining soil particles behind it.

The usual type of granular filter consists of successive layers of graded sand, gravel and stone. These are costly and if not constructed properly leads to the failure of rivetment. The plastic filter fabric was first introduced in 1958 as an alternative to granular filter. It is made by weaving or felting polymer fibr[illegible] abrasion resistance they take even large stones, weighing upto 1 tonne. The permeability rating of filters are very high (4.8×10^{-2} cm/s). Filter fabrics are usually manufactured in varying lengths (28m -370 m) and widths (1.8m-27 m) and are delivered in rolls. They are laid by just unrolling the rolls before laying the rip rap. Joining is done by overlapping or by pinning with special fibreglass securing staples into the ground.

There are several advantages of plastic filters over the commonly used granular filters. They are : 1. The filtering ability is factory controlled and cannot be altered due to careless placement. 2. It is the only type of filter that has an independent tensile strength. 3. Quick, visual inspection assures the engineer that the filter is in place, as designed when the structural materials are placed upon them. 4. It permits greater opportunity for consistency in filter design. 5. Geographic location and availability of materials (gravel and sand) are eliminated as economic considerations in the design of the filter sys-item. 6. Being light they can be transported with ease.

ments. There are many types of plastic filter fabrics ranging from woven filter cloth to mats.

They are made of polymers including nylons, polyesters and polypropylenes. Strength and intertness of these materials vary, but they are generally rot-proof, mildew proof, salt water-proof, insect-proof and rodent proof. They are also not affected by cold or hot weather. Fabrics' thickness ranges from 0.4 mm to 0.6 mm and their weight from 250 gm/m² to 400 gm/m². Their tensile strength varies from 3500 kg/m to 6800 kg/m.

Plastic filter fabrics have been used already in thousands of installations in Europe and the United States. While the long term effects (more than 20 years) of filter fabrics are yet to be studied, they are considered as a viable construction material for civil engineering works. The material used for these filters is now available in India and the manufacture of plastic filter fabrics can easily be taken up. It is estimated that the savings in cost will be between 15 to 20 per cent.

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Low-cholesterol egg

CHOLESTEROL has been accused of causing atherosclerosis and in turn ischemic heart disease ever since experimental atherosclerosis was inducted in rabbits by feeding them large amounts of cholesterol. Although the cause and effect relationship between cholesterol and coronary diseases is not yet established, there are evidences to suggest that it is one of the high risk factors if its plasma level is more than 230 mg per cent. Scientists, therefore, want to know how to lower plasma cholesterol in man. Manipulation of diet is one of the possibilities. It has been observed that Japanese men between the ages of 40 and 49, all with common ancestry but presently living in three different environments—Kyushu, Hawaii and Los Angeles—had different levels of plasma cholesterol and coronary heart diseases. As expected, it was very low in Kyushu, higher in Hawaii and still higher in Los Angeles.

Similarly, the diet of Bantus of South Africa is low in cholesterol. Their plasma cholesterol level is much lower than westerners. Moreover, Bantus living in cities and eating high-cholesterol foods have a high plasma cholesterol concentration.

In contrast, there are studies by A. Keys (1956) of University of Minnesota, U.S.A. which indicate that dietary cholesterol is of little importance because fairly large doses of cholesterol produced only a little change in plasma level. However, later studies by A. Keys *et al.* (1965) and D. M. Hegested *et al.* (1965) of Deptt. of Nutrition, Harvard School of Public Health, Boston, U.S.A. indicated that it is the source of cholesterol which really matters. Some natural sources of cholesterol may increase plasma cholesterol level more than pure cholesterol. Egg cholesterol is one of those natural sources which are highly absorbable and have been shown to increase cholesterol level considerably.

These observations and others prompted the American Heart Association to advocate the use of "modified fat diets" to reduce blood plasma cholesterol levels. This led to the modification of egg yolk fat in favour of unsaturated fatty-acids. But modified eggs high in polyunsaturated fatty-acids had no advantage over the ordinary eggs in their ability to lower blood cholesterol in rabbits, according to H. B. Brown and I. H. Page of Div. of Research, Cleveland Clinic, USA (1965)

An equally plausible approach is to lower the egg cholesterol level. An attempt has been made at the

Table 1. Effect of feeding certain compounds to laying hens[1] on egg cholesterol[2]

Compound	Level in feed (%)	Egg choclesterol				
		Pre-experimental	During experiment		Post-experimental	
		(mg/100g yolk)	(mg/100g yolk)	Decrease (%)	(mg/100g yolk)	Decrease (—) or Increase (+) for Exptl. period
Nicotinic acid	0.05	1730	1238	28.5	1335	+7.8
	0.1	1850	1268	31.4	1280	+0.9
	0.15	1813	1198	33.9	1310	+9.3
Sarpagandha powder	0.1	1838	1150	37.4	1048	—8.8
	0.2	1927	1082	43.8	1134	+4.8
	0.3	1598	1256	21.4	1020	—18.7
Garlic powder	1.0	1608	1063	33.8	1043	—1.8
	2.0	1355	1072	20.8	1097	+2.3
	3.0	1482	1072	27.6	1190	+11.0

1. Six birds were kept on each treatment.
2. Egg cholesterol was analyzed on pool samples of 5 eggs from each bird using Pearson's method at 625 m. wavelength.

Haryana Agriculture University, Hissar, to lower egg cholesterol by feeding certain cholesterol reducing substances to laying hens. Garlic dowder (*Allium sativum*), Sarpagandha powder (*Rauwolfia serpentina*) and nicotinic acid were fed, each at three levels, to laying hens. Eggs obtained from these hens before feeding the compounds, during the feeding period and after withdrawal period (each of three weeks duration) were analysed for egg cholesterol. Result obtained is presented in Table 1.

It is evident that all the three substances are capable of reducing egg cholesterol level. The lowest doses of these compounds were enough to cause a reduction in egg cholesterol level. After withdrawal of the extra amount of nicotinic acid from the feed, cholesterol level tended to increase but no consistent effect was observed when Sarpagandha and garlic feeding was discontinued. It appeared that the effect of Sarpagandha was more lasting.

From this study, it was concluded that garlic powder can be fed to laying hens for producing low cholesterol eggs without having any adverse effect on egg production and other traits.

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PLANT RESPIRATION (*Continued from page 453*)

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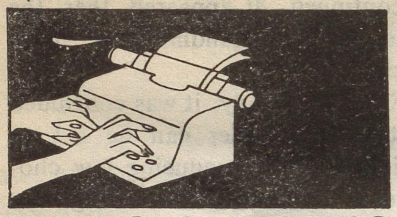
1. **STRUCTURES** *by* J. E. Gordon, *Penguin Books*, Representative in India: *Penguin Overseas*, 706 Eros Apts, 56, Nehru Place, New Delhi-24, Pp. 395, £ 1.75.
2. **CYTOLOGY** *by* P. S. Verma and V. K. Agarwal, *S. Chand & Company Ltd.*, Ram Nagar, New Delhi-110055, Pp. 495, Rs. 15.
3. **PRINCIPLES OF REACTION MECHANISM IN INORGANIC CHEMISTRY** *by* V. S. Parmar and H. M. Chawla, *Sultan Chand & Sons*, 4792/23, Daryaganj, New Delhi-110002.
4. **CIVIL ENGINEERING MATERIALS** *by* N. Jackson *E.L. B.S.*, British Council Division, 21, Jor Bagh, New Delhi-110003, P. 338, £ 2.45.
5. **GENERAL MICROBIOLOGY** *by* R. Y. Stanier, M. Doudoroff and E. A. Adelberg, *Macmillan Co. of India*, 2/10, Ansari Nagar, Daryaganj, New Delhi-110002, Pp. 873, Rs 25.50.
6. **NATURE, MOTHER OF INVENTION** *by* F. R. Paturi, *Penguins* (address as above) Pp. 159, 90p.
7. **PLANT and PLANET** *by* A. Huxley, *Penguins* (address as above), Pp. 463, £ 1.25.
8. **NEWER USES OF MATHEMATICS** *by* James Lighthill *Penguins*, (address as above), Pp. 431, £ 2.25.



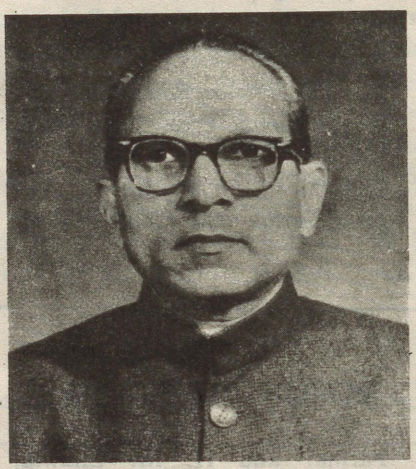
NEWS & NOTES

M. G. Krishna passes away

DEATH occurred in Hyderabad on June 5, 1978 of Dr. M. G. Krishna, Director, Central Fuel Research Institute Dhanbad. He was 55.

Early in life, Dr. Krishna had distinguished himself as a brilliant chemist and earned his Ph.D. from Leeds University in chemical engineering. He had spent most of his research years in the CSIR, starting his career at Regional Research Laboratory, Hyderabad. He became Deputy Director, Indian Institute of Petroleum, Dehra Dun in 1962 and later became its Director. At the IIP he made his mark by his vast studies on the processing and marketing of petroleum, petroleum products and petrochemicals. As Director of CFRI since June 1974, Dr. Krishna was engaged in further utilizing his vast experiences on coal utilization for chemical as well as energy uses. The nation was looking forward to his lead in the important field of energy. His death could not come at a more inappropriate period.

