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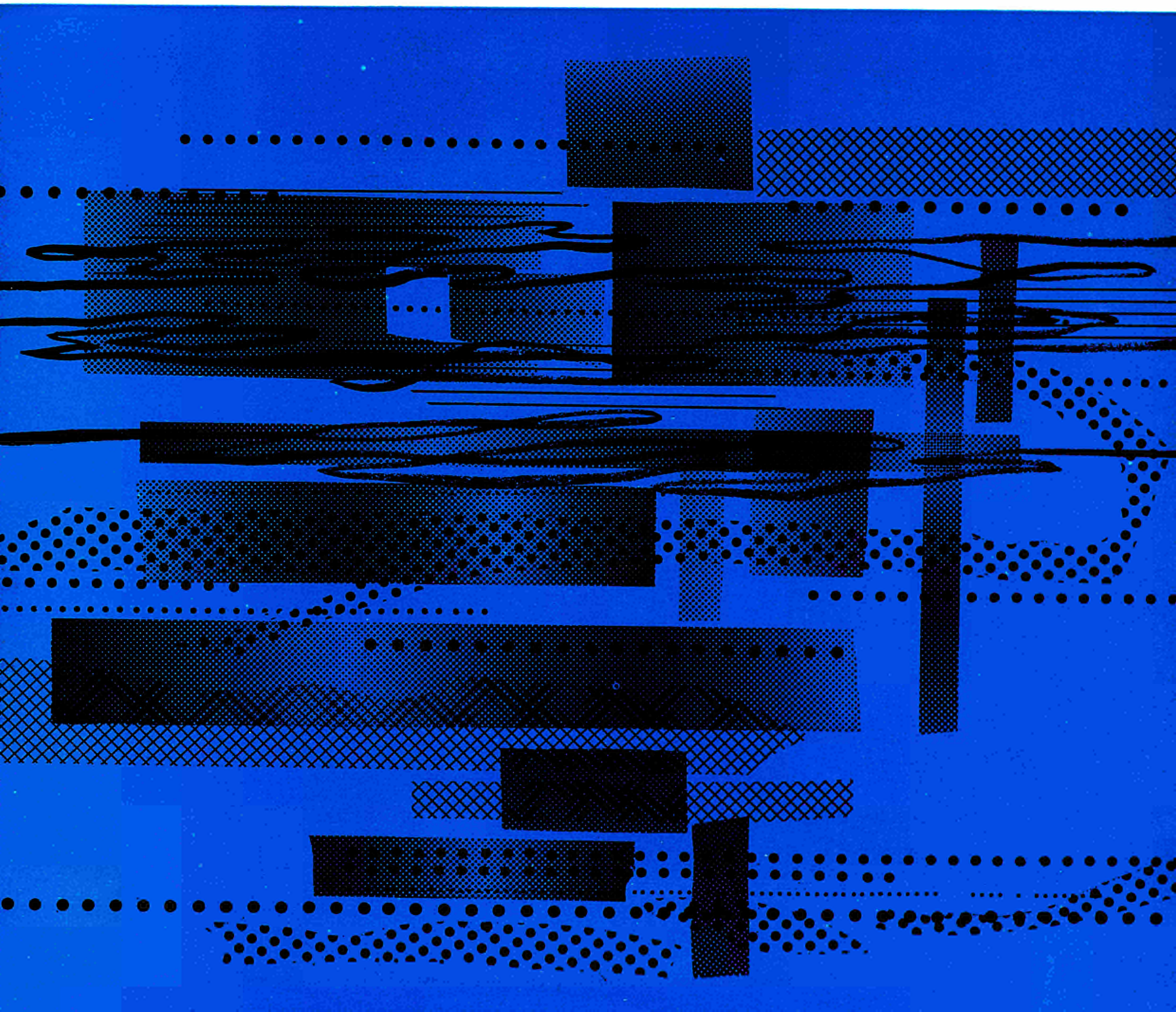
SCIENTIFIC
AND
TECHNICAL REVIEW
OF THE
COMMISSION OF THE
EUROPEAN
COMMUNITIES

MARCH 1973
VOL. XII
NO. 1



Quarterly publication

1973 - 1

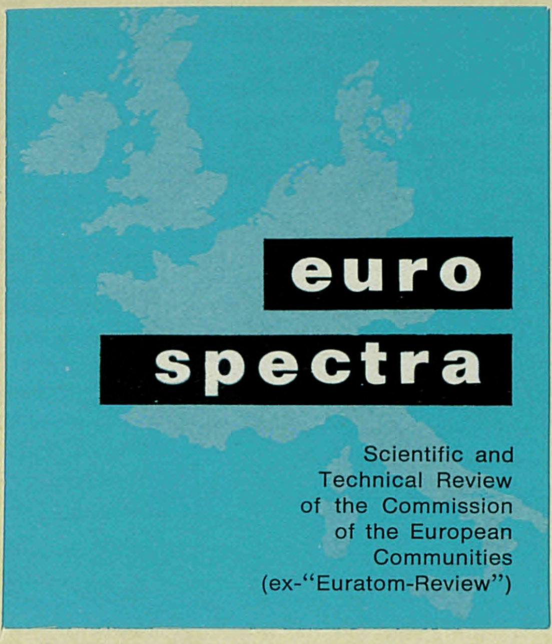
Contents

Five editions:

English, German, French, Italian and Dutch

Published and edited by:

Commission of the European Communities, Directorate-General Dissemination of Information, Rue de la Loi, 200 1040 Brussels. Tel. 350040



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Scientific and Technical Review of the Commission of the European Communities (ex-"Euratom-Review")

Picture credits: Drawings cover and pp. 26, 29, 30: Gaston Bogaert, Brussels; p. 28: Gripp, Ispra; pictures pp. 2, 6, 7: Photothèque CEC.

Printed in Belgium by Maison d'Edition s.c
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We have long been told that this will be a decisive year for the Community, and indeed it seems to have begun encouragingly.

The year has already witnessed a series of events of cardinal importance for Europe's future: in January, the enlargement of the Community with the entry of Britain, Denmark and Ireland, and the installation of the new Commission; in February, the favourable decision of the Council of Ministers concerning a four-year programme for the Joint Research Centre.

We are bound to be gratified by the steady pace at which the various Community problems are being tackled and studied; we are well aware that they are still numerous and not easy to solve, but the new Commission is clearly imbued with a dynamic spirit which augurs well for the future and — in our opinion — justifies a comforting feeling of controlled optimism.

Biochemistry of aging

GOTTFRIED JUPPE

WE HAVE ALL become used to the idea that in time we grow old. The aging process in itself clearly imposes a limit on our lives. But on the basis of present-day scientific knowledge we cannot logically explain why the phenomena of aging have to occur. There is certainly no biological necessity for them. It is possible to conceive other feedback mechanisms which could control population density and keep the number of individuals, including man, in a reasonable ecological balance.

A bacterial culture, for example, is immortal — at least theoretically. There is no intrinsic aging mechanism in bacteria. The life and size of a bacterial population are limited solely by external influences such as the supply of nutritional solution, the size of the vessel, temperature, etc., which can always be controlled and which in the most favourable circumstances allow a bacterial culture to remain active indefinitely.

Even when considering the life of higher organisms we come very close to the notion of the immortality of the individual. A plant can keep alive indefinitely through clones, as long as external conditions permit. Clones are fully formed and fully grown parts of the individual, which in themselves have nothing to do with the apparatus of biological reproduction. It simply happens that a twig of an old sequoia tree, which would certainly die sooner or later through external influences, roots in the earth and thereby allows the same individual to go on living. This process could at least in theory be repeated indefinitely.

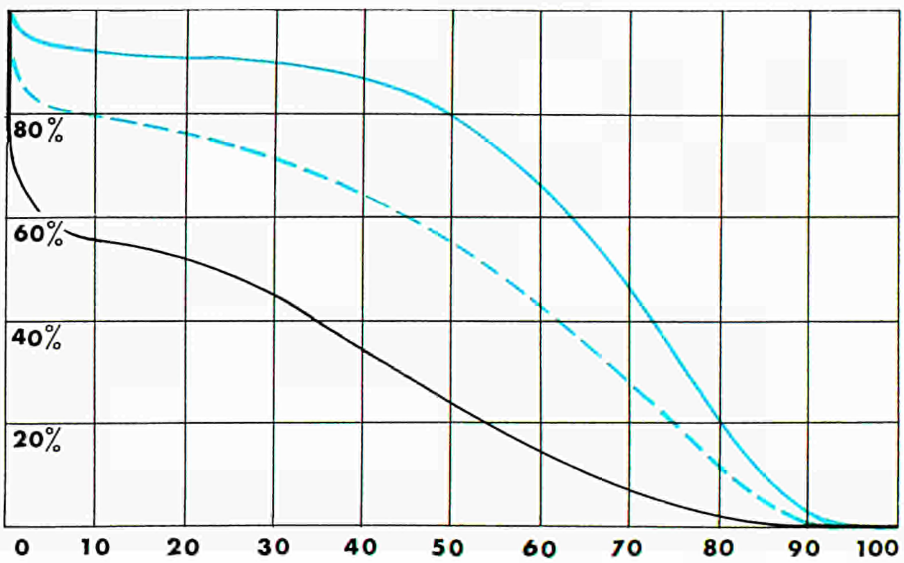
However, experience with the more highly developed animal organisms shows that there is no immortality. From the beginning of life biological changes occur which make us ever more susceptible to disease, less resistant to strain and less capable of repairing biological damage. These aging symptoms stand in a causal relationship to disease and death. Even a young individual, as yet little or not at all aged, can be destroyed by the same diseases as an old one. It is even factually established that disease does not in itself lead to aging. At all age levels there is an approximately equal probability that a given disease will result in death. Admittedly, the frequency with which an acute disease is not survived increases with age. This, however, only shows that with increasing age the body's resistance declines.

First of all we must correct one preconception: so far we have not succeeded in lengthening the human individual's maximum life expectation. It is true that *on the average* the Euro-American is living twice as long as his predecessor did 100 years ago, but his *maximum* life span has nonetheless remained more or less the same. Moreover, the Biblical tradition of "three-score-and-ten" is probably a mere legend; in all likelihood there has always been about the same percentage of people living to a high old age.

The increased life expectation in the last 100 years has really been a bonus only for the young, who have benefited from such advances as the reduction in infantile mortality, the mastery of most of the infectious diseases, the successful battle against epidemics and improvements in hygiene (Fig. 1). The days are gone when a child was named only when it had got over the smallpox. But there is no basis for the assertion now being aired by some futurologists that by the year 2050 men will be living to about 150 years of age.

Even the medicine of the future will scarcely be able to extend the maximum life span substantially. A recent US study has indicated the following picture: if it were possible to cure all heart and kidney disorders, the average age of the Euro-American would be increased by only seven years. If the cancer problem

Fig. 1: *This diagram clearly shows that in 1940 there were as many centenarians as in 1901. (On the absciss the age in years; on the ordinate the percent of survivors). The two lines in colour indicate the situation in the United States: the solid line refers to 1940, the dotted line to 1901. The line in black shows the development in India in the year 1925.*



GOTTFRIED JUPPE - *Joint Research Centre* of the Commission of the European Communities, Ispra Establishment.

were to be solved, we could expect a gain of only one-and-a-half years in life expectation. The mastery of all the infectious diseases would bring an even smaller premium. Mice isolated from all germs live no longer than those reared in a normal environment. These figures show that conventional medicine offers very little scope for raising the average age. The maximum life expectation, i.e. the absolute number of centenarians, will probably be unaffected by foreseeable advances in therapeutic and preventive medicine.

What is "aging"?

We must strike out along quite different paths from those of conventional medicine, if we wish to increase the maximum life expectation drastically, and we will get nowhere without an exact knowledge of molecular and biological processes in the cell and subcellular structures. We are just beginning to obtain a glimpse of the biochemistry of the aging cell and organism. All previous observations are now considered empirical, and have first to be translated into the language of molecular biology.

A few years ago, in England, Harman and Comfort (1) succeeded in appreciably prolonging the life of mice by adding certain organic compounds to their food (Fig. 2). While only nine out of 100 mice in a control group receiving a standard diet lived to be older than 20 months, 13 mice receiving a permanent addition of 0.5 % vitamin E survived beyond this age. When the diet was enriched with 0.5 % butylated hydroxytoluene, 61 out of 100 mice survived this limit. The addition of 1 % diethyl dithiocarbamate or 0.25 % ethoxyquin raised the percentage of survivors to 66 and 75 respectively.

These compounds all have one chemical property in common — that of intervening in oxidation reactions. Before we try to explain this effect in terms of molecular biology, let us mention two further observations. Firstly, there is another specific type of compound known to the chemist which has the property of capturing short-lived and reactive radicals such as occur in various chemical reactions, and making them inert and unreactive. In experiments on rats this type of compound too, e.g., thiourea, folic acid, cysteamine and thiazolidine carboxylic acid, has been found to prolong life when mixed with the daily food. Secondly, life under increased oxygen pressure speeded up the aging process, the maximum age of mice being appreciably lowered. But when the mice were at the same time fed with mercaptoethylamine, glutathione, cysteine, propyl gallate and other compounds, which also belong to the class of radical scavengers, this oxygen effect did not occur.

How can compounds which intervene in oxidation-reduction reactions, and radical scavengers, influence the aging process? Radicals play a decisive part in both normal and pathological life processes, including oxidation and reduction. For example, the coenzyme Q, which occurs abundantly in the organism and is a well-known hydrogen carrier, is an important redox carrier. In quinone form it can be reduced in a single-electron process to a semi-quinone radical. *In vivo*, however, the process does not stop there. The semi-quinone is reoxidized and the original coenzyme Q reconstituted (Fig. 3). Thus the function of coenzyme Q is to act as an oxidation carrier. These processes have been fully confirmed both *in vitro* and *in vivo*; for instance, the radicals formed in the meantime can be detected by electron spin resonance technique.

Coenzyme Q is similar in structure to vitamin E (Fig. 4), which is stored in very large quantities in the mitochondrial cytoplasmic membranes, the main loci of substrate oxidation in the cell. Its mode of action is also similar, as is sufficiently demonstrated by the fact that it can also be used to cure vitamin E deficiency symptoms. It may reasonably be inferred that one of vitamin E's main tasks is to regulate substrate oxidation processes at the mitochondrial cytoplasmic membranes by capturing excess oxygen biradicals before they react harmfully with these membranes. Ideally a cell should use oxygen only for enzyme reactions, which are strictly controlled by the cell's synthesizing and metabolizing apparatus. Uncontrolled and harmful oxygen reactions with organic cell material should therefore be ruled out; but oxygen does not accept this restriction, and uncontrolled oxidation reactions lead slowly but surely to reactions in which they are harmful. Nature therefore requires antioxidants such as vitamin E in order to minimize these reactions. However, complete inhibition is impossible.

What basis is there for this assumption that excess molecular oxygen leads to undesirable oxidation reactions, e.g., with the cell membranes and the endoplasmic reticulum? There is a continuous flow of oxygen through the cell membranes, a vital component of whose structure consists of lipids made up of unsaturated fatty acids. These can easily be broken down in radical-induced reactions with molecular oxygen, as can be well demonstrated experimentally *in vitro*. Once present, a radical (more about its origin later) reacts with molecular oxygen to form a peroxy radical, which triggers off a chain reaction with nearby fatty acid molecules (Fig. 5). It captures a hydrogen

	Survivors after 20 months (%)
Standard diet (SD)	9 %
SD + Vitamin E	13 %
SD + Butylated hydroxytoluene	61 %
SD + Diethyl dithiocarbamate	66 %
SD + Ethoxyquin	75 %

Fig. 2: *Prolongation of the life of mice obtained by adding certain organic compounds to their food. The effects of the addition are clearly indicated by the per-cent of survivors after twenty months.*

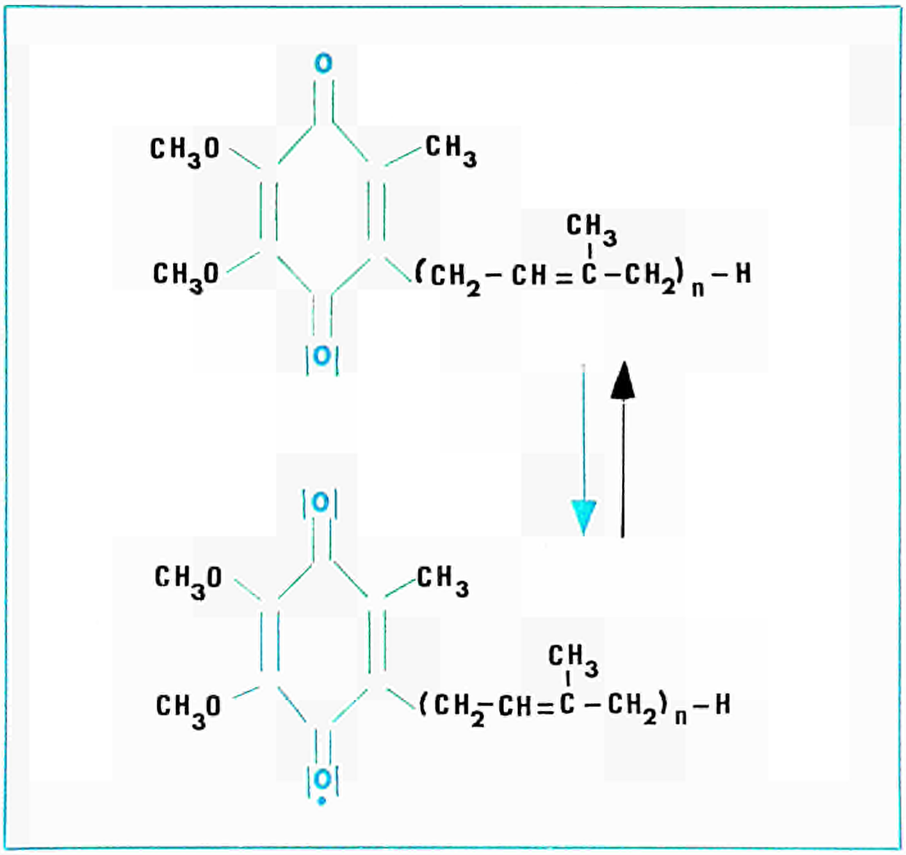


Fig. 3: *Action of coenzyme Q. The quinone form is reduced (coloured arrow) to a semi-quinone which is later reoxidized (black arrow) thus reconstituting the original coenzyme Q.*

atom from an unsaturated fatty acid molecule and in so doing itself forms a hydroperoxide. As a byproduct of this reaction a new radical is formed, which in turn reacts with molecular oxygen to form a new peroxy radical. The net result of the reaction is the direct transformation of unsaturated fatty acid molecules by means of molecular oxygen into hydroperoxides. As it is a chain reaction, a single initial peroxy radical can give rise to a large number of hydroperoxide molecules.