As a person, Dr. Krishna was an embodiment of fine culture and breeding and effused affection to all who came in contact with him. He was accessible to all—to his senior as well as junior colleagues, and was never too busy to listen to their problems and grievances.



M.G. Krishna

Many will remember Dr. Krishna as an admirable host, and for his open-hearted hospitability. In his death, India has lost an outstanding energy scientist.

Late Prof. Parija

PROFESSOR Pranakrushna Parija, M.A. (Cantab), D.Sc., F.N.A., the internationally famed botanist, passed away on June 2, 1978 at his residence at Parijatak, Cuttack. He was 88 years old.

Born on April 1, 1891 in a small village called Ichhapur in the district of Cuttack, Parija had a brilliant academic career. After completing his studies at Ravenshaw College, Cuttack, and Presidency College, Calcutta, he went to United Kingdom in 1914 on a Government scholarship and studied at the Christ College of Cambridge University. nist. In 1918, he was awarded the Frank Smart Fellowship to start his research career under the guidance of Professor F. F. Blackman, F.R.S., an eminent plant physiologist of Cambridge University. Two years later, he was employed by the Government of United Kingdom to work on the problem of fruit preservation.

Returning to India in 1921, Parija joined Ravenshaw College as Professor of Botany in Indian Education Service. He distinguished himself as a teacher and research worker. He retired as Vice-Chancellor of Utkal University. He was also the Pro-Vice-Chancellor of Banaras Hindu University for some time. He worked as member and chairman of several advisory committees of the Central and State Government and was elected to the Orissa Legislative Assembly from Balikuda constituency in 1952 general election as an independent candidate.

Professor Parija contributed a great deal to the progress of botany. While in U.K. he conducted some basic experiments on respiration of stored apples with Professor F.F. Blackman. His findings were later known as 'oxidative anabolism'. He made a survey of the algal flora of Chilka lake and the blue-green algal flora of the soils of Cuttack. He was General President of Indian Science Congress Association at the Bombay session in January 1960, and was elected Vice-President of the 10th International Botanical Congress in Edinburgh in August 1964. He was a Fellow of the Indian National Science Academy.

Professor Parija wrote to his sons and daughter in May 23, 1978, "I have always believed in simplicity. Therefore I request that on my death there should be no observance of

the ritual customs. A simple prayer and Kriya ceremony may be arranged. Any money that would have been sepnt on ritual ceremonies should be donated for the study and scholarship for needy students or to the University." This shows Professor Parija's love and affection for poor students.

DINABANDHU MISHRA
MANORANJAN KAR

Symposium and workshop on biomedical engineering

IN the last fifty years, tremendous progress has been made in almost every field of science: be it life sciences, medicine or engineering. So far, medical and paramedical men alone were left to combat health and hygiene problems of the masses. These problems are graver in developing countries where medical delivery facility is influenced by population and poverty and where health care facilities are not evenly distributed. Rural areas are the worst sufferers since the greater majority of the population lives there. Inspite of rapid strides made in almost every field, medical facilities have remained inadequate and many problems have remained unsolved. To ameliorate the lot of the common man, workers in life sciences, medicine and engineering are now pooling their efforts. A glimpse of these efforts could be had at the international symposium and workshop on bioengineering held in New Delhi. The six-day symposium and workshop in February, 1978 was attended by about two hundred participants from all over the world.

Physically handicapped have for centuries been symbolised by those disabled by orthopaedic defects. But the character of crippling deformities has been changing. The various rehabilitation schemes emphasise a person's residual capabilities and not his handicap. The aim is to make an individual adequate in all respects. "Will it be possible for us to work together so that eventually the individual with a physical disability achieves his maximum capacity?" This question was posed by W.G. Rama Rao of All India Institute of Physical Medicine and Rehabilitaion, Bombay.

P. Suhel and K. Kralj (Yugoslavia) presented a paper on stimulation of closing muscle of human urinary tract by applying radio frequency electric stimulator.

Population explosion is one of the serious problems faced by many countries today. Perhaps due to this reason, there were quite a few papers on birth control. E.S.E. Hafez from U.S.A. outlined a treatment of testes with ultrasonic waves or ionizing radiations thereby disrupting spermatogenesis. The spermatozoa are known to carry negative charge and they die in d.c. electric field. An analysis of various factors responsible for killing spermatozoa was reported by Sudha *et al.* (India). In the series of papers on fertility and sterility, there was one which dealt with a bioengineering approach to the determination of fertile period. Preliminary results of this attempt were stated to be useful in detecting ovulation period.

Samadhi is a sanskrit word meaning 'holding together'. It is a yogik exercise used by Indian meditators. N. Mohan Murali of I.I.T, Madras, presented a paper on some control mechanism concepts of meditation like inhibitory control over the receptor, inhibitory process in the recticular activating system and neurological coherence due to de-excitation of nervous system. Another interesting paper by him contained some bioelectric concepts on *Kundalini* yoga Ancient Indian philosophers believed that at seven different levels along the spinal column are seven *chakras* which are the centre of consciousness. *Sahasara* is the chakra of consciousness at the top and at the base of the spine is *Muladhara* chakra. It is believed that a fundamental power, called *Kundalini*, lies static at muladhara and, by activating or 'awakening' the *kundalini*, one can attain the highest state of consciousness. In his paper, Murali made an attempt to postulate a probable bio-electric mechanism involved in the process of awakening the *kundalini*.

Treatment of diseases through magnetism can play an important role to solve the health problems of rural masses. This method has received a good response in many countries especially in U.S.S.R. S.C. Srivastava, B.N. Sharma and S.I.B. Rizvi (India) who presented a brief report described methodology for the treatment by controlling the intensity of magnetic field.

V.P. Torchiliu *et al.* (USSR) pointed out that the use of biocompatible carriers for immobilization of enzymes and other biologically active compounds for medical applications presents a new perspective in creating new types of drugs and new methods of their administration. This could decrease the waste of rare and expensive medical preparations, they claimed.

Studies pertaining to brain signals and postnatal malnutrition were also reported. It was pointed out that during early development of neonate, considerable alternations are produced as a result of malnutrition.

E.R. Ramachandran and A.P. Agnihotry of Electronics Commission said in a report that Ballabhgarh, a satellite block of New Delhi, has been chosen as an experimental ground for a joint project of All In-

dia Institute of Medical Sciences, Indian Institute of Technology and other institutes. A mobile unit for medical electronics hygiene-health education has been put into operation. The primary objectives of such a unit will be to provide simple and basic instrumentation and equipment for diagnosis and therapy commonly required at village level.

W. J. Perkins of Computer Science Laboratory London, U.K. speaking on 'A professional Bio-Engineer?' described how bio-engineers, with the knowledge of both bio-medical problems and techniques of engineering, can provide their own technological innovations for the advancement of medicine.

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Aging genes

THE first Congress in gerontology was held in Kiev, U.S.S.R. in 1938 in which some thirtynine papers were presented. In the eleventh congress scheduled to be held in Tokyo, Japan in August 1978, more than six hundred papers will be presented and delegates from thirtynine countries will be taking part. Measured in this way, gerontology has come a long way in the intervening forty years. But the fundamental causes of aging are perhaps as much a mystery today as they have ever been.

The mean human lifespan in ancient Rome was twentytwo years and in the United States today it is more than seventyfive years. As various diseases which once killed so many people have been brought under control, the probability of dying at an younger age has decreased and with more people reaching ripe age, the mean human lifespan has increased. But the maximum human lifespan of 120 years or so has undergone very little change.

There is little doubt that the fundamental causes of a limited lifespan are somehow contained in the genetic machinery, in the DNA of the genes. Several considerations, least of which is the constancy of the lifespan of each animal species in the animal kingdom, lead to such a conclusion. DNA of nucleus is the master molecule in cell. It contains, in a coded form, all the information that the cell may require during its life time for its normal functions, and there is every possibility that causes for its senescence are also contained in it.

According to one hypothesis, the manifestation of senescence or old age is probably the result of operation of a genetic programme. As for many other developmental processes, DNA also contains information in the form of specific 'aging genes' to be switched on at a particular stage in the life of the cell or organism presaging old age and death.

Another possibility is that DNA functions like a clock, lasting for a specific period and then suddenly running out of genetic information leading to the degeneration of the cell or organism.

The third view now held by a large number of gerontologists is that the DNA, although containing a programme for all other sequential biological events, probably does not contain a programme for senescence itself and that it simply accumulates inaccurate information. When a threshold for such errors is reached, normal biological activities cease and the manifestation of old age becomes evident.

Whether any of the above hypotheses alone or in combination will explain the biology of senescence cannot be determined now. Nevertheless, most biologists agree that the fundamental causes of senescence are likely to be found in genetic machinery. May be, the Tokyo conference will throw more light on the subject.

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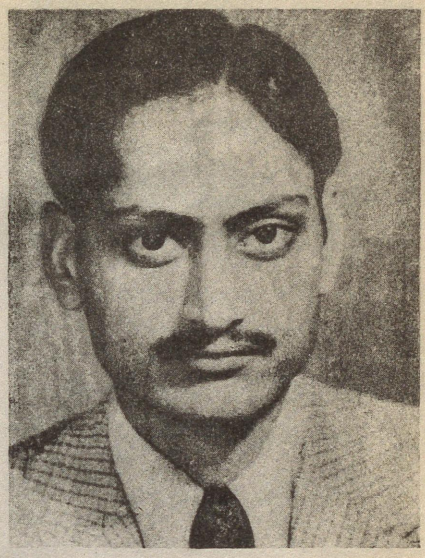
Solar energy convention

HE Central Salt & Marine Chemicals Research Institute, Bhavnagar is organizing a National Solar Energy Convention in cooperation with Bharat Heavy Electricals Limited, Department of Science & Technology and Tata Energy Research Institute from Dec. 20-22, 1978 at Bhavnagar, Gujarat. The Convention will discuss in depth the new emerging field of solar energy for rural development. Solar energy scientists and engineers are invited to send their papers for presentation at the Convention. For details, write to Prof. K. S. Rao, Secretary, National Solar Energy Convention, Central Salt & Marine Chemicals Research Institute, Bhavnagar, Gujarat.

Interview

Dr. S. K. Dubey



Dr. Dubey

"WE have highly capable scientists and teachers in the country," says Dr. Sushil Kumar Dubey, a Senior Research Officer in Biochemistry Deptt., A.I.I.M.S., New Delhi, the 1977 INSA Award winner, "I think it is possible to do better and more relevant work with the existing facilities, if only the mental priorities which drive one to work are changed." The "If" he talks about is indeed big. But, then, he hastens to add how to bring about the change in mental priorities. "A devotion to time and hard work should be generated from the very beginning, say, from primary school stage. Incentives should be provided in favour of production jobs as against easily accessible higher education. Guess papers, pass books, and the like should be banned."

It is natural for Dr. Dubey to think along these lines because he himself is a self-made man. He was born on July 8, 1949, at Faizabad, U.P. His father is a retired Army officer, who now is a farmer in their ancestral village near Ayodhya. From his childhood he was keen to learn how to operate and overhaul various kinds of machines. He was interested in animal behaviour and farming. So eventually, his interest in biological world which, according to him, is fascinating and adaptive, won over and he took up studies in it.

After doing B.Sc. and M.Sc. from Lucknow University with a first class in both, a third merit position in the latter, he did Ph.D. at All India Institute of Medical Sciences, New Delhi, in 1976. Immunochemistry and immunoreproduction interest him. The Award for the research he did, Dubey says, was a systematic work done under the guidance of Professor G. P. Talwar.

Dr. Dubey explains his research thus: Our body has the capacity to recognise foreign material entering it which might cause infection, etc., to fight the foreign material, it produces what are called antibodies. The function of antibodies is to combine with the foreign material and modify it so as to render it harmless to the body. In cases where the degree of modification is neither too high nor too low, antibodies thus made may also react with molecules that build the body. The result would be that these molecules would not be able to execute their biological functions. The body would then suffer.

This is the main theme of the research which he has been doing at A.I.I.M.S. The INSA Award has been given for the work he did on the modification of beta subunit of Human Chorionic Gonadotropin (B—HCG) which is a part of the hormone produced in women in early pregnancy. The basic idea has been to produce a vaccine which can stop pregnancy by producing suitable antibodies in women.

Regarding popularisation of science. Dr. Dubey feels that if scientific thinking has to be inculcated, it has to be done at the school level. It could best be done, according to him, by introducing into school curriculum the making of models, toys and other equipment.

DILIP M. SALWI

FOR HER (*Continued from page 496*)

Drs. E. L. Pippen and E. P. Mecchi of the Western Utility Research & Development Division, under the Agricultural Research Service Unit, at Albany, California (USA), however are of the view that it is hydrogen sulphide gas (H_2S) that contributes directly to the flavour of chicken products. According to them, H_2S also indirectly influences chicken aroma by forming secondry product.

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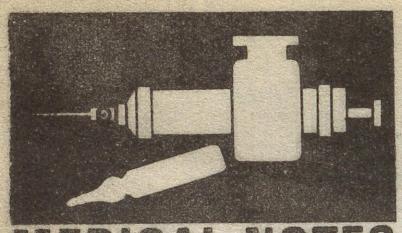

MEDICAL NOTES

Genetic factors in emotional disorders

ENVIRONMENT during infancy and childhood plays an important role in the expression of emotional disorders. However, a genetic background also seems to be important in their causation. An attempt is being made to justify the existence of genetic factors in emotional disorders, using schizophrenia and manic depressive psychosis as examples.

Definitions and incidences

Schizophrenia is a severe emotional disorder of psychotic depth characteristically marked by a retreat from reality with delusion, formations, hallucinations, emotional disharmony and regressive behaviour. Its incidence is approximately one per cent of the general population. The onset is usually between the ages of 15 and 45 years, and both sexes are affected to a similar degree.

Manic depressive psychosis is a benign, functional, mood illness marked by an innate tendency to recur, and has two phases: the positive or increased phase called manic, and the depressed or negative phase called depressive. The illness is almost twice as common in women as in men, the ratio being 5 to 3. Based on the data from different geographical areas, an overall estimate of somewhat less than one per cent may be considered as a reasonable figure for the incidence. Age-specific, first admission rates are approximately the same for each age group from 20 upto 70 years, although readmission rates tend to rise with increasing age.

Familial incidence

The incidence of the two emotional disorders seems to be common more in the families of affected probands (a proband is the affected individual in a family who first comes to the notice of the investigator) than in the general population. Their incidence appears to be correlated with the degree of relationship, i.e., first degree relatives (sib-sibe, father-child, mother-child) of the affected have a higher incidence than the second degree relatives (grand parent-grand child, uncle or aunt-nephew or niece, first cousins) (Table 1). Such a correlation provides genetic background for the disease. The genetic hypothesis is further supported by the fact that risk of having an affected child is much higher if both the parents have the disorder than only one parent (68.1 per cent vs 16.4 per cent in the case of schizophrenia).

Surveys have been conducted in the families of schizophrenic probands who also have adoptive relatives staying with them. It has been observed that in such families the incidence of schizophrenia in the biological relatives is more than in the adoptive relatives. In other words, the same home environment is not enough to precipitate the disease; a constitutional susceptibility seems to be a prerequisite for it.

Concordance rate in identical twins has been found to be higher than in non-identical twins in schizophrenia as well as manic depressive psychosis (Table 2). This observation gives a strong support to the genetic hypothesis for both these emotional disorders. The very fact that the concordance in identical twins is not 100 per cent suggests that environmental factors are equally important.

For manic depressive psychosis an autosomal dominant mode has been suggested. However, looking at its spectrum of expression it appears that either a polygenic

Table 1. Average empirical risk (%) of schizophrenia and manic depressive psychosis in relatives of proband cases

Relationship to proband	*Schizophrenia**	*Manic depressive psychosis***
Step sibs	7.8	—
Half sibs	7.3	—
Full sibs	13.0	11.7
Children		
one parent affected	16.4	—
both parents affected	68.1	—
Parents	9.8	12.8
Grand parents	3.9	—
Grand children	4.3	—
Nephews and nieces	3.9	—
Uncles and aunts	—	5.0
Cousins	—	2.5

*Data after Kallman and Barrera (1942) Kallman (1946)
**Data after Slatter (1938-51) as quoted by Kallman (1954)

Table 2. Percent concordance (++) and discordance (+−) for schizophrenia and manic depressive psychosis in twins*

	Identical		*Non-identical*	
	++	+−	++	+−
Schizophrenia	71	29	12	88
Manic-depressive psychosis	77	23	19	81

*After Stern (1973)

transmission or the effect of several distinct major genes is involved. The latter hypothesis can take care of the difference in incidence of this disorder in the two sexes, as mentioned earlier, if an assumption is made that the genetic threshold for expression is higher in males than in females.

Genetic counselling

A practical application of these findings is the availability of genetic counselling in emotional disorders. Families in which one or more individuals have an emotional disorder may have a concern for the future children. There does not seem to be a simple formula to predict the probability of having an affected child in many of these disorders. Risk figures are calculated on the basis of large population surveys. Based on these figures necessary advice may be given. An illustration of the use of these statistics may be given from the empiric risk figures available for schizophrenia and manic depressive psychosis (Table 1). For example, if one of the parents has schizophrenia the risk of having an affected child is about 16.5 percent.

However, if both the parents have this disorder the risk figure rises to about 68 per cent. This kind of information provided by a genetic counsellor may be helpful in planning a family and taking necessary preventive measures. Hence genetic studies have an important role to play in the general welfare of a family with emotional disorders.

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Caffeine—a threat to humans?

CAFFEINE in just two or three cups of coffee shoots up the blood pressure and speeds up the heart and breathing. The adrenal glands pour out two hormones that make the nervous system work harder. All these striking, potentially harmful effects have been detected by Vanderbilt University's scientists, in one of the most careful studies of caffeine effects ever done. The researchers conclude that medical science does not as yet know whether habitual coffee-drinking increases the risk of developing heart disease or other illness. As for advice to the average coffee user, it is too early to make any recommendations, the study's principal author Dr. David Robertson said.

Many other authorities agree. But not all. Dr. William Lukash said that it is fairly well established that caffeine is a potent drug, and he would use common-sense approach to limit coffee intake to no more than three or four cups a day. Lukash and two Navy colleagues told the American Medical Association in 1975 that drinking 5 to 10 cups a day can lead to headaches, irritability and nervousness. They said that 30% of coffee drinkers have digestive distress directly attributable to their coffee use. All authorities agree that coffee should also be limited in certain medical patients—for example, with any heart rhythm disturbance.

Results of research done by Dr. Robertson *et al*, published recently in the *New England Journal of Medicine*, reveals the effects of caffeine in nine healthy young persons—six men and three women—aged 21 to 30. All were ordinarily non-coffee-drinkers, and none was allowed any coffee, tea, cola drinks or drugs for three weeks before the experiment. They also had their salt intake controlled, because excess salt can affect the result. Tea drinking was barred because tea also contains caffeine.