The hydroperoxide molecules can decompose both *in vitro* and *in vivo*, forming highly reactive hydroxy and alkoxy radicals. These attack other molecules as well as unsaturated fatty acids indiscriminately, and even protein molecules or nucleic acids are not safe from them.

At room temperature this hydroperoxide decomposition is admittedly very slow, but it is catalysed by transition metals, so that in the presence of iron ions the reaction is about 100 million times faster than normally. The cellular fluid contains sufficient concentrations of iron, copper and other transition elements to catalyse hydroperoxide decomposition and form highly reactive hydroxy and alkoxy radicals.

Pigments of aging

What are the products of the radical-induced oxidation of lipid fatty acids? They are — at least in part — the lipofuscins or aging pigments. Lipofuscins are coloured compounds which are continually deposited in the tissues, particularly the heart and brain cells, and are in themselves harmless and unreactive. Aging pigments amounting to about 0.3 % of the weight of the human heart are deposited in it during every ten years of life. Chemical analysis shows that lipofuscins are decomposition products of lipid fatty acids. It is known

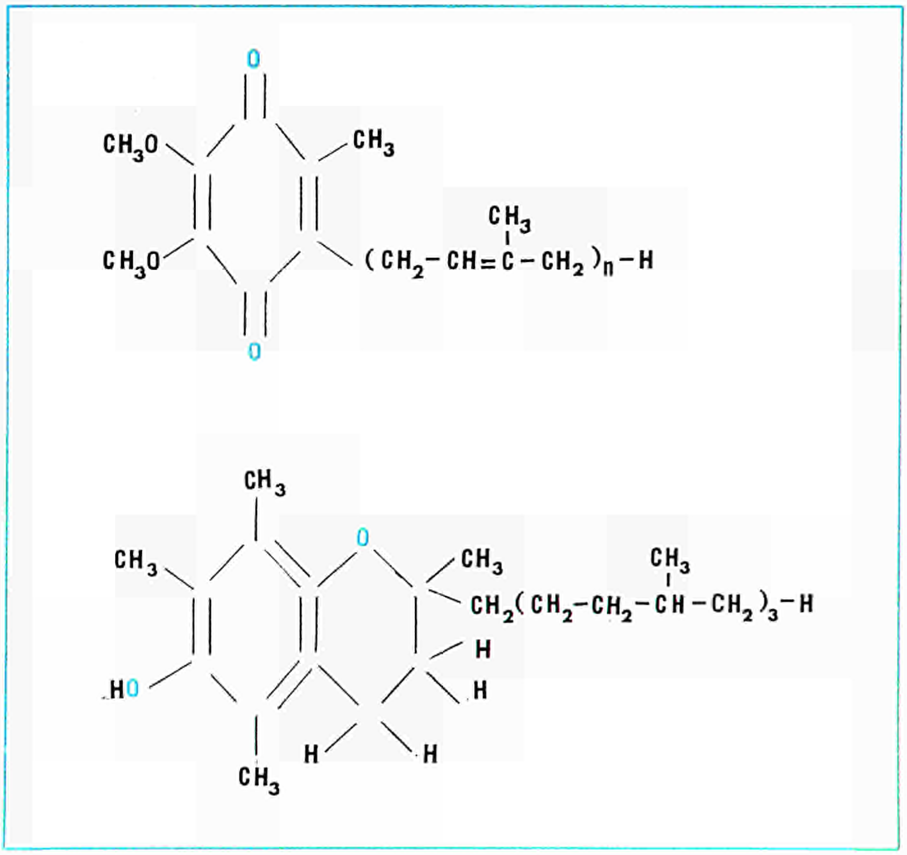
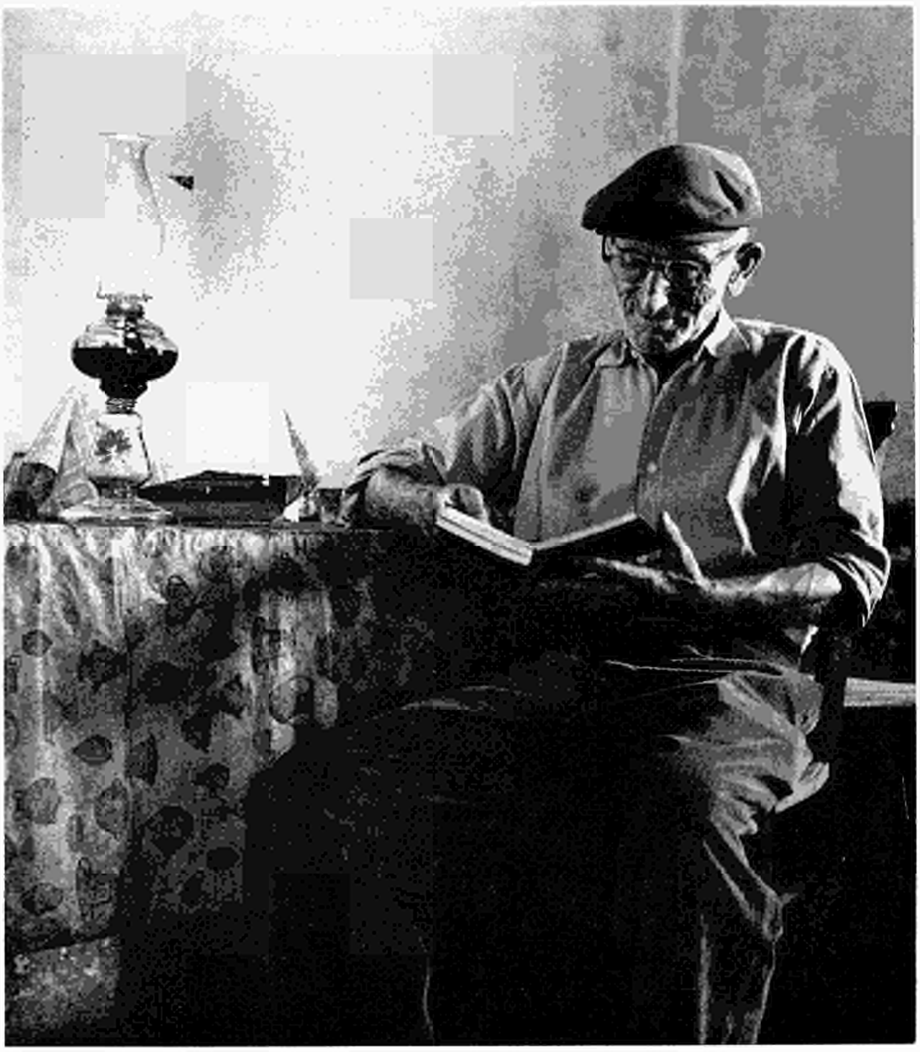


Fig. 4: *Structures of coenzyme Q (upper) and Vitamin E (lower): they are very similar, as well as their mode of action.*

Fig. 5: *Radical-induced oxidation of unsaturated fatty acids.*

Start	$R^\bullet$	+	O_2	$\longrightarrow$	$ROO^\bullet$
Chain	$ROO^\bullet$	+	HR	$\longrightarrow$	$ROOH + R^\bullet$
	$R^\bullet$	+	O_2	$\longrightarrow$	$ROO^\bullet$
Net reaction	HR	+	O_2	$\longrightarrow$	$ROOH$
Sequel reaction	$ROOH$	$\longrightarrow$	$RO^\bullet$	+	$OH^\bullet$



that the oxidation of unsaturated fatty acids in the cell membrane lipids is accompanied by the formation of malonaldehyde. A sensitive technique, the thiobarbituric acid test, was developed for the detection of malonaldehyde; with this test it can be shown that malonaldehyde formation depends on the concentration of vitamin E in the mitochondrial cytoplasmic membranes. The more vitamin E is stored, the less malonaldehyde formation there is; and it is possible *in vitro* to convert malonaldehyde with proteins into compounds which have a fluorescence spectrum similar to that of lipofuscins.

The lipofuscins are not the only decomposition products which are formed during the radical-induced oxidation of polyunsaturated lipid fatty acids. A number of observations suggest that other reaction products much more reactive than the lipofuscins are formed, which can deactivate critical enzyme systems, and in particular can paralyse the cell's energy-producing systems. This effect occurs in addition to the destruction of the mitochondrial membranes, the sites of the Krebs cycle reaction and of the electron transport chain — processes which are of great significance for the gaining of energy.

A further indication that vitamin E protects cell membranes against oxidative destruction is that hydrogen peroxide, a powerful oxidant, attacks the membranes of red blood cells. However, the haemolysis is only significant when 100 ml serum contain less than 0.5 mg vitamin E. This finding was recently developed into a semiquantitative detection of vitamin E concentrations in the blood.

It is certain that radical-induced oxidation reactions are at least partly responsible for biological degeneration. Obviously, however, other non-oxidative radical reactions also play a part in the aging process.

Physiological aspects of aging

In studying the phenomena of aging it is better to look for physiological degenerative syndromes and to disregard pathological aspects. One degenerative syndrome is clearly the shrinking and wrinkling of the skin of aging persons. It is worth while to study this phenomenon, which consists in a stiffening of the supporting connective tissue. This tissue represents about 30 % of the substance of the human body and is mainly composed of the scleroproteins collagen and elastin. What does collagen look like, and how does it alter with advancing age? Initially the scleroprotein tropocollagen is formed from the cells of the connective tissue. The tropocollagen molecules have a microstructure in which three peptide chains are arranged in a helix. Three amino acids, proline, hydroxyproline and glycine participate in each winding (Fig. 6). These chains are linked together relatively loosely by hydrogen. The tropocollagen molecule has a molecular weight of about 300 000, and is 2 800 Å long and 14 Å thick.

The final collagen fibres are formed when the tropocollagen molecules, which are twisted like ropes, bunch together side by side. They are then linked with one another by main valency bonds. With increasing age the number of main valency linkages increases. This is due to a cross-linking reaction, which is obviously radical-induced; as a result the supporting connective tissue shrinks and the skin becomes wrinkled. The increasing stiffness of the protein structure can be determined quantitatively by mechanical, isotonic or isometric measurements, and evaluated as an aging parameter.

Cross-linking reactions of the scleroproteins are to a large extent innocuous for the organism. But much more serious consequences could be expected if with increasing age similar radical-induced cross-linking reactions were to occur in other proteins of the organism. All the enzymes which catalyse metabolism are also proteins. Unlike the scleroproteins of the supporting connective tissue, however, they have an active chemical function to fulfil. Their effect is related to a particular and unchanging geometrical molecular structure, which alone ensures the specificity of the action of a given enzyme (transferases, oxydoreductases, hydrolases, isomerases, etc.). The spatial structure of a specific enzyme molecule is always such that only a particular kind of substrate molecule can be fitted into it and acted upon. The action of the enzyme proteins is closely related to their secondary structure (e.g., α-structure of a polypeptide chain), tertiary structure (unregular but characteristic folding of the α-helix) or quaternary structure (e.g., tertiary units in pairs). Cross-linking reactions such as occur in the scleroproteins with increasing age would have disastrous consequences for enzyme protein molecules. The fusion of two molecules into one would inevitably alter the geometrical properties, and the enzyme would thereby lose, or at least change, its specificity of action. The result would be an unusable enzyme molecule, or even worse, an enzyme molecule catalysing a wrong metabolic reaction. In both cases the organism would be weakened, and any repair systems available would be subjected to considerable — or even excessive — stress.

The fact that immunological reactions increase with advancing age shows clearly that proteins undergo negative changes during the course of life. The γ-globulin values become greater and the average weight of the spleen increases. Apparently there are continual changes in several protein molecules. Types of protein appear which differ from those proper to the body, leading to immune and anaphylactic reactions. Many diseases of old age, such as rheumatoid arthritis, are clearly attributable to autoimmune reactions, and these reactions are explicable not only as a pathological but also as a degenerative syndrome. With young mice skin grafts are about 75% successful; with old mice the rate is almost zero. It is therefore hardly surprising that regular dosing with immunosuppressors prolongs the life of mice.

Age and nucleic acids

What happens if with increasing age the nucleic acids of the organism also take part in cross-linking reactions? For every cell function there is a specific *DNA* molecule in the chromosome set. This molecule synthesizes a corresponding *RNA* molecule, which in turn constructs a specific protein, usually an enzyme. The enzyme catalyses a reaction which is necessary for cell functioning. The molecular components of *DNA* are found to be adenine nucleotide (abbreviated to A), cytosine nucleotide (C), guanine nucleotide (G) and thymine nucleotide (T). In *RNA* the first three of these nucleotides are again used, but uracil nucleotide (U) is incorporated as the fourth component instead of thymine nucleotide (Fig. 7). These mononucleotides are grouped as triplets in both *DNA* and *RNA*. Each triplet controls the incorporation of a particular amino acid during protein synthesis. The triplet is an information unit, a code. The guanine-adenine-uracil sequence (G-A-U), for example, is responsible for the incorporation of the amino acid asparagine.