At various times on two separate days, without knowing what they were drinking, the nine subjects were given either doses of caffeine in an otherwise ineffectual beverage, or a caffeine-free drink. After they consumed the caffeine, it was found that on the average:

(i) Their adrenaline output increased by 207 per cent and the output of a related chemical—norepinephrine—by 75 percent;

(ii) Blood pressure increased by about a tenth;

(iii) Breathing rates increased by 20 per cent ;

(iv) Heart rates at first dropped slightly, then after about an hour increased.

Many effects lasted for about three hours of observation. Most subjects also showed a sharp increase in the output of renin, a kidney enzyme commonly found elevated in persons with high blood pressure.

In 1973, Boston University researchers studied the coffee habits of 12,759 hospitalized patients, including 440 with acute myocardial infarction (heart blockage). They said drinking one to five cups of coffee a day had apparently increased heart disease risk to 60%, and drinking six or more cups 1 to 20 per cent. But, other studies have cast serious doubts on this finding. It is possible, said the Vanderbilt group, caffeine tips some susceptible persons from normal to high blood pressure. It is also possible that moderate coffee drinking does not really result in a great difference in health.

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Smoking and birth pill—together a health hazard

A U.S. Food and Drug Administration's advisory committee recently recommended that the government should tell women who use birth control pills to stop smoking because the two together markedly enhance the risk of heart and circulatory diseases. The Food and Drug Administration, which is responsible for overseeing oral contraceptives, accepted the recommendation and announced that it would issue new warnings about the effect of using the pill and smoking. The Advisory Committee on Obstetrics and Gynecology reviewed a number of scientific studies on the issue of oral contraception and smoking. Among the scientific studies reviewed was one made public in October last year in Britain, by the Royal College of General Practitioners. It had found that the death rate from circulatory and heart diseases was almost three times higher in pill taking smokers than the pill taking nonsmokers. Each package of birth control pills, the Advisory Committee advised should include warnings that combined use of the pill with smoking results in risks of serious cardiovascular side effects, "especially in women older than 35".

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Valproic acid for epilepsy

THE U.S. Food and Drug Administration (FDA) recently approved valproic acid as an anticonvulsive drug and experts predict it would help more than a half million victims of epilepsy, some of whom suffer many seizures daily. Valproic acid is chemically similar to sodium valproate, a drug that has been available in Europe for a decade. It will be marketed in the U.S.A. by Abbott Laboratories of Chicago under the brand name Depakene. The FDA said that it had found valproic acid to be effective in treating petitmal epilepsy, a brain disorder that causes momentary loss of consciousness. The more serious epilepsy, grand mal, is characterized by sudden loss of consciousness, muscle spasms and foaming from the mouth. The U.S. Epilepsy Foundation believes that at least 560,000 epilepsy patients who have more than one seizure a year and who are not controlled by other drugs can benefit from valproic acid. And because it appears to be the safest anticonvulsive drug, the Foundation says, it offers the prospect of vastly improved therapy for people who are suffering from side effects of other drugs.

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SCIENCE FOR THE YOUNG

The diet of Eskimos

FOR sustaining normal and healthy life, a balanced diet containing all the essential constituents is necessary. Such a diet may be a combination of milk, meat, fruit, cereals and vegetables.

The question that has long fascinated nutritionists is : How have the Eskimos, living in the far north for generations, maintained their life style on a diet comprising entirely of meat and fish?

The word, Eskimo, means 'eater of raw flesh'. Most of the food eaten by Eskimos is raw, frozen or cooked lightly. These diets are notably high in protein and fat but low in carbohydrate content. In fact, the active Eskimo diet contains more protein than the diet of any other ethnic group. The protein consumed beyond the body's requirement serves as a source of calories as well as of blood glucose. Eskimo blood glucose is chiefly biosynthesised from dietary amino acids. Absence of diabetes amongst Eskimos is a clue to the role of diet in diabetes.

Modern Eskimos, when given processed food, are known to experience gastrointestinal disorder. The absence of sugar in the traditional diet of Eskimos for centuries has reduced the intestinal level of sugar-splitting enzymes like sucrase and lactase. Many Eskimos suffer from indigestion and diarrhoea after conusming sweet foods or beverages.

The native diet of Eskimos consists mainly of whale, seal and walrus oil which provide them the required calories. One of the unique features of Eskimos nutrition is the mechanism by which fatty acids in these oils are utilised for energy, and the way they affect composition of body fat and cell membranes. Consumption of high fat and low carbohydrate diet causes ketone bodies to form in the liver. During the process of metabolic oxidation, fatty acids are broken down to corresponding short chain fatty acids, acetyl coenzyme—A, and energy. The ketone bodies are subjected to further oxidative conversion into pyruvic acid and are subsequently utilised through glycolytic pathway in the liver. Body tissues in Eskimos adapt to the utilisation of ketone bodies as a source of energy. In case of normal human beings energy is obtained from glucose. As such, Eskimos serve as an example of an important metabolic phenomenon.

Eskimos derive an abundant supply of vitamin B through caribou meat and other foods of animal origin. Although, they do not get enough of vitamin C from foods of animal origin, they never suffer from scurvy. Similarly, vitamins A, D, E and K pose no nutritional problems to them as they are abundantly available in the oils and fish and marine animals. However, the Eskimos diet is deficient in calcium.

With the changing times, the Western dietary habits are steadily infiltrating into the Eskimos community. There are now increasing instances of metabolic disorders in them like heart troubles, diabetes, hypertension, and other ailments common to the civilized man.

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Fun with magic numbers

THROUGH ages, mathematicians have played with numbers in their leisure time. While handling elements of the infinite sets of natural, whole and integral numbers, some were successful in finding out some numbers (or set of numbers) which had peculiar properties of their own. A few examples of such numbers/set(s) of numbers are given below :

(1) *Group dance of numbers :* The set of numbers 1, 12, 123, 1234, 12345, ..., 123456789 has a peculiar property of its own. The property is known as the "group dance of the

numbers".

$1 \times 8+1 = 9$
$12 \times 8+2 = 98$
$123 \times 8+3 = 987$
$1234 \times 8+4 = 9876$
$12345 \times 8+5 = 98765$
$123456 \times 8+6 = 987654$
$1234567 \times 8+7 = 9876543$
$12345678 \times 8+8 = 98765432$
$123456789 \times 8+9 = 987654321$

(2) *The number 12345679* : The number 12345679 is another number with a peculiar property. If it is multiplied with 9 and then with any number from the set 0, 1, 2,.. 7, 8, 9, we get a number in which all the places (i.e., units, tenths, hundredths, etc.) are occupied by that same number.

$12345679 \times 9 \times 1 = 111111111$
$12345679 \times 9 \times 2 = 222222222$
$12345679 \times 9 \times 3 = 333333333$
$12345679 \times 9 \times 4 = 444444444$
$12345679 \times 9 \times 5 = 555555555$
$12345679 \times 9 \times 6 = 666666666$
$12345679 \times 9 \times 7 = 777777777$
$12345679 \times 9 \times 8 = 888888888$
$12345679 \times 9 \times 9 = 999999999$

3. The next dance of the set of numbers is literally known as:

"Tic Tac Toe, All in a Row,
All Roads Lead to Rome."

$0 \times 9 + 8 = 8$
$09 \times 9 + 7 = 88$
$098 \times 9 + 6 = 888$
$0987 \times 9 + 5 = 8888$
$09876 \times 9 + 4 = 88888$
$098765 \times 9 + 3 = 888888$
$0987654 \times 9 + 2 = 8888888$
$09876543 \times 9 + 1 = 88888888$
$098765432 \times 9 + 0 = 888888888$
$0987654321 \times 9 + (-1) = 8888888888$
$09876543210 \times 9 + (-2) = 88888888888$

4. *The tower of numbers.* It is the property of the set of numbers 1, 11, 111, 1111,....., 111111111 (Fig 1).

1 x 1	=	1
11 x 11	=	121
111 x 111	=	12321
1111 x 1111	=	1234321
11111 x 11111	=	123454321
111111 x 111111	=	12345654321
1111111 x 1111111	=	1234567654321
11111111 x 11111111	=	123456787654321
111111111 x 111111111	=	12345678987654321

Fig. 1

5. *The rhyme:* Have a look at the rhyme of the number, 142857 in the example.

$1\,4\,2\,8\,5\,7 \times 1 = 142857$
$1\,4\,2\,8\,5\,7 \times 2 = 285714$
$1\,4\,2\,8\,5\,7 \times 3 = 428571$
$1\,4\,2\,8\,5\,7 \times 4 = 571428$
$1\,4\,2\,8\,5\,7 \times 5 = 714285$
$1\,4\,2\,8\,5\,7 \times 6 = 857142$
$1\,4\,2\,8\,5\,7 \times 7 = 999999$

6. *The square of numbers :* The peculiarity in the results of the squares of numbers ending with 5 is that they always end with 25.

$5^2 = 25$
$15^2 = 225$
$25^2 = 625$
$35^2 = 1225$
$45^2 = 2025$
$55^2 = 3025$
$65^2 = 4225$
$75^2 = 5625$
$85^2 = 7225$
$95^2 = 9025$.....and so on.

7. *A peculiarity among the integral numbers :* "A number minus the reverse of the number is equal to a multiple of 9."