The phenomenon of cross-linking reactions in *DNA* or *RNA* molecules and its consequences have already been studied: if cells are irradiated with *UV* light, "premutations" occur in radical-induced reactions in the *DNA* molecules. One of the results of this is that two thymine nucleotides are bonded into a single molecule in a cross-linking reaction. Difficulties subsequently occur in the replication of the *DNA* molecule and in the transcription. The processes which occur here have been well studied in another case of premutation formation. Clearly-characterized premutations can also be induced by means of nitrous acid, which specifically attacks the adenine nucleotide (A) and transforms it into a hypoxanthine base (HX). The original thymine-adenine-cytosine (T-A-C) triplet (codon) thus becomes a thymine-hypoxanthine-cytosine (T-HX-C) triplet. During the formation of the complementary thread in the course of the identical replication, adenine would pair with thymine (thymine always pairs with adenine, adenine with thymine, cytosine with guanine), so that the "anti-triplet" (anti-codon) adenine-thymine-guanine (A-T-G) would be formed. But the adenine has become

Fig. 6: *Structure of collagen. Tropocollagen is composed of three amino acids (proline, hydroxyproline and glycine) whose structures are shown on the left. They form peptide chains (centre) linked together by hydrogen bonds. The final collagen structure is shown on the right: tropocollagen molecules are twisted like ropes and linked together by main valency bonds. The aging process causes the number of valency bonds to increase, and the whole connective tissue loses elasticity.*

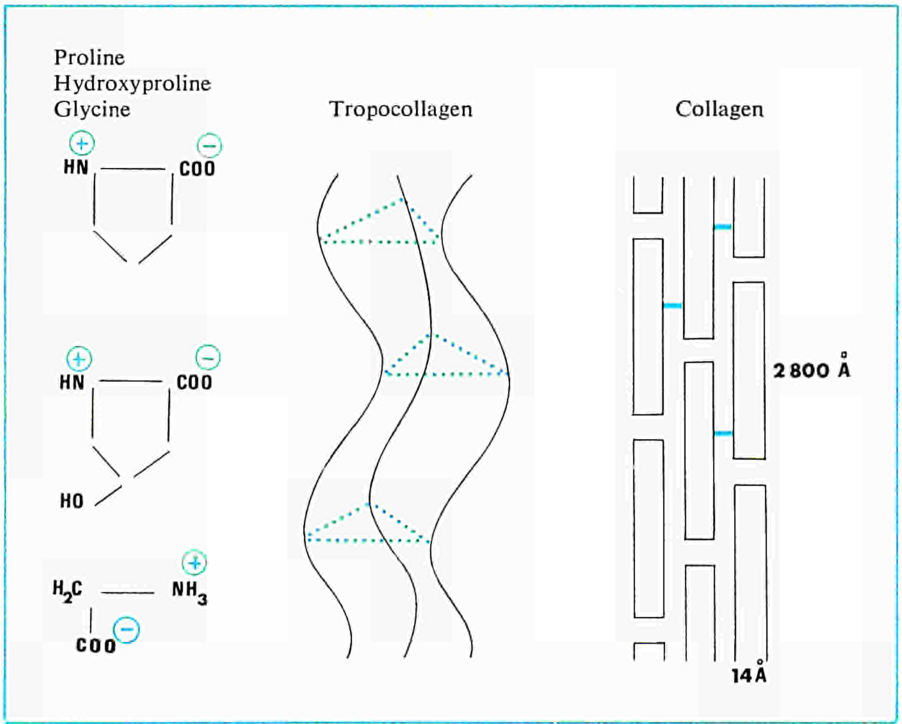
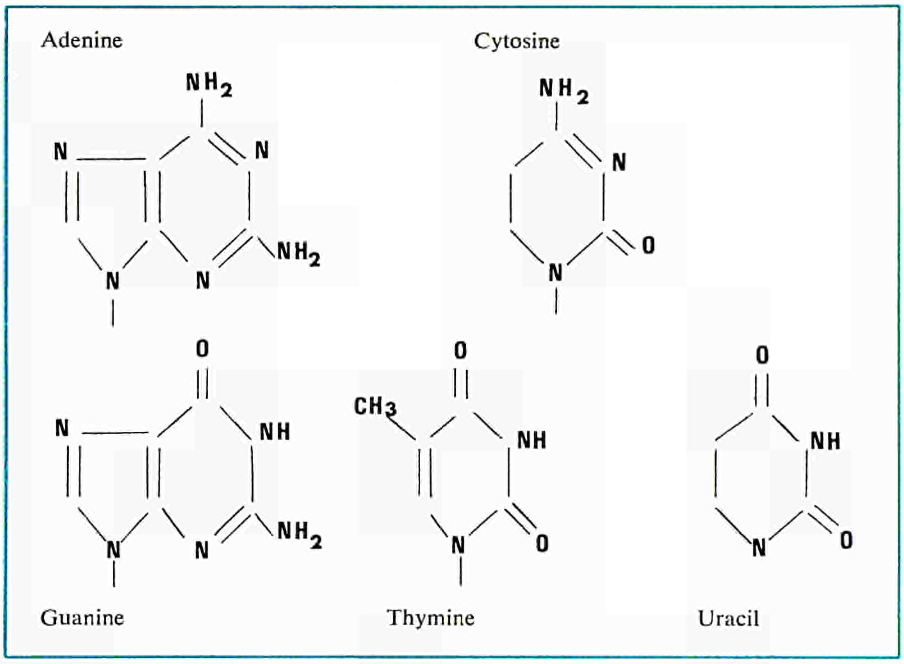


Fig. 7: *Components of* DNA *are cytosine, guanine, thymine and adenine nucleotides.* RNA *contains the same nucleotides except thymine, which is replaced by uracil.*



hypoxanthine, and hypoxanthine does not pair with thymine but with cytosine. Thus the identical replication leads not to A-T-G but to A-C-G. After the subsequent separation of the double helix this A-C-G triplet pairs with thymine-guanine-cytosine. Thus the original premutation triplet T-A-C has been changed into T-G-C, which is now continually transcribed and replicated (Fig. 8). This has important consequences for amino acid synthesis, because during protein synthesis the triplet T-A-C codes the incorporation of methionine, while T-G-C codes threonine. Thus after the premutation an enzyme is formed from the damaged *RNA* molecule which contains threonine instead of methionine at some particular point of the molecule. The ferment is no longer what it should be. It is valueless and could even be harmful if it were to catalyse a cell reaction different from the one expected.

There is another well-studied case which shows us approximately what would happen if in a cross-linking reaction a base dimer should occur which is twice as heavy as it should be. It is possible deliberately to incorporate acridine mutagens in nucleic acid. The acridines include pigments such as acriflavine and acridine orange, and therapeutic agents such as atebrin and rivanol. These molecules have roughly the molecular size of a base, but once incorporated in nucleic acids they cannot pair with an anti-base in the reduplication and transcription processes. During the replication of a matrix thread, in which an acridine molecule is incorporated instead of a base, an *RNA* molecule is formed in which one base is completely missing. The acridine molecule of the matrix thread is therefore not able to incorporate an anti-base in the complementary thread. Now, however, the nucleic acid molecule has become disordered not only in a single base frequency, as in the premutation case, but in all base frequencies after the location of the accident. In place of the triplet sequence 1-2-3 (responsible for incorporating a given amino acid during the peptide synthesis), followed by 4-5-6 (responsible for the incorporation of another amino acid), 1-2-4 may occur as the first triplet after the loss of the base 3 (Fig. 9). This triplet incorporates an amino acid different from that incorporated by 1-2-3. The second triplet to occur is 5-6-7, which codes the incorporation of a different amino acid from 4-5-6. The further construction of the nucleic acid molecule leads to corresponding miscodings.

Similar miscodings can occur when base dimers are formed in the nucleic acids in cross-linking reactions. How do cross-linking reactions generally occur? It has been sufficiently proved that reactive hydrogen, hydroxy or organic radicals

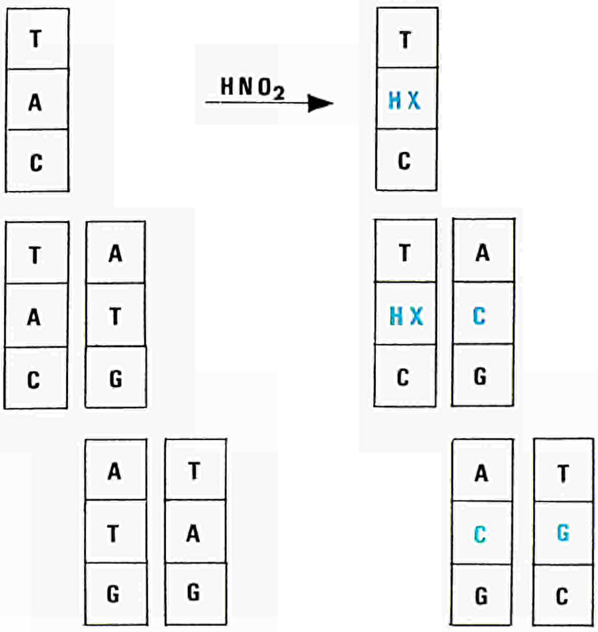


Fig. 8: *Premutations in* DNA *molecules induced by nitrous acid (HNO_2). Nitrous acid transforms the adenine nucleotide (A) into a hypoxanthine base (HX); consequently a thymine-adenine-cytosine triplet (T-A-C) is transformed into a thymine-hypoxanthine-cytosine triplet (T-HX-C). During identical replication, that latter triplet constructs an adenine-cytosine-guanine (A-C-G) triplet, and not an adenine-thymine-guanine (A-T-G) triplet as a thymine-adenine-cytosine (T-A-C) codon would do. In this way, during replication a thymine-guanine-cytosine (T-G-C) triplet results instead of the thymine-adenine-cytosine (T-A-C) triplet, being from now on continuously transcribed and replicated.*

(such as occur in the above-mentioned peroxy reactions) are at least partly responsible. For example, if artificially-produced hydrogen radicals, such as are also formed in biological systems, are allowed to react with *DNA*, an electron spin resonance spectrum is obtained which can clearly be assigned to a thymine radical (Fig. 10). The thymine radical then reacts in a cross-linking reaction to become a thymine dimer.

Do radiations have an aging effect?

The radicals concerned can also be produced by high-energy radiation. A similar derivative of a thymine dimer is obtained by radiolysis of an aqueous thymine solution (Fig. 11). During the radiolysis of water — water which is abundantly present in the organism either directly or as a hydrate sheath — the main substances formed are hydrogen, hydroxy radicals and solvatized electrons. Hydroxy radicals spontaneously attack thymine molecules and form hydroxylated thymine radicals. The subsequent reactions of the base radicals, leading to the formation of a dimer, or with molecular oxygen to form peroxy radicals, can be followed in the test tube.

High-energy radiation induces many of the degenerative syndromes of aging. The extent to which life is shortened depends on the degree of damage to the chromosomes. The fact that the influence of radiation on life expectation diminishes with increasing age shows that in old individuals similar chromosomal aberrations are already present before irradiation.

We are still largely in the dark as to how radiation damage can subsequently be repaired. If radiation is administered continuously at very low dose-rates, the aging effect is appreciably slighter than if the same total amount of radiation is administered in a single acute dose. It is to be inferred that in the former case the slight continuous damage is not accumulated, but continuously repaired.

These repair mechanisms are apparently active metabolic processes which only take place in the presence of oxygen. Moreover the recovery process occurs as though it were enzyme-controlled. After the absorption of high doses recovery can no longer keep pace with the damage inflicted. Yet another process seems to take place as a passive repair mechanism, i.e. the elimination of aberrations through cell selection on the basis of cell division. Only those cells which replicate themselves quickly can get rid of aberrations through cell selection. These include the bone marrow cells, the cells of the mucous membrane of the stomach, the epithelial cells and the germ cells. Thus it is not possible to observe any increase in chromosomal aberrations in bone marrow with increasing age.

Other types of cells cannot benefit from selection, because they no longer divide in the adult individual. These include the brain cells. They too degenerate, but the damage sustained can be healed only by enzyme-controlled repair mechanisms. This, however, is not always successful. It has been calculated that a seventy-year-old has lost more than 20 % of his original brain cells and that many others are functioning badly.

Two further circumstances are noteworthy.

1. Only cells of the first kind, which can get rid of aberrations through cell selection, develop cancer. Cells of the second kind, which can only make use of the enzymatic repair mechanism, do not develop primary cancer.
2. In the male gonads cell divisions occur continually and somatic mutations in spermatogonia can be eliminated rapidly by cell selection. On the other hand,

Fig. 9: *Incorporation of an acridine mutagen into* DNA *leads to mistakes in paring of the bases during replication and transcription processes. Numbers in black represent the original bases which during replication and transcription pair with corresponding partner bases (numbers in colour). In this figure, an acridine molecule (A) occupies the position of the partner base 3, which is then missing. During the following replication of the complementary chain, also the original base 3 disappears, and as first codon a base sequence 1-2-4 instead of 1-2-3 results.*

Matrix thread	1	2	3	4	5	6	7
Complementary thread	1	2	3	4	5	6	7

Matrix thread	1	2	3	4	5	6	7
Complementary thread	1	2	(A)	4	5	6	7

Replication	1	2	4	5	6	7	8
Complementary thread	1	2	4	5	6	7	8

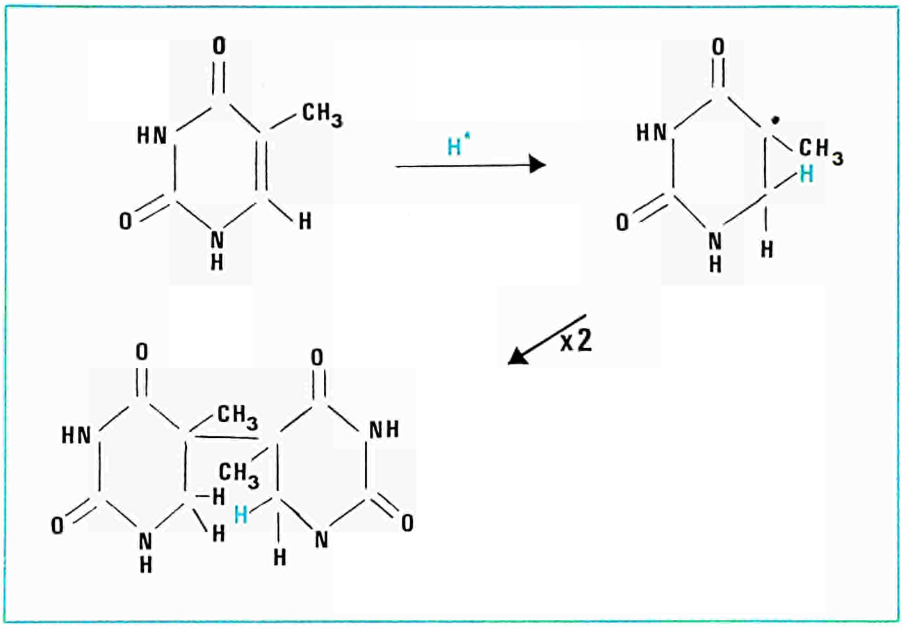


Fig. 10: *Reaction of thymine molecules with hydrogen radicals gives rise to the formation of thymine radicals, which subsequently dimerize forming stable molecules.*

in the female the oocytes, which remain in the ovaries for a long time without cell division, store up aberrations, some of which survive meiosis. It has been known for some years that both in mice and men the offsprings of old mothers have more hereditary defects and a shorter life expectation than those of younger mothers. The father's age is immaterial. Mongolism, for example, is due to such a genetic effect. It occurs many times more frequently in children of mothers over forty years of age than in the children of twenty-year-old mothers.

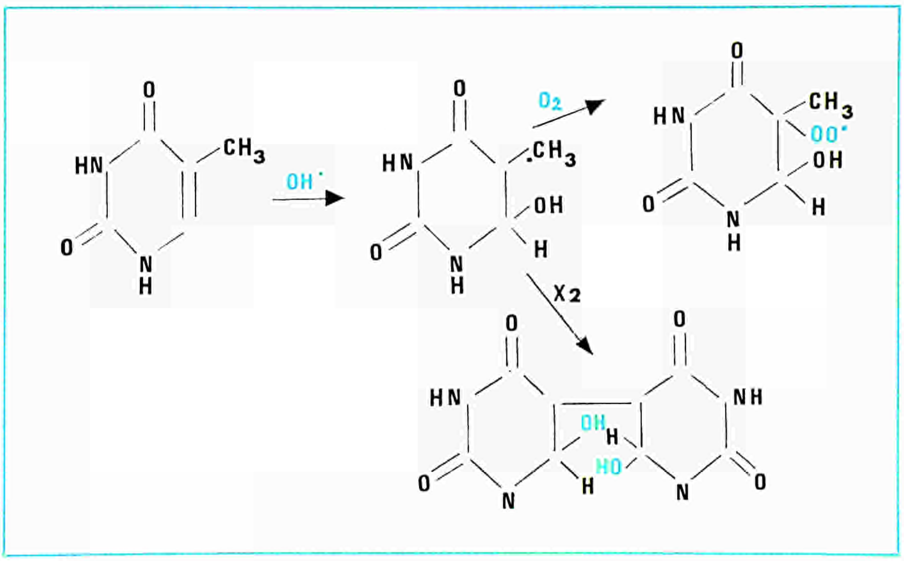
Many symptoms of aging can be simulated by the administration of high-energy radiation. This might suggest that cosmic radiation is responsible for cross-linking and other deleterious radical reactions, but this is certainly incorrect. The influence of cosmic radiation is negligible and is spontaneously repaired almost entirely. A single dose of 1 000 rad is certain to kill a mammal, but the same dose is not dangerous when administered over a period of a year. The dose absorbed from cosmic radiation is 1/10 000th of this, being only 0.1 rad per year. No doubt it may still be held responsible for extremely rare genetic mutations, but not for cumulative cell and molecular aberrations.

The ozone in the air is certainly a much more dangerous source of chain-inducing radicals than natural radiation. Normal concentrations of about 0.2 ppm, which can rise to 0.6 ppm through air pollution, deliver about 100 000 times higher radical concentrations via the lungs than those received by the tissues from cosmic radiation.

We are still far from having a full picture of the aging process. This applies both to the causes and to their effects on molecular-biological processes. But it is nonetheless clear that some of the negative changes which from birth onward tend via feedback mechanisms to impair the inner equilibrium of the organism can be convincingly explained in terms of cumulative damage to the macromolecules.

EUSPA 12-1

Fig. 11: *Radiolysis of an aqueous thymine solution leads to the formation of hydroxy and other reactive radicals. The attack of hydroxy radicals gives rise to the production of subsituted thymine radicals which can form either dimers or — with molecular oxygen — peroxy radicals.*



Literature: (1) A. COMFORT : *Geriatrics,* (1970) *25,* p. 3. (2) H.J. CURTIS: *Biological Mechanisms of Aging,* Charles C. Thomas, Publisher, Springfield, Illinois, 1966. (3) H. EYRING: *Sci. News,* (1970) *98,* p. 270. (4) D. HARMAN: *J. Gerontol.,* (1956) *11,* p. 298. (5) D. HARMAN: *J. Am. Geriatrics Soc.,* (1969) *17,* p. 721. (6) P.J. LINDOP, G.A. SACHER: *Radiation and Aging,* Taylor and Francis, Ltd., London 1966. (7) D.B. MENZEL: *Annu. Rev. Pharmacol.,* (1970) *10,* p. 379. (8) R.A. PASSWATER, P.A. WELKER: *International Laboratory,* (1971) *24,* p. 37. (9) W.A. PRYOR: *Chem. Eng. News,* (1968) *46,* p. 70. (10) W.A. PRYOR: *Chem. Eng. News,* (1971) *49,* p. 34. (11) H.J. RHASE: *Sci. Amer.,* (1970) *223,* p. 75. (12) A.L. TAPPEL: *Geriatrics,* (1968) *23,* p. 98. (13) L.A. WITTING: *Progr. Chem. Fats Other Lipids,* (1970) *9,* p. 519. (14) *Aspects of the Biology of Aging,* Symp. Soc. Exp. Biol., Vol. XXI, Academic Press, Inc., New York, N. Y. 1967.

A teledocumentation network for Europe

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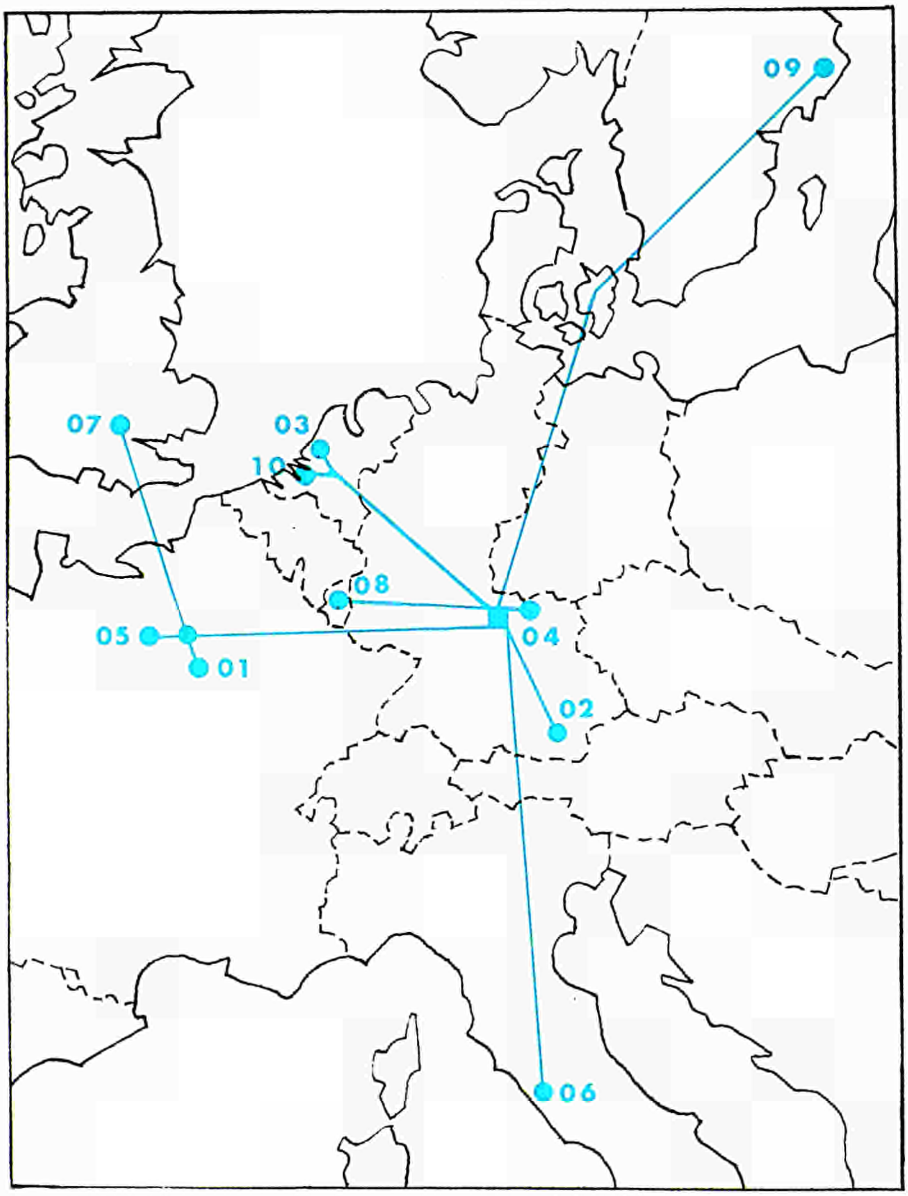


THIS REVIEW, in its issue of September, 1971 (Vol. X, No. 3), mentioned the resolution of the Council of Ministers of the European Community which emphasized the importance of technological information transfer in Europe. On 24 June 1971, the Council in fact stated that it is important for the economic progress of our continent that scientific, technical and economic documentation is made available to all possible users at the most favourable conditions of rapidity and cost. The Council also suggested coordinating all the actions that could add to the progressive constitution of a European network of documentation and information. The efforts of the Commission of the European Communities *(CEC)* are very well known in this field where its Centre for Information and Documentation *(CID)* of Luxembourg can be considered a pioneer in information storage and retrieval and in general in mechanized documentation.

It was therefore natural that the collaboration already existing between the *CID* of the *CEC* and the similar services belonging to "sister" organizations like *ESRO* and *ELDO*[1] was also developed at operational levels.

The *ESRO/ELDO* Space Documentation Service, which is a common service to these two organizations, is operating a network of teledocumentation display terminals on a continental scale. The original suggestion to establish a comprehensive mechanized documentation service stemmed from a report of a group of experts from *COPERS*[2] which evaluated the need of aerospace documentation as a function of the needs of the proposed *ESRO* and *ELDO* programmes. Following the recommendations of this group, a general agreement was negotiated by

Fig. 1: *Location of terminals in the* SDS *Teledocumentation network:*
01 - *Paris (France),* ESRO *H.Q.*
02 - *Munich (West Germany),* ZLDI
03 - *Noordwijk (The Netherlands),* ESTEC
04 - *Darmstadt (West Germany),* ESOC
05 - *Paris (France),* ESRO *H.Q.*
06 - *Frascati (Italy),* ESRIN
07 - *St.Mary Cray (Great Britain),* TRC
08 - *Luxembourg (Grand-Duchy),* CID *Commission of the European Communities*
09 - *Stockholm (Sweden),* RIT
10 - *Noordwijk (The Netherlands),* ESTEC

ESRO with the *National Aeronautics and Space Administration (NASA)* in 1964 and from the beginning *ELDO* was associated with this agreement.

A joint *ESRO/ELDO Space Documentation Service (SDS)* was then created in 1964 with the aim of providing scientific and technical documentation to government establishments, universities and industry in the Member States (see Table I).

The *SDS* was assisted by a *Documentation Consultative Committee (DCC)* to ensure liaison with users and documentation centres in Member States and regulate the principles to be used in charging "for services rendered" to external users.

In 1969, after negotiations with *NASA*, *SDS* envisaged adopting in Europe the *RECON* (*RE*mote *CON*sole) on-line retrieval system, developed in the United States for *NASA* by the *Lockheed Missile and Space Co.*, Palo Alto (California).

In July 1969, the first terminal was installed on-line in Paris and a version of the *RECON/DIALOG* program was adapted under contract with *Lockheed* to be used on the *IBM 370/155* at *ESOC* (the *E*uropean *S*pace *O*perations *C*entre of *ESRO*) in Darmstadt.

This was the first step in the development of the *SDS* network of display terminals installed in seven European countries to date, (1972) (Fig. 1). At the beginning only *NASA* file documents were available, covering mainly space research; later, other files were added such as the *CAC* (Chemical Abstracts Condensates) test file, *METADEX* (Metals Abstracts file of the American Society for Metals), *COMPENDEX* (Engineering Index), *ESRO DATABANK* (electronic components data and test results), *GRA* (Government Research Announcements, previously US Government Research and Development Reports) and *NSA* (Nuclear Science Abstracts).

At the beginning of 1972, the Commission of the European Communities decided to test and evaluate the performance of the *SDS* system, by connecting to the *RECON* network with a terminal located in Luxembourg at the Centre of Information and Documentation (*CID*, Directorate-General XIII — Dissemination of Information). The terminal became operational on 1 July 1972.

[1] *ESRO* (*E*uropean *S*pace *R*esearch *O*rganization), *ELDO* (*E*uropean *L*auncher *D*evelopment *O*rganization).

[2] *CO*mmission *P*réparatoire *E*uropéenne de *R*echerches *S*patiales.

The SDS/RECON System

The *RECON* system is an information retrieval system defined by the following characteristics:

- is of concept-coordination type;
- works in the interactive, on-line mode;
- has a remote processing capability.

"*Concept-coordination*" means that the documents are described by a set of keywords (descriptors), defining by their association the contents of each document unit (Fig. 2). They are retrieved by logic associations of descriptors, by means of the usual boolean operators OR, AND, AND NOT.

"*Interactive*" means that the system response time for each elementary enquiry is of the order of magnitude of that of the human operator, so that a real interaction has to occur at the man/machine interface.

The system user, by means of a very simple language, is able to visualize on a TV screen a fraction of a dictionary, select pertinent descriptors, combine them by boolean operators and display a document surrogate on the same screen when required, in a real conversational routine.

"*Remote-processing*" means that the user can have access to the system by means of visualization terminals which can also be located far from the central computer. The link between the central (computer) and the remote stations (terminals) is realized normally by means of four wire telephone lines, at a signal rate of 2 400 bit/sec. Each remote terminal is equipped with a small (1 kbyte) buffer memory, a keyboard, a TV screen and a 30 character per second teletype (Fig. 3).

As can be seen immediately, the system can be considered "classical" as far as the fundamental document-handling method is concerned. The concept-coordination document analysis is in fact widely used in all the most important documentation systems.

ENDS (*E*uropean *N*uclear *D*ocumentation *S*ystem), developed by the *Euratom/CID*, is designed also on these lines.

Even so, all systems of this kind are in fact computerized extensions of the peek-a-boo method, the concept-coordination idea seeming to be still the only one that can be applied with success to the handling of large databases (more than one million documents).

In fact, although indexing programs for automatically built Thesauri and automatically indexed document references are available at a reasonable price, the concept-coordination principle cannot be dispensed with.

Future systems of course will be able to analyse a free language text on-line and logically using very sophisticated methods of language treatment. Unfortunately, however, we do not yet know enough about the mechanism of this analysis as performed by the human brain and of the synthetic interpretation of full texts. Therefore the concept-coordination principle can still be considered acceptable and, until now, the only one compatible with the demands of fast access to large files.

As far as the efficiency of systems of this kind is concerned, measurements on the *ENDS* system have shown that a large scale concept-coordination documentation system is characterized by 34-44% pertinence[3] and 75% recall ratio

[3] In this context any retrieved document which answers the question as it was formulated is defined "pertinent"; "relevant" documents are those among the pertinent which are of real interest and value to the user.

Table I: *Countries participating as members* (M) *or observers* (O) *in* ESRO *and* ELDO.

Country	ESRO	ELDO
Australia	—	M
Austria	O	—
Belgium	M	M
Denmark	M	O
France	M	M
West Germany	M	M
Ireland	O	—
Italy	M	M
Netherlands	M	M
Norway	O	—
Spain	M	—
Sweden	M	—
Switzerland	M	O
United Kingdom	M	M

Fig. 2: *Structure of the NASA Thesaurus: each descriptor bears a code specifying its hierarchical position and relations: BT (broader term), NT (narrow term), RT (related term). Synonyms relations (UF = used for) are also indicated.*

COMPONENT RELIABILITY
0202 0903 1504 1505 2806
BT RELIABILITY
RT AIRCRAFT RELIABILITY
CIRCUIT RELIABILITY
CUMULATIVE DAMAGE
QUALITY CONTROL
SPACECRAFT RELIABILITY
STRUCTURAL RELIABILITY
COMPONENTS
1504
(USE OF A MORE SPECIFIC TERM IS RECOMMENDED--CONSULT THE TERMS LISTED BELOW)
UF PARTS
RT ACCESSORIES
ANTENNA COMPONENTS
ASSEMBLIES
ENGINE PARTS
FRACTIONS
INGREDIENTS
MODULES
REDUNDANT COMPONENTS
SEGMENTS
SPACECRAFT COMPONENTS
SPARE PARTS
STRUCTURAL MEMBERS
SUBASSEMBLIES
COMPOSITE FUNCTIONS
1902 1903
BT # ANALYSIS (MATHEMATICS)
FUNCTIONS (MATHEMATICS)
REAL VARIABLES
COMPOSITE MATERIALS
1507 1704 1801 1805 1809
UF COMPOSITES
PYROGRAPHALLOY
REINFORCED MATERIALS
NT BORAL
CERMETS
COMPOSITE PROPELLANTS
LAMINATES
METAL MATRIX COMPOSITES
MICARTA
PLYWOOD
REINFORCED PLASTICS
THREE DIMENSIONAL COMPOSITES
WHISKER COMPOSITES
RT AIRFRAME MATERIALS
BIMETALS
CARBON FIBERS
CLADDING
COATINGS

COMPOUNDS

COMPOSITE STRUCTURES
1507 1704 1801 1805 1809 3202
NT BORAL
LAMINATES
PLYWOOD
RT # COMPOSITE MATERIALS
HONEYCOMB CORES
HONEYCOMB STRUCTURES
STEEL STRUCTURES
STRUCTURES
COMPOSITE WRAPPING
1507 3202
RT # COMPOSITE MATERIALS
FILAMENT WINDING
ISOTENSOID STRUCTURES
SPIRAL WRAPPING
WRAP
COMPOSITES
USE # COMPOSITE MATERIALS
COMPOSITION
0601 1704 1805 3406 3408
(USE OF A MORE SPECIFIC TERM IS RECOMMENDED--CONSULT THE TERMS LISTED BELOW)
RT # COMPOSITION (PROPERTY)
CONTENT
FORMULATIONS
INGREDIENTS
STOICHIOMETRY
COMPOSITION (PROPERTY)
3408
NT ATMOSPHERIC COMPOSITION
ATMOSPHERIC MOISTURE
ATOM CONCENTRATION
BODY COMPOSITION (BIOLOGY)
CARBON DIOXIDE CONCENTRATION
CHEMICAL COMPOSITION
CONCENTRATION (COMPOSITION)
GAS COMPOSITION
IONOSPHERIC COMPOSITION
LUNAR COMPOSITION
METEORITIC COMPOSITION
METEOROID CONCENTRATION
MOISTURE CONTENT
PLANETARY COMPOSITION
PLASMA COMPOSITION
RT COMPOSITION
GRADIENTS
HENRY LAW
LUMPING
MIXTURES
RAOULT LAW
SOLUTIONS

Fig. 3: *Diagram of an SDS/RECON video display terminal:*

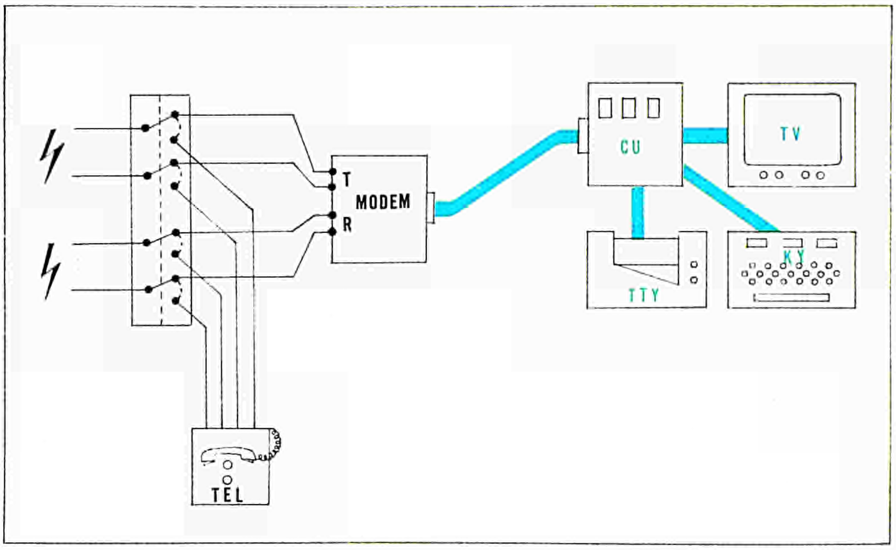
MODEM = modulator and demodulator equipment

CU = terminal control unit

TTY = teletype, local printer

KY = keyboard

TEL = telephone switch for alternative voice communication.