$82 - 28 = 54 \quad (=9\times6)$
$65 - 56 = 09 \quad (=9\times1)$
$875 - 578 = 297 \quad (=9\times33)$
$371 - 173 = 198 \quad (=9\times22)$
$956 - 659 = 297 \quad (=9\times33)$
$6523 - 3256 = 3267 \quad (=9\times363)$
$87654 - 45678 = 41976 \quad (=9\times4664)$
and so on.

8. *The tower of odds* :

(a) $56^2 - 55^2 = 111$
$556^2 - 555^2 = 1111$
$5556^2 - 5555^2 = 11111$
$55556^2 - 55555^2 = 111111$

(b) $57^2 - 54^2 = 333$
$557^2 - 554^2 = 3333$
$5557^2 - 5554^2 = 33333$
$55557^2 - 55554^2 = 333333$

(c) $58^2 - 53^2 = 555$
$558^2 - 553^2 = 5555$
$5558^2 - 5553^2 = 55555$
$55558^2 - 55553^2 = 555555$

(d) $59^2 - 52^2 = 777$
$559^2 - 552^2 = 7777$
$5559^2 - 5552^2 = 77777$
$55559^2 - 55552^2 = 777777$

(e) $60^2 - 51^2 = 999$
$560^2 - 551^2 = 9999$
$5560^2 - 5551^2 = 99999$
$55560^2 - 55551^2 = 999999$

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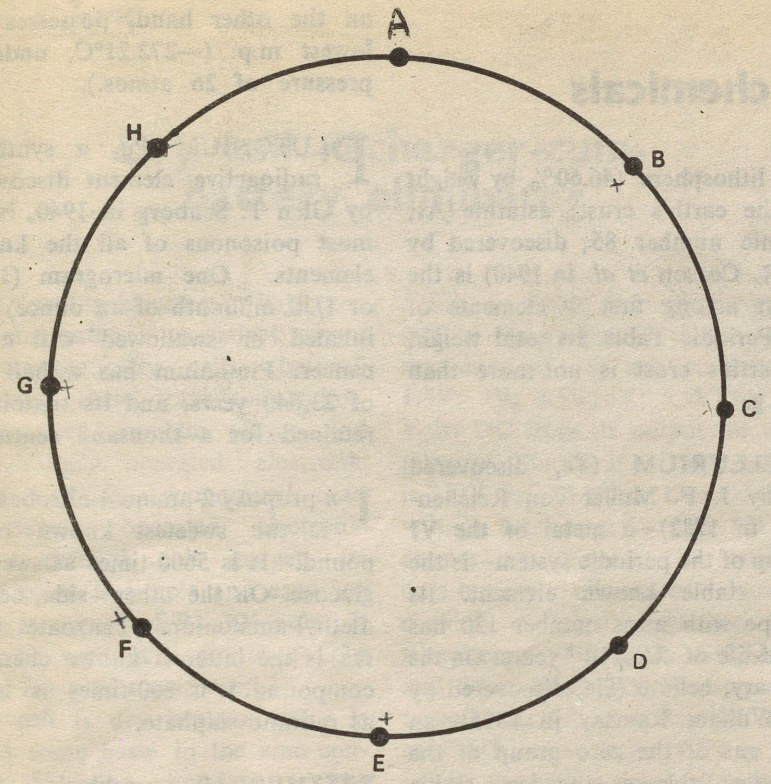
Brain teaser

SHOWN in Fig. 1 are eight points, marked A, B, C,..... etc., lying on the circumference of a



circle. Start counting from any one of these points and move either in clockwise or anticlockwise direction along the circumference of the circle. Stop at the point when you count six; place a coin at this point. Continuing in this manner you have to place seven coins at seven points leaving, just one point vacant. There is one restriction, of course ; you can't start from a point already occupied by a coin. Generally, you will find yourself stuck after you have placed 4 or 5 coins. So, apply your brain as well as some logic if you want to solve this deceptive but simple problem.

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(*Answers on page* 494)

Science quiz

1. A bacterium which changes shape (pleomorphic)
   (a) *Lactobacillus*
   (b) *Acetobacter*
   (c) *Azotobacter*

2. Drosophila of plant kingdom is
   (a) *Aspergillus*
   (b) *Neurospora*
   (c) Yeast

3. A dicot plant with parallel venation of leaf
   (a) *Calophyllum*
   (b) *Crocus sativa*
   (c) *Nigella sativa*

4. A monocot plant with reticulate venation of leaf
   (a) *Dioscorea*
   (b) *Indigofera reticulate*
   (c) Maize

5. Common alloy forming fuse wire is
   (a) Sn/Cu/Zn
   (b) Zn/Cu
   (c) Sn/Pb

6. A piece of ice is floating on water. After it melts the level of water
   (a) Goes up
   (b) Goes down
   (c) Remains same

7. Wavelength of X-rays is of the order of
   (a) 10^{-4} cm
   (b) 10^{-6} cm
   (c) 10^{-8} cm

8. Oxidation takes place at
   (a) Anode
   (b) Cathode

9. Zn does not alloy with
   (a) Ag
   (b) Pb
   (c) Cu

10. A non-metal with the highest melting point is
    (a) Carbon
    (b) Sulphur
    (c) Copper

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Be quick with chemicals

THE total number of officially known chemical elements today is 106. The discovery of the newest element (atomic number 106) was announced on September 9, 1974, by an American group of scientists led by Dr. Albert Ghiorso. Prior to this discovery, element 105 (Hahnium) and element 104 (Kurchetovium) were the heaviest known atoms. Earlier, in February 1971, a British research team had presented their case for the creation of the first superheavy element with atomic number 112. But their claim is yet to be officially accepted. Further in this line, on June 17, 1976, the discovery of three new superheavy elements (atomic numbers 116, 124, and 126—the latter two eka-actinides) was announced by Dr. Robert V. Gentry and four other U.S. scientists. Nuclei of these elements were found as trace elements in inclusions in Madagascan mica in monazite. Not only this, the scientists also described the preliminary data for the presence of Element 114 and eka-actinides 125 and 127.

THOUGH hydrogen (discovered by Henry Cavendish in 1776) is the lightest of all the known elements, lithium (Li, discovered by Arfvedson in 1817) is the lightest among the metals. Whereas hydrogen weighs 0.090 kg/m^3, lithium weighs 533.25 kg/m^3. On the contrary, osmium (Os, discovered by Smithson Tennant in1804) is the heaviest known metal (weighing 22,585.80 kg/m^3). The heaviest gaseous element is radon (Rn, atomic weight 22, atomic number 86) which weighs 10.02 kg/m^3.

WHEREAS oxygen (O, discovered by Carl Wilhelm Scheele in 1772) is the commonest element of the lithosphere (46.60% by weight in the earth's crust), astatine (At, atomic number 85, discovered by D. R. Corson *et al.* in 1940) is the rarest among first 94 elements of the Periodic Table. Its total weight in earth's crust is not more than 0.30 g.

TELLURIUM (Te, discovered by J. F. Muller von Reichenstein in 1782)—a metal of the VI Group of the periodic system—is the most stable known element. Its isotope with mass number 130 has a half-life of 2.2×10^{21} years. On the contrary, helium (He, discovered by Sir William Ramsay in 1895)—an inert gas of the zero group of the Periodic Table—is the least stable among all the elements. Helium-5 has a half-life of 2.4×10^{-21} seconds.

XENON (Xe, discovered by Sir William Ramsay and Morris William Travers in 1898)—another inert gas of the zero group of Periodic Table—has the highest number of isotopes (30 in total), whereas hydrogen has the least number of isotopes (only 3; *viz*, protium, H^1; deuterium, H^2 or D^2; and tritium, H^3 or T^3).

GOLD (Au, known before 3000 B.C.) is the most ductile element known. One troy ounce (31.103 g) of gold metal can be drawn to 43 miles (69.20 km).

BORON (B, discovered by Joseph Louis Gay-Lussac *et al.* in 1808, in France), has the highest tensile strength. It can sustain a force of 283×10^5 kg/cm^2.

TUNGSTEN (W, discovered by J. J. & F. d'Elhuyar of Spain in 1783) has the highest m.p. among the elements (3417 ± 10°C). Helium, on the other hand, possesses the lowest m.p. (—272.21°C, under a pressure of 26 atmos.).

PLUTONIUM (Pu, a synthetic radioactive element discovered by Glen T. Seaborg in 1940, is the most poisonous of all the known elements. One microgram (1 μg or 1/30 millionth of an ounce) of it inhaled or swallowed will cause cancer. Plutonium has a half life of 23,640 years, and its toxicity is retained for a thousand centuries.

1-*n*-propoxy-2-amino-4-nitrobenzene is the sweetest known compound. It is 5600-times as sweet as glucose. On the other side, benzyl diethyl-ammonium benzoate (Bitrex) is the bitterest known chemical compound. It is 200-times as bitter as quinine sulphate.

WHEREAS perchloric acid ($HClO_4$) is the most acidic known compound (pH value of its normal solution is zero), caustic soda (NaOH), caustic potash (KOH) and tetramethylammonium hydroxide (Me_4NOH) are the most alkaline compounds recorded to date (the pH value of their one Normal solution is 14). The most powerful acid in terms of its power as a hydrogen ion donor is a solution of antimony pentafluoride in fluorosulphonic acid ($SbF_5 + FSO_3H$).

THE longest chemical name recorded in the chemical literature is that of a bovine, NADP-specific enzyme glutamate dehydrogenase, which contains in its structure 500 amino acids. Its full name is composed of nearly 3600 letters.