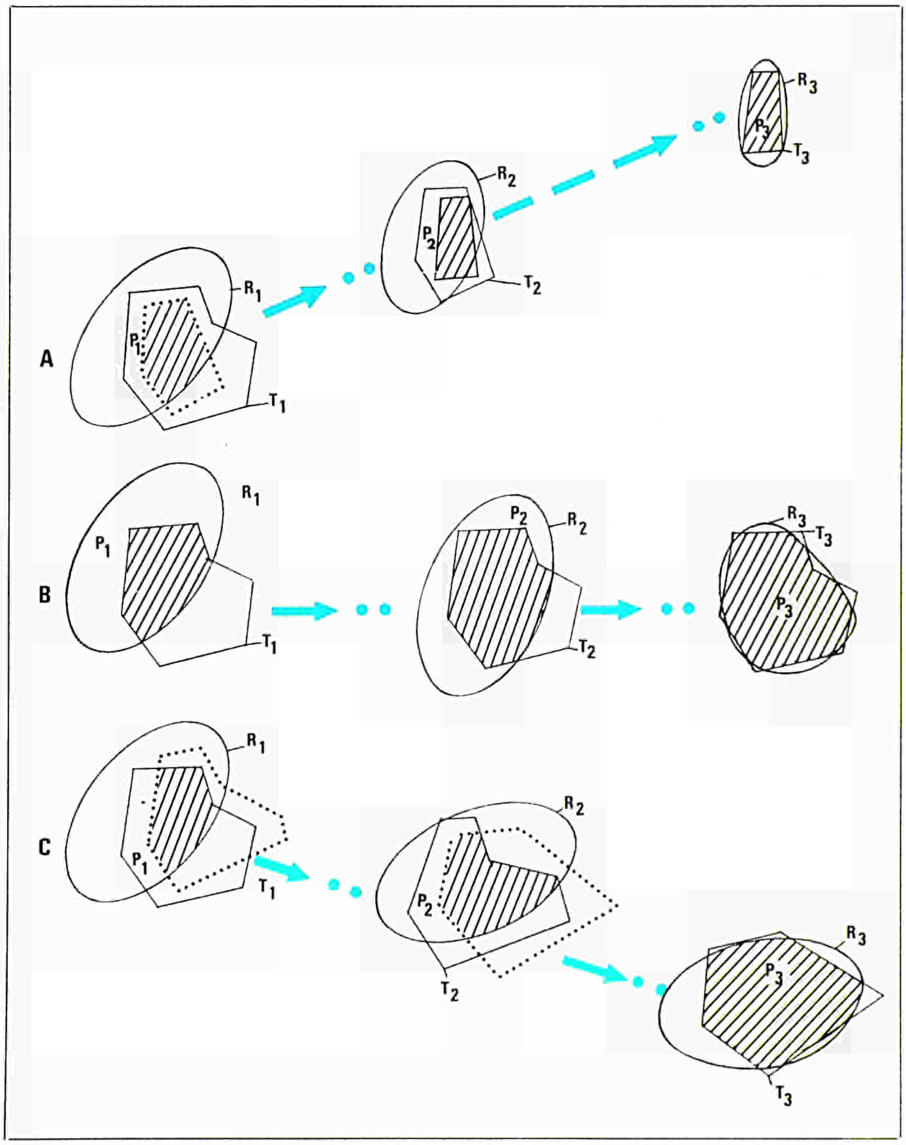


Fig. 4: *Different evolution or search strategy during three iterative screening/reformulation processes:*

R_1, R_2, R_3 = sets of retrieval documents

T_1, T_2, T_3 = sets of documents pertinent to the search (target)

P_1, P_2, P_3 = sets of pertinent and actually retrieved documents.

Sequence A: *The size of the target having been pre-evaluated, the user — after a first query formulation which gave unsatisfactory results [only a rather limited number of pertinent documents (P_1) was retrieved and part of the target (T_1) had been missed] — changed the query formulation and focussed it on a particular aspect, or subset, of the target. The target became smaller (T_2) until finally the set of pertinent and actually retrieved documents (P_3) coincided with it (T_3), being neatly covered by the retrieval operations (R_3) of the last formulation.*

Sequence B: *in this case the user, the ideal target well in mind, gradually adapted the query formulation to cover a maximum of it. The third query formulation retrieved almost all the pertinent documents practically without "noise" (non-pertinent documents retrieved).*

Sequence C: *in this case the user completely changed both his mind and the search strategy. A complete change of T, R and P (the result of different query formulations and target) is clearly to be seen in the picture; the result, however, corresponds to the aim: target covered by retrieval operations, with a minimum of non-pertinent documents retrieved.*

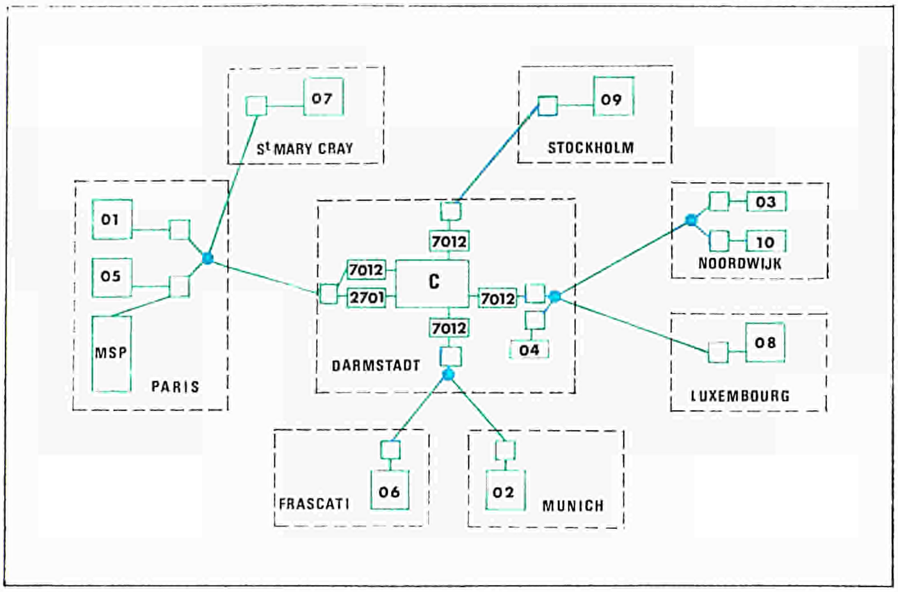


Fig. 5: *Structure of the* SDS/RECON *network:*
C: Computer
01-10: terminals (location as in Fig. 1)
MSP: medium speed printer
—●< *: amplifiers - diffusers*
-□- *: MODEMS*
7012: control units (computer side)

for a random search. These reasonably high efficiency levels are due to the structure of dictionaries such as the Euratom Thesaurus, to the tight terminology control and the high performance hierarchical postings. It has also been demonstrated that in concept-coordination systems like *ENDS* the pertinence can be very much improved (up to 70%) —losing only a small percentage of the recall ratio figure—by reorganizing the document order in the printout. By using one of these methods, the information (more or less pertinent) obtained during the screening of a sample of the documents retrieved by a boolean formulation, can be used to attribute weights to all the remaining document references of the retrieved set. A cut can then be made, discharging all the documents whose weight is less than a fixed threshold value.

Similar performance figures have been obtained in various concept-coordination systems operating in different fields, provided that the terminology used in the field has the same scientific character as in *ENDS*.

Very high performance figures are obtained also in the *ESRO/RECON* system when the feedback effect on the search strategy is obtained by iterative on-line query formulations.

In fact the complete flexibility of the *RECON/DIALOG* software allows the operator to take into consideration and build on the Thesaurus hierarchies, or ignore them if necessary. Furthermore, the conversational aspect of the query formulation allows the user to come back to his original formulation several times (more than 90 times), amend it and add new concepts when necessary. Such procedure improves both pertinence and exhaustivity.

Another phenomenon associated with interactive searching is the effect of the interaction of the user with the system that allows the searcher to change his previous ideas in a continuous learning routine. The target itself (set of documents in the system memory that can be considered as the pertinent answer to a given query) can change during the conversational search, so that both the retrieved set and the target shift during the development of the search strategy and tend to coincide (Fig. 4).

This phenomenon explains the much higher efficiency of on-line systems as compared with batch processing, especially when the user himself operates the terminal.

Hardware and Software

The *SDS/RECON* system hardware structure consists of a computer that can be interrogated by remote consoles in order to carry out the search strategies.

The basic structure of the network is shown in Fig. 5.

At present the information stored in an *IBM 370/155* computer at *ESOC* in Darmstadt, West Germany, is available to ten terminals installed in seven European countries (Fig. 1).

The computer (1.5 Mbyte of core memory) is used by *ESOC* in a multiprogramming environment (*MVT:* multiprogramming with variable number of tasks), *RECON/DIALOG* being one of the tasks and needing about 170 kbyte in the Central Processing Unit *(CPU)* with ten terminals on-line.

The computer configuration (Fig. 6) used by the system requires a very large random peripheral memory. Apart from the disk packages, three data cells are available to-date on the system giving a total of 1 200 Mbytes of storage capacity.

The total *RECON/DIALOG* software has a volume of about 500 kbyte (although only 170 k is resident in the Central Processing Unit with 10 terminals) and constitutes 120 modules written mainly in assembler language.

The data link between a terminal and the central computer station is realized as is shown in Fig. 7 for the particular case of the Luxembourg-Darmstadt connection. The typical data link chain is characterized by two control units, one at the computer and the other at the terminal, linked together through two *MODEMS* or data sets, by a telephone line. If the line is a dedicated four wire line for data transmission, a couple of telephone switches are necessary, equip-

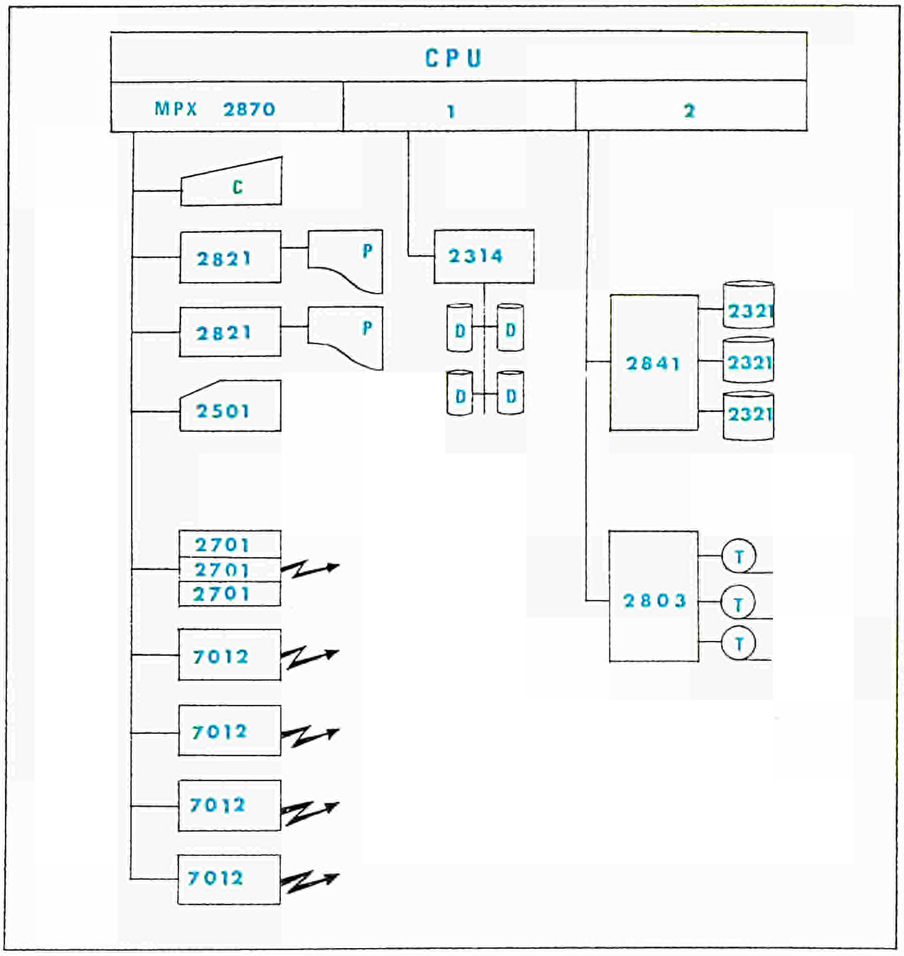


Fig. 6: *Block diagram of the part of the IBM 370/155 computer* (ESOC, *Darmstadt) used for the SDS/RECON system. Disks are used to store index files with pointers to the information stored in data cells. Data cells are used for linear files, inverted files and the dictionary.*

CPU: central processing unit (partition 170 kbyte)

MPX: multiplex

1.2: selector channels

C: console

P: printer

2821: printer control units

2701: controle units for remote fast printers

7012: control units used for the connection of the computer to the SDS/*RECON network (see also Fig. 5)*

2501: card reader

2321: data cells

T: tapes

D: disks

2841: data cells control unit

2803: tapes control unit

2314: disks control unit

ped with telephone sets for point-to-point alternative voice communications.

The computer is always in permanent contact with all the terminals in parallel through one of the two pairs of the four wire telephone line where a forced carrier is permanently transmitted, and phase modulated, by the data. The other pair of each four wire link is used by the terminal equipment to send back messages to the computer. Here the carrier is present only when a terminal is authorized to transmit by the computer.

This is the half duplex mode. Such a system allows the connection of several terminals to the same main transmission line (party line mode) and allows the design of tree-shaped networks, thus providing the possibility of sharing the costs of the main links among the users (see the Paris-Darmstadt connection in Fig. 5).

The terminals are interrogated (polled) sequentially by the computer following a

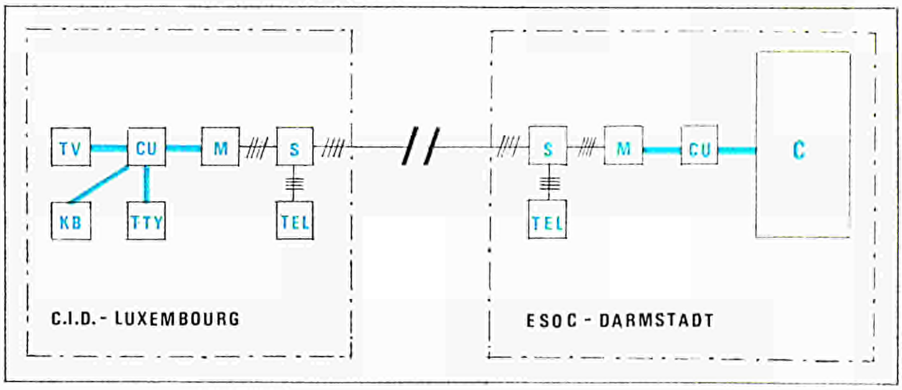


Fig. 7: *Diagram of the data link Luxembourg* (CID) - *Darmstadt* (ESOC):

CU : control units

M : MODEM

KB : keyboard

TTY : teletype

S : switch

TEL : telephone

C : *computer*

polling sequence, or cycle. Each terminal receives all the polling signals but reacts only when it recognizes its address. Since the polling cycle is one second, each terminal is interrogated with this repetition frequency and the operator has the impression of working alone in the network.

But, fortunately enough for him, he is not really the only one using the system, so that the operational costs can be divided among the users. Following the *SDS* charging policy, a user who wants to install a terminal at his premises has to pay *ESRO* a $ 22 500 per year connection fee. On top of this, he has to add the rental cost of the terminal itself and that of the telephone lines, which gives in total an average cost of $ 50 000 per year per terminal of the type currently in use. However, cheap teletype compatible terminals are planned to come into service very soon.

Bibliographic searches are also centrally processed by *SDS* for external customers. In this case, the costs are for example $ 100 per retrospective search and $ 150 per random terminal working hour.

Utilization of the SDS/RECON system

Let us see now how an interactive documentation system like the *SDS/RECON* system works. As we have already seen, the system can be made accessible to remote users by terminals linked to the central processor *via* telephone lines. The user can operate at the terminal in real time using a very simple symbolic language that will allow him to execute operations like the choice of a file, the visualization of the Thesaurus of the chosen file, the display of the hierarchical keyword chains, the selection and logical combination of the pertinent descriptors and finally the display of the references obtained by the boolean combinations.

The user/system interface is realized by a keyboard, by a TV screen (Fig. 8) to display the information obtained from the system and by a local printer, a teletype used for recording the search strategies.

As an example we describe here a very simple search: "Determination of krypton-85 by gas chromatography" (Fig. 9), assuming that the user does not know the terminology used in the system and had no opportunity to examine any Thesaurus before the search.

He will enter a special character [the operator (!)] which will be interpreted by *RECON* as a "Begin Search" command.

The system will start by asking the user a series of routine questions as shown in Fig. 9/A. The same figure presents the list of files accessible on-line from the terminal. In this case the user selects file No. 7, the Nuclear file, since the question is nuclear-oriented.

The user verifies (Fig. 9/B) the contents of the memory usings a special tutorial command (? FILES) and learns that file No. 7 contains a database of 190 610 documents and covers a maximum of four years (from 1968 up to August 1971).

He then proceeds to look at the terminology used in file No. 7 to see if

Fig. 8: VDU *terminal showing a set history on the screen.*

there is any descriptor that can translate his question. Once the Thesaurus is visualized by entering the "Expand" operator (") followed by the term KRYPTON he gets, 5-10 seconds later, the image of Fig. 9/C on the TV screen. By using paging commands he obtains the image of Fig. 9/D thus learning that KRYPTON-85 belongs to the Thesaurus of file No. 7 and has been used to index 253 documents.

The user now decides to select only the documents to which the term was assigned (by entering # E ϕ1) and gets, within about 10 seconds, the following *RECON* answer, both on the TV screen and on the teletype:

1 (first set of documents)
253 KRYPTON-85.

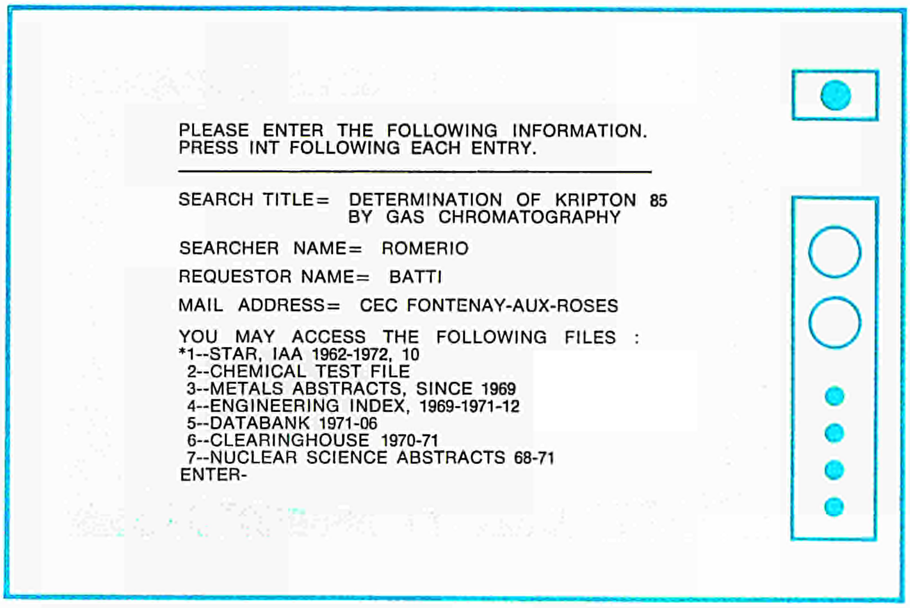
This informs him that the documents have been selected and from now on they can be manipulated as set No. 1.

Fig. 9/E shows the TV image obtained after the "expansion" of the term CHROMATOGRAPHY that shows three related terms (RT column).

Fig. 9/F shows the related terms amongst which GAS CHROMATOGRAPHY is listed. The user now decides to select both the term CHROMATOGRAPHY (816 documents) and GAS CHROMATOGRAPHY (28 documents) and the system executes by creating sets Nos. 2 and 3.

In Fig. 9/G we see the search strategy with the results of three logical equations: set 1 and set 3, one reference, set 1 and set 2, three references and the logical sum of the partial results, giving a total of four documents (set 6). Set No. 7 shows the same result obtained by using a more compact query formulation.

Fig. 9/H shows one of the retrieved documents, one of the most pertinent, belonging to set 7, and Fig. 9/I shows the four documents retrieved, in another format and all displayed in the same image.



PLEASE ENTER THE FOLLOWING INFORMATION.
PRESS INT FOLLOWING EACH ENTRY.

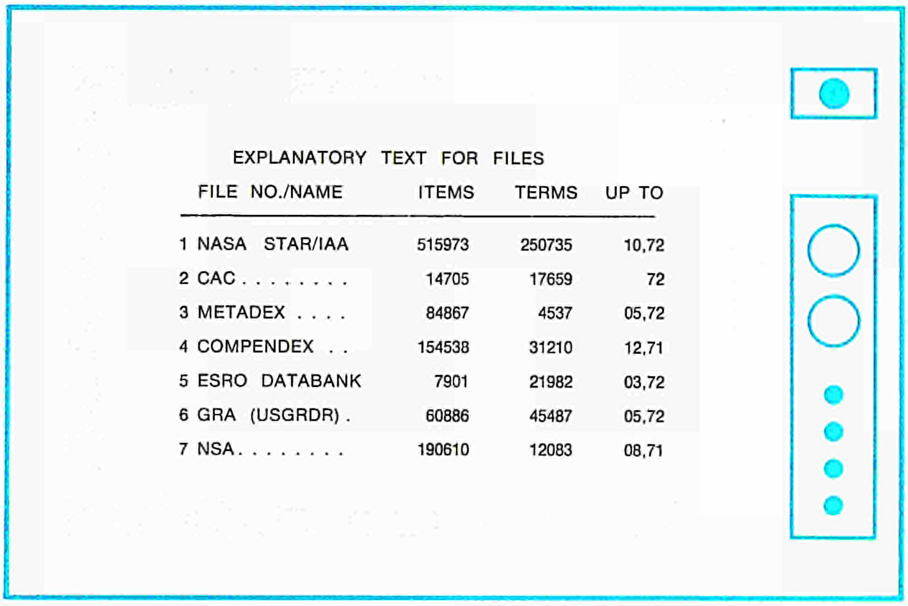
SEARCH TITLE= DETERMINATION OF KRIPTON 85
BY GAS CHROMATOGRAPHY

SEARCHER NAME= ROMERIO

REQUESTOR NAME= BATTI

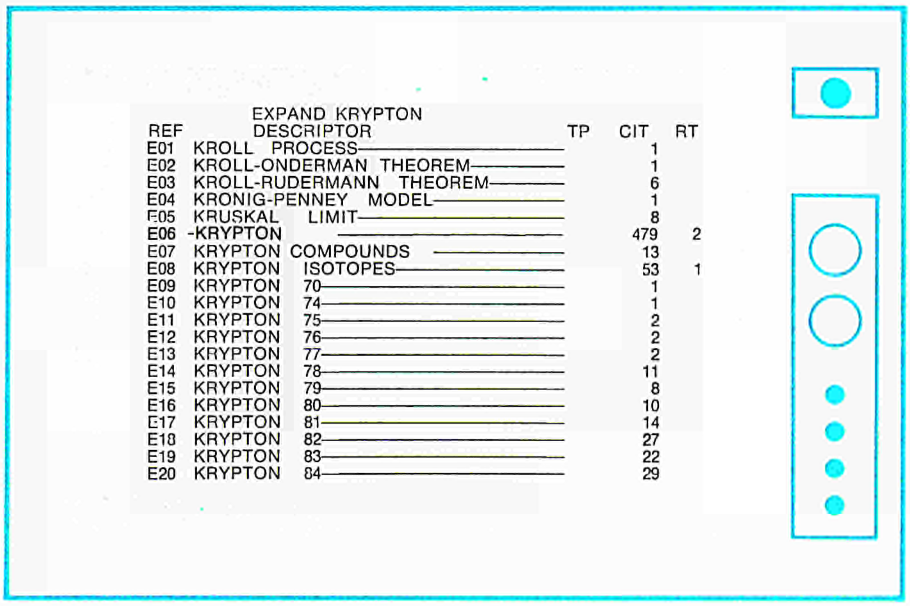
MAIL ADDRESS= CEC FONTENAY-AUX-ROSES

YOU MAY ACCESS THE FOLLOWING FILES :
*1--STAR, IAA 1962-1972, 10
2--CHEMICAL TEST FILE
3--METALS ABSTRACTS, SINCE 1969
4--ENGINEERING INDEX, 1969-1971-12
5--DATABANK 1971-06
6--CLEARINGHOUSE 1970-71
7--NUCLEAR SCIENCE ABSTRACTS 68-71
ENTER-



EXPLANATORY TEXT FOR FILES

FILE NO./NAME	ITEMS	TERMS	UP TO
1 NASA STAR/IAA	515973	250735	10,72
2 CAC	14705	17659	72
3 METADEX	84867	4537	05,72
4 COMPENDEX . .	154538	31210	12,71
5 ESRO DATABANK	7901	21982	03,72
6 GRA (USGRDR) .	60886	45487	05,72
7 NSA	190610	12083	08,71



EXPAND KRYPTON

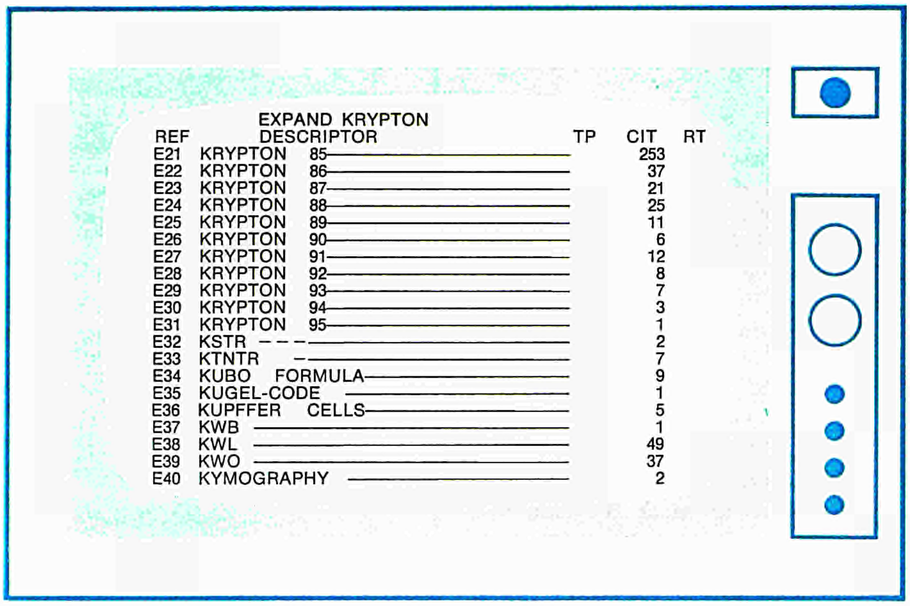
REF	DESCRIPTOR	TP	CIT	RT
E01	KROLL PROCESS		1	
E02	KROLL-ONDERMAN THEOREM		1	
E03	KROLL-RUDERMANN THEOREM		6	
E04	KRONIG-PENNEY MODEL		1	
E05	KRUSKAL LIMIT		8	
E06	-KRYPTON		479	2
E07	KRYPTON COMPOUNDS		13	
E08	KRYPTON ISOTOPES		53	1
E09	KRYPTON 70		1	
E10	KRYPTON 74		1	
E11	KRYPTON 75		2	
E12	KRYPTON 76		2	
E13	KRYPTON 77		2	
E14	KRYPTON 78		11	
E15	KRYPTON 79		8	
E16	KRYPTON 80		10	
E17	KRYPTON 81		14	
E18	KRYPTON 82		27	
E19	KRYPTON 83		22	
E20	KRYPTON 84		29	

Fig. 9: *Sequence of the operations involved in a search:*

9/A: "Begin Search" routine layout;

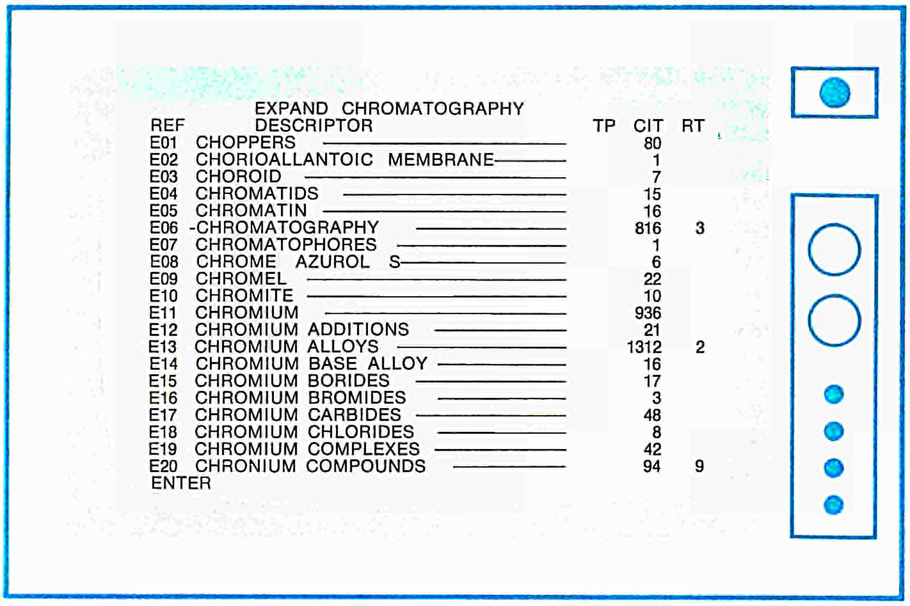
9/B: Answer to the explanatory question "? FILES";

9/C: Part of dictionary obtained by expanding "KRYPTON";



EXPAND KRYPTON

REF	DESCRIPTOR	TP	CIT	RT
E21	KRYPTON 85		253	
E22	KRYPTON 86		37	
E23	KRYPTON 87		21	
E24	KRYPTON 88		25	
E25	KRYPTON 89		11	
E26	KRYPTON 90		6	
E27	KRYPTON 91		12	
E28	KRYPTON 92		8	
E29	KRYPTON 93		7	
E30	KRYPTON 94		3	
E31	KRYPTON 95		1	
E32	KSTR ---		2	
E33	KTNTR		7	
E34	KUBO FORMULA		9	
E35	KUGEL-CODE		1	
E36	KUPFFER CELLS		5	
E37	KWB		1	
E38	KWL		49	
E39	KWO		37	
E40	KYMOGRAPHY		2	



EXPAND CHROMATOGRAPHY

REF	DESCRIPTOR	TP	CIT	RT
E01	CHOPPERS		80	
E02	CHORIOALLANTOIC MEMBRANE		1	
E03	CHOROID		7	
E04	CHROMATIDS		15	
E05	CHROMATIN		16	
E06	-CHROMATOGRAPHY		816	3
E07	CHROMATOPHORES		1	
E08	CHROME AZUROL S		6	
E09	CHROMEL		22	
E10	CHROMITE		10	
E11	CHROMIUM		936	
E12	CHROMIUM ADDITIONS		21	
E13	CHROMIUM ALLOYS		1312	2
E14	CHROMIUM BASE ALLOY		16	
E15	CHROMIUM BORIDES		17	
E16	CHROMIUM BROMIDES		3	
E17	CHROMIUM CARBIDES		48	
E18	CHROMIUM CHLORIDES		8	
E19	CHROMIUM COMPLEXES		42	
E20	CHRONIUM COMPOUNDS		94	9

ENTER

EXPAND CHROMATOGRAPHY

REF	DESCRIPTOR	TP	CIT	RT
R01	-CHROMATOGRAPHY		816	3
R02	GAS CHROMATOGRAPHY		28	
R03	PAPER CHROMATOGRAPHY			
R04	THIN LAYER CHROMATOGRAPHY			

9/D: Part of dictionary obtained by paging the image reproduced in Fig. 9/C;

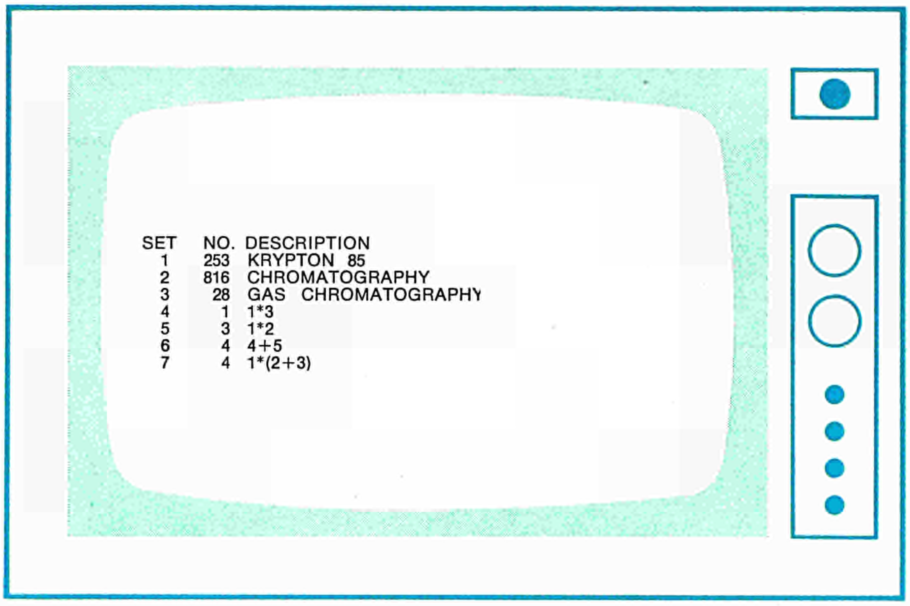
9/E: Answer obtained to "EXPAND CHROMATOGRAPHY" (see also Fig. 10);