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Do it at home

Dry cell recharger-cum-battery eliminator

DRY-cell-recharger-cum-battery-eliminator is a gadget meant to recharge dry cells (battery) and to operate transistor radios, transistorised cassette player, and other battery operated electronic devices. It is economical to use battery operated electronic devices through this gadget. Its construction is simple and easy to make at a cost of Rs. 30/- only. It could be used at a stretch for 24 hours for either purpose.

No cell is dry because there is always some paste in the zinc container. The zinc container of the cell is cathode (—) and the metal capped carbon rod (+) is anode. The paste or mixture of manganese dioxide, ammonium chloride and coke powder, pressed tightly between carbon rod and zinc container, which is sealed with tar, acts as an electrolyte. Due to electrochemical reaction within the zinc container, the cell is able to hold charge and deliver current. Recharging system of the dry cell is a system similar to one used in electroplating.

Fig. 1 shows the electronic circuit of the gadget which provides a maximum of 500 mA current with 1.5V; 3V; 4.5V; 6V; 7.5V; 9V; 12 Volts DC from its output for either purpose. The input voltage required is 230V AC 50 Hertz. One can select voltage between 1.5V and 12V DC as per requirement. The recharger cum-battery eliminator basically consists of three parts : step-down transformer (T), bridge rectifier (R) and filter circuit (F). The step-down transformer (T) provides the necessary AC low voltages (1.5V to 12V) supply through a selector switch to the bridge rectifier (R) (500mA 20V) which converts AC voltage into DC voltage. The low frequency choke (20V/500 mA), in series with the filter circuit (F) is for limiting the output current. The resistor (2k 1 w) and two capacitors (1000 mfd 12V, 250mfd 12V) in parallel with the filter circuits provide a steady DC output with minimum ripple current. This ripple current, along with the direct current, ionises dissolved zinc oxide from the electrolyte and deposits zinc back on the zinc container. After assembling components in a suitable metal box (11 cm.×7cm.), check its connections thoroughly and then insert the mains plug in the 230V A. C. socket. All the bare wires of the transformer, secondary coils and leads of components are to be covered up by convenient pieces of Amp. tube or any other similar insulating tube. At the end of output terminals, fix two crocodile clips or a similar socket outlet.

Never keep dry cells in the charging unit when the charger is not connected with the main supply. Otherwise, cells become discharged through resistor and transformer winding. The quality of recharged cells depends upon their age and how they were used when they were new. However, a dead or a fully discharged cell will not be able to hold any charge. The electromotive force of any cell drops even though the cell remained idle for a long time. At the same time, it may damage electronic devices if the cells are kept unused in it for a long time. The life of a cell is limited. To get a longer recharged life, one must interrupt its service life and recharge it at least once in a month. While charging, the positive terminal of the charger is to be connected with the positive (+) of the cell and the negative terminal

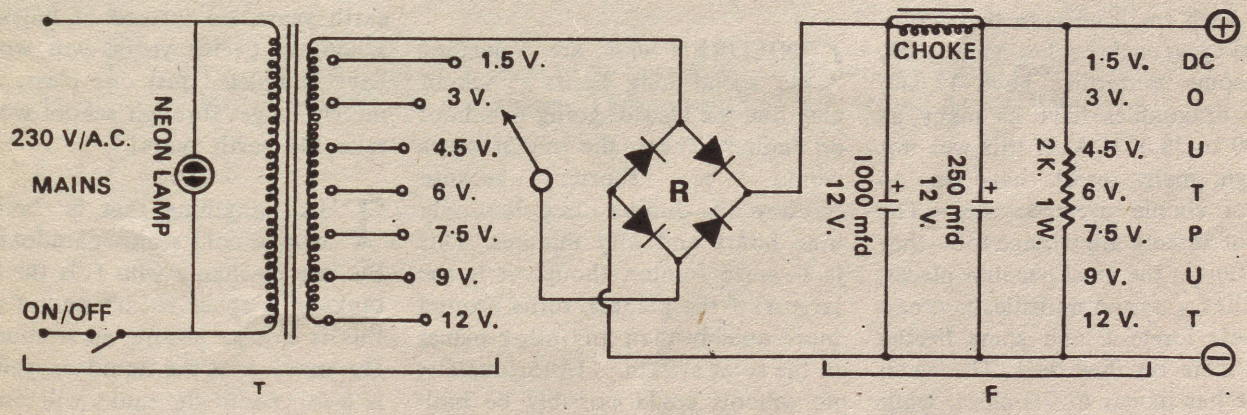

Fig. 1

Table : 1

Cell Type No.	*Recommended charging duration*
286 (9V)	5 hours
276 (6V)	4 hours
1055	
1035 (1.5V)	2-4 hours
1015	
with any other type.	

with the negative (—) of the cells.

Components

Transformer	: Primary 230V AC : 50Hz, secondary; 1.5V-3V-4.5V-6V-7. 5V-9V-12V AC, 500mA,—1 pc.
Low frequency choke	Capacity 20V 500 mA type, 1 pc.
Rectifier(R)	Bridge rectifier stack, type 500mA, 20V; —1 pc.
Electrolytic capacitor	: 100 mfd 12V, 1 pc; 250 mfd 12 V, 1 pc.
Resistor	: 2K-1 watt according to rectifier-1pc.
Switch	: Band or selector switch 1 pole 7 way, 1-pc.; on/off switch-1 pc.
Enclosure	: Metal Box-11 cm. × 7 cm.-1 pc.
Misc.	: Neon 1-amp. (230V type); crocodile clips and plug socket; wires, solder, resin; screws; knob; Amp. tube; mains plug, etc.

SUPRIYA KUMAR BOSE

Solution to Brain teaser

First, place a coin at the point A. For this, you can start from either points F or D and chose any of the two alternative paths—F-E-D-C-B-A or D-E-F-G-H-A. Now, move successively along the following paths and occupy the points one by one: G-H-A-B-C-D; C-B-A-H-G-F; H-G-F-E-D-C; B-C-D-E-F-G; E-D-C-B-A-H; E-F-G-H-A-B.

Answers to Science Quiz

1. (b)	6. (c)
2. (b)	7. (c)
3. (a)	8. (a)
4. (a)	9. (b)
5. (c)	10. (a)

Science oddities

YOU and I have just two eyes, but the lowly insects have many thousands of eyes. Insects have compound eyes composed of many separate little eyes. Houseflies have 4,000 such small units in their compound eyes, cockroaches have 1,800, and some butterflies have 17,000, while dragonflies have as many as 20,000 to 30,000! As if this was not enough, many insects have one to several simple eyes as well. The ears of insects are strange too—they are often in the most peculiar places. Termites, ants and stoneflies have ears in their forelegs, and some beetles have them on their feet. The water beetle has its ear on its chest, while the locust has one on each side of its abdomen, and gnats and midges have them at the base of their antennae. Oddest of all, flies and butterflies have taste organs on their feet!

CHILDREN who are reluctant to spend long hours at school may like the idea of going to school on Jupiter. There the school hours would be shorter because the day on Jupiter lasts for only nine hours and fifty minutes. This is because Jupiter, though it is the largest of the planets, turns around more quickly than any other planet in the solar system. Unfortunately, no schools could possibly be built on Jupiter, for (quite apart from other unfavorable conditions) there is no oxygen in its atmosphere. There is also onother big snag in this idea. Though the day is short, each year on Jupiter is equal to twelve earth years. So instead of finishing school in twelve years, you would have completed just one class, and merely to get through school would take 144 earth years!

THAT anything that is boiling can be cold seems paradoxical. But the mechanic who fills the fuel tanks of a space rocket knows that this is not as absurd as it sounds. He knows that the liquid oxygen he is feeding into the tanks will slowly get warmer, till it reaches its boiling

point of —183°C. Some other substances boil at even lower temperatures. Fluorine, for example, changes from liquid to gas (the temperature at which this happens, is as we all know, the boiling point) at —187°C, while nitrogen vaporises at —196°C. The boiling point of hydrogen is still lower—it boils at —253°C.

"LIGHT as air" is a misleading expression, because the envelope of air that surrounds the globe can hardly be called light—it weighs 51,000,000,000,000,000 tons. This seems a staggering figure, but then the atmosphere is about 960 km deep. As the upper layers press down on the lower ones, a pressure of approximately 1 kg/sq. cm is produced on the surface of the earth. We do not normally perceive this, but if we go up in an aeroplane our ears would begin to hurt because of the unequal pressure on either side of the ear drum. This is why modern aeroplanes have special pressurised cabins.

PLANTS are probably the world's greatest miners. Each year they 'extract' more than five billion tons of various minerals from the soil through their root systems. This is more than five times the total amount of all the important metals mined by man with his sophisticated technology and machinery. Besides, even with highly specialised methods, man cannot profitably extract most minerals from their ores, unless the metal content is rather high (more than 25 per cent for iron). Plants, on the other hand, can mine enormous quantities of metals which may be present in concentrations even lower than one per cent!

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Corrigenda

On page 352 (*SR* May 1978) the answer to **Science quiz,** clue No. 8, is (c) and not (a).

On page 394 (*SR* June 1978) in Fig. 1, 8th row, the fourth element from left is Ku and not Ru. The symbol of element 103 in the same figure is Lr and not Ir.

On page 423 (*SR* June 1978) the values of the various components as given in the list are correct. Those given in Fig.1 should be ignored.



FOR HER

Another alternative to pill

IN view of recent controversies over various birth-control methods, many women may be interested to know of a new over-the-counter vaginal contraceptive called Encare oval. Introduced in USA recently, it has been used in Europe for over four years. The insert which is activated by the heat of the body to form a spermicidal barrier across the cervix is effective after ten minutes and lasts for two hours. The spermicide, nonoxynol 9, has been safely used in foams, creams and suppositories for about 20 years.