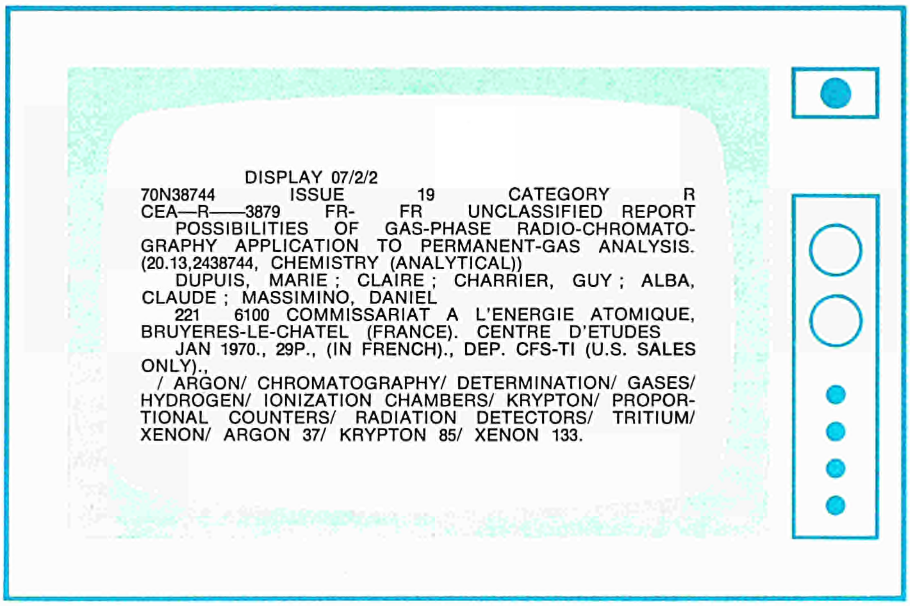
9/F: Answer obtained to "EXPAND E06" of Fig. 9/E; in column RT it may be seen that the narrower terms are present;

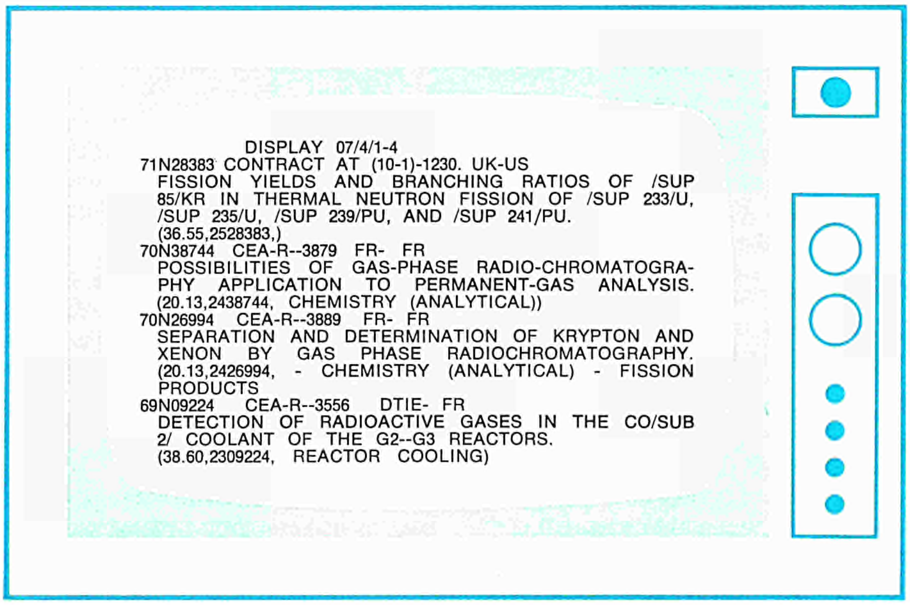
9/G: Set history; the descriptors "KRYPTON 85", "CHROMATOGRAPHY", "GAS CHROMATOGRAPHY" are combined in boolean algebra for query formulation in four different ways in order to cover a maximum of the target;

9/H: Second document obtained as an answer to the query formulation shown in Fig. 9/G;

9/I: Set of documents obtained as an answer to the query formulation of Fig. 9/G, in format 4.







If at this point the user is satisfied, he can either have the documents printed at the teletype associated to the terminal at the speed of 30 characters/sec (24 seconds per document), or give a print command that will be executed off-line by the system on a line printer (300, 600 or 1 200 lines/min). (The off-line print-out will begin with the information of Fig. 9/B that will be used for its identification.) By entering the "End Search" command, the user will now realize that he spent in total 5-10 minutes at the terminal.

The information contained in a document surrogate like that shown in Fig. 9/H consists of an identification alphanumeric code (accession number), the title, a notation of contents (micro-abstract) whenever the title is not exhaustive, bibliographic information like the review name, page, etc. and finally the set of descriptors used to index the document.

Even if the surrogate does not show a complete abstract, the information it contains allows easy identification of the interesting documents.

The RECON language

The language that has to be used with the *RECON* system at the user/terminal interface is very simple and powerful as has been shown in the preceding paragraph. The version of the *RECON/VDU* (*V*ideo *D*isplay *U*nits) shown in Fig. 10 allows the display, on the TV screen, of 24 lines of 40 characters, the last two of which can be used to enter the commands to be sent to the computer (after receipt of the code ENTER from the computer).

The various commands can be grouped as follows:

1) *Master commands (MCs)*

These commands can be executed only if entered at a terminal having the so-called "master status". Normally there is only *one* master terminal in the network and the MCs are used to supervise the system.

The MCs fall mainly into the following categories:

a) User status commands for putting a terminal IN or OUT OF the polling list with or without printer, with or without master status.

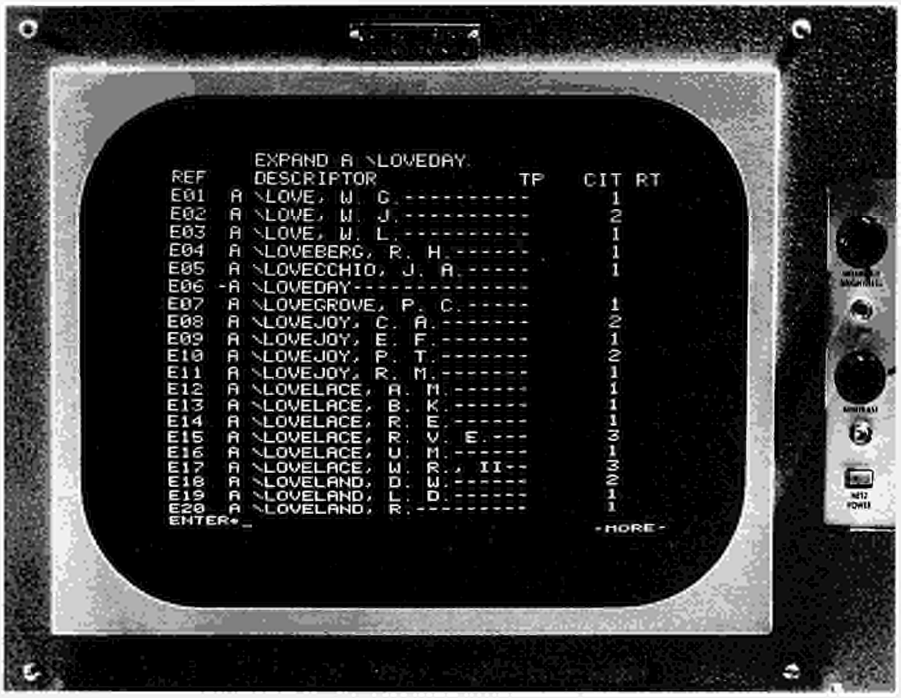


Fig. 10: *Details of the TV image "EXPAND AUTHOR'S NAME LOVEDAY". The expanded term appears always in position E06 on the screen.*

b) Monitoring commands to supervise a terminal if requested.

c) System status commands for statistical and accounting purposes.

2) *General commands (GCs)*

The GCs are used to preset the system for a search, to perform tutorial or explanatory routines or to exchange messages between terminals.

In particular there are:

a) *Begin and End Search commands* — The "Begin Search" command (!) will produce a series of routine questions to the user, as has been previously described, and will allow him to choose the file against which the search has to be processed. With the "End Search" command (—) the system generates a set of questions concerning the user's feelings about the system efficiency and performance.

The time spent at the terminal ("sit down time") is immediately calculated by the system between any "Begin" and "End" command and it is displayed on the screen. The user can bypass the routine questions by using the "Begin Bypass" (! B) or "End Bypass" (= B) commands.

b) *Switch Files* — During a search the user can continue a search performed in one file, say the aerospace file, to another, say the metallurgical file, by using the "Switch File" command (. File N), where N stands for the file number.

c) *Set History* — This command is used to show on the TV screen the so-called "set history", i.e. the series of selected descriptors and of logical combinations executed during a particular search, each operation being identified by sequential numbers from 1 up to 98 (set 99 being used for a special purpose).

d) *Tutorial commands* — A series of tutorial displays showing information about the system is obtained by using a set of commands beginning with the character (?).

e) *Message capability* — It is possible to send messages from one terminal to all others (broadcasting mode) or to a particular terminal (select mode).

3) *Operation commands for terminology access (OC/T)*

The EXPAND operator (") followed by a term in free language gives access to the Thesaurus of the selected file. The system will display 20 dictionary terms showing the "expanded" term in the sixth position. In Fig. 10 an example of the system answer to the question "expand author name: LOVEDAY" is shown. In the example, the author's name LOVEDAY was given in the code E06 (REF column), its frequency of use is zero (see the citations in column CIT) and it has therefore zero related terms (RT column). The term is obviously not in the dictionary. This command can give access to the list of the Thesaurus descriptors, to the author names and the corporate sources of any particular file. When (") is used followed by the REF code number it enables the display on the screen of the list of related terms of any term of the dictionary (see Figs. 9/E and 9/F). These terms will be displayed on the screen, preceded by the REF code R01, R02... etc.

4) *Operation commands for search strategy development (OC/S)*

The command serial (SELECT, INTERSECT, COMBINE, KEEP and LIMIT) perform the actual search strategy that translates the user's question into the system language.

The result of any operation of this kind will be a set of document references obtained by term selection or manipulation, anyone characterized by a particular reference number. Fig. 11 shows an example of search strategy having a total of 52 sets.

The SELECT operator (#) enables the user to make a choice of the terms he wants to use in the search (see sets 1 to 26, Fig. 11), i.e. descriptors, authors' names or corporate authors' names. Operator (#) can be used either followed by the free language term or by the reference code (REF column) of the "expand dictionary" image of the monitor. When (#) is followed by a term in free language, a right hand truncation mask (?) can be used to select all the terms beginning with a fixed group of letters (# TERM?).

When (#) is followed by a REF code, it also gives the operator the possibility of selecting a range of terms. For instance, (# E1 – E22) will enable the selection of the terms having REF codes between E1 and E22 of the terms "expanded" on the screen.

Fig. 11: *Example of a complete search, showing the sequence of different steps taken by the user:*

1-26: first terminology selection;
27-32: first search strategy (set 27 includes terms from 1 to 12, set 28 from 13 to 26, set 29 terms 16 and 17, set 30 terms from 18 to 25); set 31 shows the query formulation;
33-36: second search strategy (sets 33 and 34 are formed by terms 3 to 26 and 14 to 17 respectively); boolean formulation appears in set 35;
37: first partial result, 52 references;
38-46: second terminology selection, after screening of set 37;
47-50: third search strategy;
51: screening of set 49 and not 50; three documents kept on 26 are transferred into set 99;
52: second partial result, 63 references;
P37-P53: print commands for set 37 and set 53; 115 references.

```
SEARCH TITLE ENGINE NOISE REDUCTION
DATE/FILE        5-25-72/1
SEARCH BY        KALLENBACH ESRO SDS PARIS
REQUESTOR
ADDRESS

SET    NO. IN    DESCRIPTION OF SET
NO.     SET      (+=OR, *=AND, —=NOT)
----   ----      ------------------------
                 LIMIT ALL )ALL/66-72
 1      297      NOISE (SOUND)
 2     2896      NOISE
 3       12      NOISE HAZARD
 4      263      AERODYNAMIC NOISE
 5      230      ENGINE NOISE
 6      455      JET AIRCRAFT NOISE
 7       47      JET NOISE
 8      646      ACOUSTICS
 9      758      NOISE INTENSITY
10      252      SOUND PRESSURE
11      653      AIRCRAFT NOISE
12      416      FAR FIELD ?
13       40      LOUDNESS
14       43      NOISE ATTENUATION
15       66      NOISE ELIMINATION
16     1447      NOISE REDUCTION
17     1095      ATTENUATION
18       49      NOISE SUPPRESSOR
19      123      SUPRESSOR?
20      694      SHIELDING
21      166      BAFFLE?
22      115      ATTENUATOR?
23       84      DEFLECTOR?
24      124      LINING?
25      445      SCREEN?
26      163      SOUND INTENSITY
```

```
27     5868   1+2+3+4+5+6+7+8+9+10+11+12
28      188   13+26
29     2537   16+17
30     1744   18+19+20+21+22+23+24+25
31       62   (27+28)*29*30
32       47   LIMIT )31/68-72
33     2940   (3+4+5+7+8+9+10+11+12+13+26)
34     2610   14+15+16+17
35       39   33*34*30
36        5   LIMIT )35/66-67
37       52   32+36
38      328   ACOUSTIC ATTENUATION
39     1903   DAMPING
40      115   SUPPRESSION
41      385   E5,E6,E8
              E6: ABSORBERS
42      188   SHROUD?
43       33   COWLING?
44       35   SILENCER?
45       20   MUFFLER?
46        9   BLAST DEFLECTOR?
47     2969   38+39+40+41+42+43+44+45+46
48      123   (14+15+16)*(30+47)—37
49       86   48*(27+28)
50       60   LIMIT )49/68-72
51       26   49-50
                KEEP  51/12
                KEEP  51/20
                KEEP  51/22
52       63   50+99
P37/2/1-50          ,FOR 002 MORE HIT PRINT
P37/2/51-52
P53/2/1-50          ,FOR 013 MORE HIT PRINT
P53/2/51-63
     TOTAL ELAPSED TIME IS 097.54 MIN.
```

The INTERSECT operation enables the building and display on the monitor of a matrix showing the results (number of references) of all the possible AND or OR combinations of two groups of sets of the search strategy. It can give a very useful indication of the utility and advantages of a logical combination, before actually doing it.

The COMBINE ($) operator allows the system to execute boolean query formulations using the AND, OR and AND NOT operators (*, +, —) of document sets. The 123 references of set No. 48 of Fig. 11 have been obtained in answer to the command:

$ (14 + 15 + 16) * (30 + 47) — 37.

By using operator KEEP (( ) the user can transfer the content of an entire set, or any particular document found during the document screening operation, into a special set characterized by sequential number 99 (set of the pertinent documents). Fig. 11 shows, as a result of the screening of the 26 documents of set No. 51, that three documents have been kept and transferred to set 99 (the 12th, 20th and 22nd references of the set). Set No. 52 (63 documents) shows the results of the logical sum of set (50) with set (99).

The LIMIT ( )) operator is used to limit the search to a certain period of time (year), type of documents or range (document reference number).

Fig. 11 shows that the search was at first limited to the years 1966-72 (LIMIT

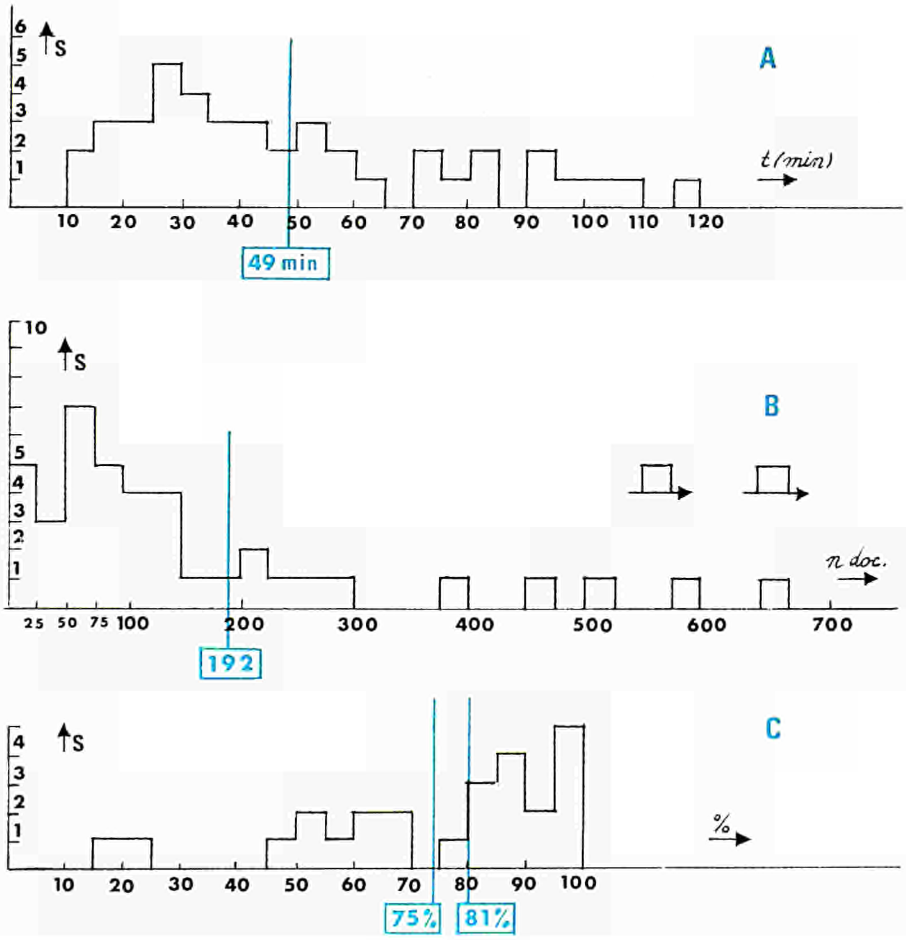


Fig. 12: *Schematization of the results obtained by evaluation of a group of 42 (A and B) and 25 (C) searches as performed by an external user of the system:*

Diag. A: time spent per search ("sit down time"); average: 49 minutes;

Diag. B: number of documents retrieved per search; average: 192 references;

Diag. C: pertinence of search results; mean value: 75-81 %.