According to the manufacturers, the insert which measures 2.5 cm by 4 cm is easier and more convenient to use than foams and other topical contraceptives, and provides double protection. Tests show that the barrier it forms stops sperms even without the spermicide. In a German survey of over 10,000 women who used the product, 43 pregnancies were reported. This means that for every 100 women who used it for a year, one pregnancy could be expected—a rate comparable to that of the pill and I. U. D. Thus it appears to compare favourably with other methods of contraception that do not require a doctor's prescription and supervision. Finally, Encare oval costs $3.75 for a package of 12 inserts. Although it does not need a prescription, manufacturers advise women to discuss birth-control options with their own doctors.

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Chemistry of cooked chicken

CHICKEN—the domestic fowl—is the most abundant gallinaceous bird in the world. Belonging to the order *Galliformes*, it has descended from the wild red jungle fowl (*Gallus gallus*) of South East Asia and has been domesticated throughout the world. Because of its high palate and delicacy, non-vegetarians throughout the globe rank chicken as their most favorite food. There are believed to be about 4,000,000,000 chickens in the world, or nearly one chicken for every member of the human race.

People eat cooked chicken (roasted, boiled, fried, or curried) with high taste. What is cooked chicken's taste due to? Certainly, it must be due to some chemical substances. Surprisingly, it is not one, two, ten, or twenty chemicals that constitute chicken's taste and aroma; there are as many as 227 chemical compounds—mostly organic— which collectively contribute to the high taste and flavour of this 'unfortunate' bird, killed and eaten at the rate of about 50,000 per day in India alone.

In 1967, a group of American chemists, led by Dr. M. Nonaka, at the Western Regional Research Laboratory, in Albany (California), took an odorous fraction isolated from boiling chicken meat and subjected it to fractionation by capillary gas chromatography. In this way, 227 compounds in all were isolated, out of which 62 were specifically identified. They included sulphur compounds, aldehydes, ketones, aromatic compounds, furans, esters, hydrocarbons, alcohols, and terpenes.

The same year, Drs. H. H. Koehler and M. Jacobson, at Washington State University in Pullman (USA) prepared aqueous extract of ground, raw white and dark chicken muscles, dialysed them, and then tested their tastes. On heating, dialysed extracts produced significantly stronger chicken flavour than filtrates of non-dialyzed material. The dialysates were fractionated; the second of the four fractions from both white and dark meat dialysates on heating produced full chicken aroma and taste. All the four fractions were tested qualitatively for sugars, amino acids, amines, purine compounds and mercaptans. Infrared and ultraviolet spectra as well as pH values were also determined. The flavour-forming fractions were found to contain glucose, fructose, ribose (and another sugar which could not be identified), lactic acid, a number of amino acids, (16 in the white muscles and 11 in dark muscles), a variety of amines, inosine, IMP (inosine monophosphate), GMP (guanosine monophosphate), some carbonyl compounds, and a few —SH group-containing compounds (sulfhydryls).

(Continued on page 485)

Science in Industry

Flash distillation for desalination

DESALINATION technology is of great advantage to the coastal regions of the country. Among the desalination techniques so far developed, distillation processes are most suitable for desalting of ocean waters.

To develop a desalination process indigenously, investigations were undertaken at the Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar, some years ago and a flash distillation plant of 500 litres/hr capacity was designed and operated successfully. The process is based on the principle of distilling out the saline water under reduced pressure to produce fresh water. When a bulk of hot saline water is allowed to enter a low pressure chamber the water gives off vapours. The vapours so generated are condensed suitably over cold tubes, yielding distilled water. The institute's flash distillation plant has two stages. The design of a 250,000 litres/day capacity plant has also been prepared.

The total investment required for putting up a plant capable of producing 2,50,000 litres of fresh water per day (three shifts) is estimated at Rs. 40 lakh. The cost of production of a thousand litres of fresh water works out to Rs. 20.

Pulps and drugs from plants

SCIENTISTS of the National Chemical Laboratory, Pune, have shown that some Indian plants can yield rayon grade pulp and drugs. They have succeeded in obtaining several useful chemicals of industrial importance from Indian plant sources. Mesta stems (*Hibiscus cannabinus*) and *Dalbergia paniculata* wood yield excellent chemical pulp. *Boswellia serrata* yields standard quality pulp for rayon yarn. The NCL scientists are also testing cotton linter pulp for viscose rayon. In another experiment, NCL scientists have obtained a chemical parthenium from *Parthenium hysterophorus* which is known to possess anti-cancer activity. A number of parthenium derivatives have been prepared which will be tested at the Cancer Research Centre, Bombay for their anti-cancer activity.

Another team of scientists at NCL has obtained vanillin from groundnut shell which is an agricultural waste available in large qualities in the country. The process is being developed for obtaining maximum yield of this important industrial chemical.

Flavours and plant colours have been obtained from the bark of *Morus alba*.

NCL Scientists are also testing whether neem can be added to soil with fertilizers for better use of nitrogen by plants. Several extracts of neem oil have been tested and the extract showing the maximum effects of slow release of nitrogen to the soil has been identified. The main component is ollic acid.

If the experiment succeeds, considerable quantities of urea can be saved by adding neem oil or neem cake to the soil.

Another group of scientists at the NCL has developed a process for the manufacture of *quinapyramine sulphate and quinapyramine chloride* which are valuable veterinary drugs to prevent loss of cattle due to trypanosmiasis.

The two alkaloids vincristine and vinblastine from *Vinca rosea* (Sadaphuli) leaves have been proved to be very effective against leukemia. Work on the isolation of VCR and VLB from plant using modern methods of chromatography is in progress.

Arsenic determination in drinking water

THE National Environmental Engineering Research Institute Nagpur, has modified and fabricated a glass assembly for the estimation of arsenic.

The NEERI method is more sensitive than the Atomic Absorption Spectro-photometric method and is also easier to handle than the apparatus mentioned in the Manual of Standard Methods. At NEERI this apparatus is being used on a routine basis for the quantitive estimation of arsenic in drinking water. The maximum allowable concentration of arsenic in drinking water is 0.05 mg/l.

The principle of this method is that inorganic arsenic is reduced to arsine gas by metallic zinc in acid solution in an arsine generator. The determination of arsenic has been of importance to public health agencies for many years because of the toxicity of arsenic compounds. Also several incidents have demonstrated that arsenic in water may be carcinogenic.



BOOK REVIEWS

VISTAS IN ASTRONOMY, An International Review Journal, Vol. 20. 21 Parts 4 and 1, 1977, *Pergamon Press*, Headington Hill Hall, Oxford, England. each $ 15.

The increasing sophistication of astronomical observation and physical theory during the past two decades has widened greatly the horizons of the universe around us. Astronomical observations have revealed the existence of celestial objects as well as events that were not suspected even fifteen years ago. Cases in point are quasars, radio galaxies, pulsars, exploding galaxies, putative black holes, black body 3.2 cm microwave background radiation, the supposed relic of the creation of the universe, and the like. Similar advances in physical theory, in particular, in Einstein's relativity theory that launched cosmology some sixty years ago, have not only yielded many new ideas but also extensions of Einstein's relativity itself. Some of the new developments in physical theory are the gravitational collapse phenomenon, the effect of magnetic turbulence and cosmical electrodynamics, the role of nuclear physics in understanding stellar evolution, supernovae explosions, etc. As a result astronomy has become an exciting intellectual game for great telescopes and great minds. It is now virtually a garden where hundred flowers continually contend.

The series of publications titled *Vistas In Astronomy* was launched in the early 1960s to keep track of this multitudinous observational as well as theoretical work. Each publication of the series gave an up-to-date view of the state of astronomy. The journal under review is designed to continue the aim of the original series but much more regularly, by publishing articles by internationally famous workers in the field. It thus provides a periodic survey of contemporary astronomy and its allied offshoots. It is indispensable reading for anyone wanting to remain *au fait* with the current state of astronomical research.

JAGJIT SNGIH

PRINCIPLES OF GENETICS (Second Edition) *by* Irwin H. Herskowitz, *Macmillan Publishing Co.* New York. (2/10, Ansari Road, Daryaganj, New Delhi-110002), 1977, Pp 836+XXIV, $ 16.95.

THROUGH the books entitled *Genetics* (1962, 1965), *Basic Principles of Molecular Genetics* (1967) and *Principles of Genetics* (1973) Irwin Herman Herskowitz has served genetics students well since 1962. The book under review is the 2nd edition of the 1973 book, but it is indeed a new one as it has been completely rewritten. It is now one of the best books available in the market.

The book contains 30 chapters broadly distributed among seven parts. Each part attempts to answer an important but specific question. Part one answers the question "What the genetic material is" in first two chapters; part two answers the question "What the genetic material does" in next three chapters; part three answers "How the genetic material is varied packaged and distributed" in next nine chapters; part four answers "How the products of genetic action interact" in next three chapters; part five answers "How the genetic material chooses the parts that are present and functional" in next seven chapters; part six answers "How the preceding came about and gave rise to the present genetic material" in next five chapters; and, lastly, part seven highlights the applications and implications of genetics in agriculture, ecology, law and religion, behaviour, medicine and genetic engineering. In other words, this book deals in detail with "the study of the properties, functions and significance of self-replicating nucleic acids", that is, the genetic material. Each chapter, after a short introduction, has a series of related conclusions as sub-titles arranged in such an order that the most fundamental one comes first and the most complicated one last. Each conclusion is then supported in the text with experimental evidences, etc.

In chapter 4 on "Transcription", the legend of the Fig. 4-1 reads as "The tailoring of giant nuclear transcript into mRNA and Hn-RNA." The tailoring of giant nuclear transcript into mRNA and HnRNA is then explained appropriately in the text also. This point is rather confusing. In the biochemical literature the giant nuclear transcript has itself been termed as HnRNA and it is not that HnRNA is produced by "tailoring" of the giant nuclear transcript, as given in the book. On the other hand, till recently, the contention was whether or not the giant nuclear transcript (HnRNA) acts as precursor for mRNA. A large number of recent experiments have gone in favour of the former.

The book gives in a clear-cut manner the most recent advances in molecular, biochemical and microbial genetics and also gives examples of bacteria and viruses rather generously. In it the genetic "principles are dealt with rather than history, no distinction is made between classical and modern genetics, and presentation aims to be logical rather than chronological." It is therefore recommended to post-

graduate students; undergraduates will find this book a little hard to understand.

In the present form this important book is beyond the means of most Indian students. Publishers should bring out an Indian or paperback edition.

SUBHASH S. ARORA

POLICY DECISIONS AND PLANNING *by* Anand Khare, *Bablu Book Co.*, 232, H.M.T. Layout, Bangalore, Karnataka-560054, Pp. 127, Rs 27.

THE Operational Research (O.R.) approach to management decision problems in policy-making has not been very popular in Indian business world or government organisations. In the book under review Dr. Anand Khare emphasizes the importance of O. R. approach to 'well outlined and positive policy decisions' for successful performance of any organisation. He deals with the applications of Management Decisions Techniques (MTD) that have greatest profit potential and could aid operational efficiency of the organisation. Broadly, these applications relate to planning, organising, controlling and development.

The book is divided into two parts. While the first half treats concepts of decision-making techniques, the second half discusses their applications to project planning and organisational structure.

Dr. Khare aims at acquainting the reader with basic conception underlying the problems of decision making. This he has done with a remarkable success by providing a simpler and readily digestible genesis of a somewhat complicated subject. In the process he gives an interesting but a cursory account of several decision-making techniques including Linear and Dynamic Programming, Games Theory, Information Theory, Queueing Theory and PERT/CPM.

One cannot but agree with the author that for the success of policy decisions, both personal qualities of the decision-maker and the techniques applied by him are equally important factors. In the first two chapters on 'Spirit of the Organisation' and 'Creative Drive' the author discusses personal qualities demanded of the executive—for what he describes as 'creative tasks' differentiating these from routine tasks as essential for dynamic understanding of the problems involved. Dr. Khare's own ideas about organisational structure are explicitly stated in the last chapter of the book. He demonstrates practical wisdom by often asking our educational institutions to become self-reliant and 'nobody's lame duck.' He suggests an appropriate model for functioning of a department in an educational institution. The heuristic model discussed by the author at length for a commercial enterprise reflects valuable insight.

However, the book has its shortcomings. Reading through the pages, one gets a feeling that Dr. Khare has been too precise and brief in his treatment of topics he should have dealt with at length. The whole treatment of MDT has been compressed to a mere 27 pages. One expected much more than a mere exposition of the concepts involved. Material presented lacks in integrity. The switchover from one topic to another is abrupt and disjointed. A broader and more integrated approach, one feels, would have increased the value of the book to a great extent.

SUBHASH DEO

INVISCID GAS DYNAMICS by Pradip Niyogi, *The Macmillan Company of India Ltd.*, 2/10, Ansari Road, Daryaganj, N. Delhi-110002, 1977, Pp. 482. Rs. 40.50

WITH the tremendous progress that has taken place during the last two decades in the field of air and space propulsion, many branches of knowledge have sprung up and grown to gigantic size. One such is the subject of gas dynamics. This subject is however not completely new. It originated in the nineteenth century but got its present status and importance only because of rapid developments, in the recent past, of jet propulsion, supersonic aircrafts, space vehicles and artificial satellites.

The book under review is a commendable piece of work. Well graded topics ranging from elements of thermodynamics to the hypersonic flow and supersonic aerodynamics of the wings give an insight into the subject. The book is written in an easy-to-follow style and various physical concepts are well explained. There are a large number of problems at the end of each chapter and difficult ones are provided with hints. References for those who want to probe the matter further are also given. Advance level material pertaining to the topics like flow for which Mach number is nearly unity, or far more than unity, is given in the latter part of the volume. In the opinion of the reviewer, the book can be useful to those who have even the slightest affiliation with aeronautics, space sciences and allied fields. There are, however, sporadic instances of misprints. The price of the book, too, is high even though its publication has been subsidised by National Book Trust.

R. K. BHATNAGAR

INTRODUCTION TO SEMICONDUCTOR DEVICES by K. J. M. Rao, *Oxford and IBH Publishing Co.*, 66, Janpath, New Delhi-110001, Pp. 221, Rs. 16.00

AFTER the discovery of p-n junction transistor, semi-

conductor devices drew a considerable attention of the scientists and engineers. Since then there has been a fast development in the field of semiconductor physics and devices. Many semiconductor devices reached the manufacturer straight away from the laboratory without becoming a part of teaching course. However, devices like Gunn and IMPATT diodes, which are now commercially available, have recently been introduced in the courses of Indian Universities and institutes.

The author, who is with the National Defence Academy, Pune, has attempted to introduce basic principles of these semiconductor devices along with considerable mathematical calculations. Approximately half of the book is devoted to the physics of semiconductor materials and current flow, properties of p-n junctions and transistors. The rest deals with junction field effect transistors, metal oxide semiconductor field effect transistors, microwave semiconductor devices like Varactor, PIN, IMPATT, Tunnel and Gunn diodes, and opto-electronic devices, including solar cell and laser.

Although the author has attempted to include new semiconductor devices and has tried to make their discussion interesting, the book lacks emphasis on their limitations and scope. The reviewer feels that the chapter on microwave semiconductor devices is poorly written. While describing IMPATT diode, the author does not mention the concept of small and large signal analyses—an important feature. The author has calculated the small-signal impedance of the device, but he has given no information on how the power output and efficiency of the device can be obtained from it. This information can be obtained only by the large-signal analysis taking into account the effect of an ac voltage on conductance and susceptance of the IMPATT diode. The author writes (p. 174), 'Even though the theory of the Read diode is simple, the diode is difficult to fabricate.' He forgets to mention an alternative IMPATT structure which is widely fabricated and is commercially available.

The book was published at a time (1977) when it was well known that when a simple p-n junction is reversed biased into avalanche break down, the IMPATT operation can be achieved. This was experimentally shown as far back as 1965. In fact, simple p-n junction IMPATT diodes are now commercially available. But this has not been mentioned. If space was the problem, the author should have given a list of references for further reading.

The book is of use to the students of physics and electronics engineering, who are studying semiconductor devices.

VIJENDER SHARMA

NUMERICAL PROBLEMS IN PHYSICS *by* D. D. Mulherkar, *Macmillan Co. of India*, 2/10, Ansari Road, New Delhi-110002, Pp. 90 Rs. 6.50.

HERE is a small book on a subject, which, without going into details, would help a student grasp the art of tackling problems in physics. It contains over 400 exercises and problems carefully designed to suit the requirements of the plus 2 level of ISCE/AIHS boards and the Medical, IIT and Engineering entrance examinations. Some of the problems, claims the author, are original, drawn fron his extensive teaching experience. Hints for solving difficult problems are given wherever necessary.

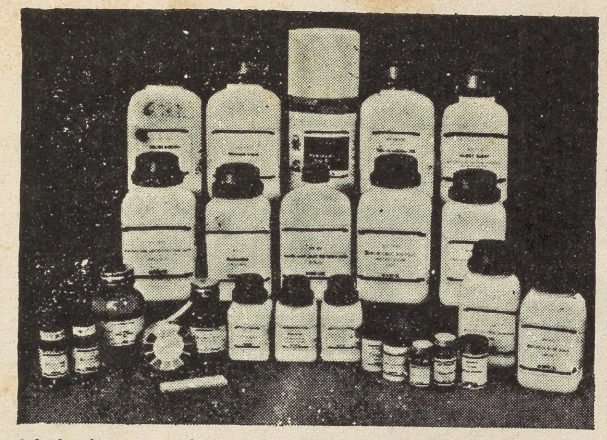
The author has however introduced the formulae and the concerned theory so briefly that even which symbol stands for what is not mentioned! Though, for a student conversant with the subject matter, such a treatment would prove no problem, for a beginner it would be instead a "symbolical" problem!

SOLAR NOISE STORMS by E. O. Elgaroy, *Pergamon Press*, Headington Hill Hall, Oxford OX3 OBW, England, Pp. 363, $ 18.

THIS is a highly specialised monograph written by a scientist who has been working i' the field for more than two decades now. The author hopes that "it would be of value for the planning of new experiments and that the reader be inspired to new and fresh attacks on the problem." It would be of great value to observatories in India where work in this field is in progress.

RADIO GALAXIES, by A. G. Pacholczyk, *Pergamon Press*, (as above), Pp. 293, $ 25.

THIS specialised monograph is a sequel to the earlier monograph *Radio Astrophysics*, to be followed by one on evolution of radio sources, the problem of quasars, their red shifts and radio cosmology. The monograph would serve as a text book as well, for it contains introductory material and the requisite background. Students with an average background in physics and astronomy would also be able to follow the subject. The monograph is however primarily addressed to radio astronomers and researchers working on the interpretation of observational data.



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