ALL/66-72) while further time limitations were introduced in the course of the search strategy (see sets No. 32, 36, 50).

5) *Operation commands for document reference access (OC/D)*

At any time, during a search strategy, the user can have access to the document references obtained by using the OC/S commands, and therefore appearing in the set history, by displaying them on the screen or printing them out. The DISPLAY DOCUMENT operator (%) followed by a set number of the search strategy will allow the system to display on the TV screen the references of the set, one by one, by repeating the (%) command. Any document reference can also be displayed directly if its accession number is known. The entry of the PRINT (&) operator followed by the set number will enable the contents of that set to be printed out off-line on a high speed printer at the end of the *RECON* session.

The document references are accessible, by using both the (%) and (&) commands, in five formats:

- format 1: only the accession numbers. 80 accession numbers can be displayed on the screen at a time.
- format 2: the complete format with accession number, title, microabstract, authors, corporate source, bibliographical data and descriptors. Documents in format 2 are displayed one by one on the TV screen (Fig. 9/H).
- format 3: Dump format, containing all the information of format 2.
- format 4: Only accession number, title and microabstract (Fig. 9/I). Four documents are displayed in one screen image.
- format 5: Similar to format 2, but without descriptors.

Conclusion

To give an idea of the performance characteristics of the *ESRO SDS/RECON* system it is necessary to speak again of the well-known retrieval parameters, the pertinence and exhaustivity ratios, also called precision and recall.

Exact figures concerning the average exhaustivity ratio of the system are not available, but the analysis of the results of some iterative formulations and comparison with searches carried out in other systems and concerning databases similar to those of the *SDS* system suggest an average figure of about 75% exhaustivity. However, accurate pertinence assessments for a group of searches done on one of the *SDS/RECON* terminals in Paris have been calculated. These searches were elaborated directly by the engineers of a large French company working in the aerospace field and their results have been evaluated by the user himself.

Fig. 12 shows three histograms concerning the statistical distribution of the time spent per search (Diag. A), of the number of retrieved document references per search (Diag. B) and of the pertinence ratios per search as calculated by the users (Diag. C).

In a group of 42 searches the user spent 49 minutes per search on average and was able to retrieve an average of 192 references per search. The average arithmetic pertinence ratio per search is 75 % on a group of 25 searches. The pertinence of an average search is 81% if it is calculated by dividing the total number of pertinent documents (5 184 references in 25 searches) by the total number of retrieved documents (6 311 items) in the same group of searches. These figures are rather high and are the results of the screening-feedback-reformulation process that are available in an on-line system like *RECON*.

If we take into consideration that a *RECON* terminal can be located in any place accessible by a telephone line with a normal voice channel capacity (300-3 400 Hz spectrum), the utility and flexibility of the system need not be stressed.

The *ESRO/ELDO* Space Documentation Service in its programs to expand the existing network up to 40 terminals by 1975, plans to link *VDU* through the normal dial-up public network to the *RECON* system. Some tests have also demonstrated the possibility of making the conversational retrieval capability available to the user through the public TELEX network. Customers' access to the *SDS* system by TELEX will ensure enormous possibilities for its utilization.

EUSPA 12-2.

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Energy and the Limits to Growth

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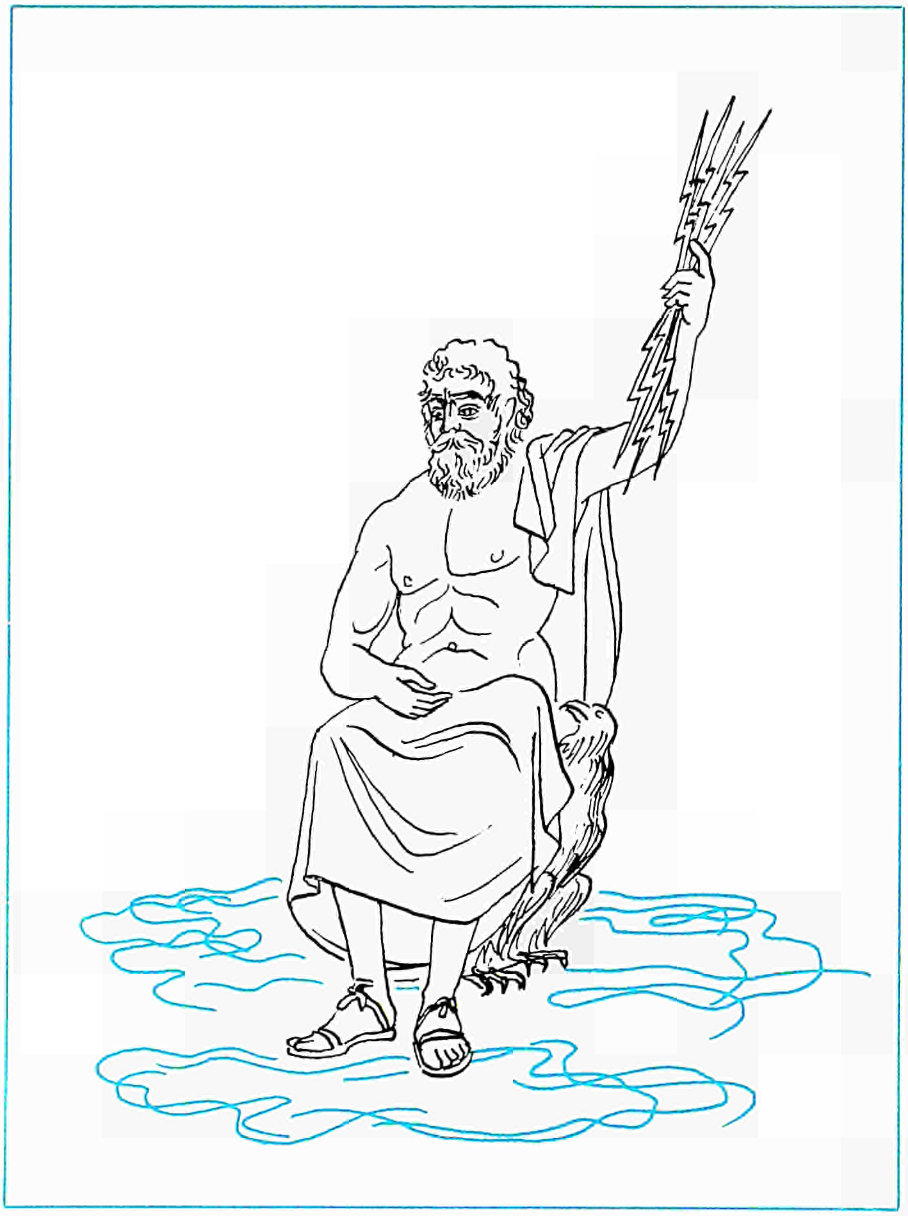


THE BACTERIUM'S MAIN AIM in life is to multiply. Its very *raison d'être* is to make two *DNA* molecules out of one, so as to program two bacteria to carry out the project of life using proteins and thus to start to reproduce all over again. The virus is only partially a bacterium since, enclosed in a covering of protein, it consists of only a fragment of *DNA*, and not having the enzymes necessary for any metabolic synthesis and energy transfer, it is unable to reproduce itself. For this purpose it makes use of the physicochemical machinery of other cells: it infects them.

There are two conclusions to be drawn from this. Firstly, to prevent an organism from expanding gives rise to illness. Secondly, this illustrates the counterproductive nature of any measure intended to protect a macroorganism like the human race from itself in its growth process, which would mean opposing with limited means and resources a process of exponential growth which is in itself necessary for mankind, but at the same time detrimental. In this apparent dilemma, the key factor is energy as a raw material.

Growth forecasts

Energy can be used as the key for obtaining many of the raw materials which pose a threat to humanity by becoming scarce. Seawater can be desalinated or turned into hydrogen, while minerals, fertilizers and food may be extracted from the sea and the earth's crust so that an energy consumption budget of about 10-20 kilowatts per head for a future world population might be feasible[1]. Weinberg (1) gives a possible energy budget for a future civilization (Table 1). With these values, even though they may have been estimated rather generously, and a generally accepted maximum possible world population of 20-40 thousand million—a figure which would seem to be far from desirable—the likely energy consumption will

[1] The amount of energy consumed in the form of food which is just sufficient to maintain the normal functions of the human body is about 100 watts, whereas the real average energy consumption per American citizen today is about 10 kilowatts, from which a "civilization factor" of 100 could be deduced.

be 100 to 800 · 10^{12} watts[2]. It should be noted that the values given are absolute and do not constitute an analysis of whether society is technically and economically capable of ensuring a growth gradient from now on of $e^{0.07 \cdot x}$ (x = years) for electrical energy consumption and $e^{0.04 \cdot x}$ for total energy consumption.

No shortage of energy supplies

In addition to supplies of fossil fuels for the next 150-500 years, there are also reserves of fissile and fusionable materials—the uranium and lithium contained in seawater (0.17 ppm) and the uranium and thorium (15 ppm) and lithium (2 ppm) in the earth's crust—sufficient to satisfy the world's energy needs for some millions of years. The converters necessary for this are either already in existence (thermal reactors) or may be expected to be capable of operation in the foreseeable future (breeders and fusion reactors). The water used to cool a seawater-cooled nuclear reactor itself contains many times the amount of uranium consumed by the reactor, and there is an obvious technical solution which can be concluded from this.

The atomic power stations which are to be set up in "*power parks*" in the sea for environmental reasons—because of the enormous quantities of heat to be disposed of—would be able to supply electricity to the coast and from there inland via superconductors, electricity produced in a self-sustaining cycle without the need for any fuel from outside. Energy reserves are therefore unlimited even without the use of the sun's rays as a direct source of energy, an idea which even today is still regarded as rather outlandish. This does not, of course, exclude the possibility of temporary and localized shortages.

The Carnot mill

The problem in obtaining energy is therefore not the lack of energy reserves, but rather one of being able to convert, in a clean and efficient manner, the energy contained in coal and oil today and in nuclear fuels tomorrow into a convenient and portable form. There can be no doubt that the best candidate for this is electricity: clean, noiseless, odourless and versatile, it is energy in a very noble form. However, "*noblesse coûte*": the Carnot and other efficiency ratings for conversion in boilers, turbines and generators is 40% at the most now, leaving 60% of the energy to go to waste in the environment. This, as stated above, has little effect on energy reserves, but has an adverse influence locally on the heat economy of the earth and its pollution.

On the whole, there is no justification for fears that man's conversion of energy in various ways on the earth's surface will cause the earth to heat up to an intolerable extent. The maximum possible world consumption of energy given above—800 thousand million watts—represents only a small proportion, about 1%, of the solar energy of 0.47 × 173,000 · 10^{12} watts striking the earth's surface and reflected in the form of long-wave radiation. Quite theoretically, and ignoring feedback effects, this would mean an increase in the temperature of the earth's surface, according to the Stefan-Boltzmann Law, of $\Delta T = 0.7$ °C.

The way this would affect the weather or the much-quoted melting of the polar caps is difficult to assess quantitatively, but qualitatively it has been ascertained that in the last 50 years the earth's surface temperature, by the above effect and also the "greenhouse effect" due to the increased carbon dioxide and water content of the air, has not in fact increased, but has actually decreased by 1-2 °C because of dust particles and increased cloud formation directly reflecting the sun's rays. Here it should be mentioned with regard to pollution that the carbon dioxide content of the atmosphere, one of the parameters affecting its temperature, has increased by 20% in the last 100 years owing to the exponential growth in the burning of fossil fuels. This is, however, in no way harmful for the environment. In the carboniferous period there was about 10 times as much carbon dioxide in the atmosphere as there is today, which was extremely beneficial to photosynthesis and hence to flora and fauna, which seem hypertrophied to us. This is, moreover, the reason why additional carbon dioxide is sometimes fed into greenhouses. Although there is therefore no need to fear the general heating up of the earth, the artificial production of energy can locally be prohibitive, e.g., in the Los Angeles area, where it is already in excess of 5% of the incident solar energy.

Electricity from hydrogen

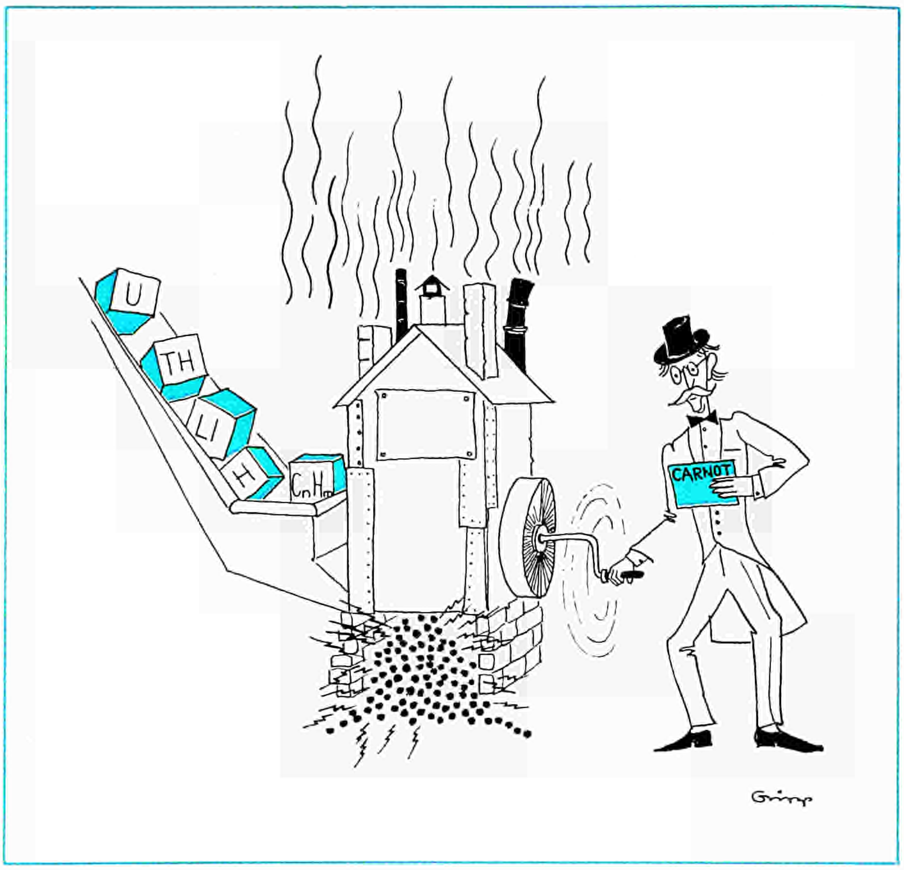
Electricity, practical and versatile as it is, has, as was made clear above, the

Table I: *Energy Budget per Capita for a Steady-State Civilization (kilowatts fuel equivalent)*

Present U.S. level		*10.0*
Adjustments for the future		
Steel, aluminium and magnesium production	*0.1*	
Recovery and recycle of scarce elements (copper, zinc, tin, lead, mercury, gold, silver, titanium, etc.)	*2.0*	
Electrolytic hydrogen	*2.5*	
Water by desalting (100 gal/day)	*0.3*	
Water transport to cities	*0.1*	
Air conditioning to cities	*0.3*	
Intensive food production	*0.2*	
Sewage and waste treatment	*0.5*	
Total adjustments		*6.0*
Contingency		*4.0*
Total budget		*20.0*

* *1 gallon (amer.) = 3,78 l (ed).*

[2] One can afford to be generous with such assumptions as far as this kind of exponential mechanism and doubling times is concerned, an error of a factor of 2 leading to a deviation of only 10-20 years.



unfortunate side-effect of high losses during production. In addition to this, it is often used unwisely, for purposes which do not exploit to the full this valuable form of energy, such as for heating and other domestic uses. It is a waste of energy and from the point of view of entropy absurd to make coffee at 100 °C using electricity produced by turbogenerators working at temperatures of around 600 °C. Heating one litre of water from 0 to 100 °C (energy content 100 kcal) uses up 160 kcal with gas, but with electricity about 300 are needed. In view of this, the engineers' laborious struggle to improve the efficiency of our present heat engines by 1 or 2% is just as pointless as being careful with the pennies and over-liberal with the fivers in the housekeeping.

Although the energy requirements of a society can to a large extent be satisfied more economically by the direct combustion of fossil fuels, the burning of hydrocarbons does have damaging effects on the environment. This, together with the unfortunate if not exactly calamitous dwindling of fossil fuels, leads one to look for a substitute which makes use of the assets of chemical energy but is free of its drawbacks. What are the characteristics of hydrocarbons? In the compact form of coal or oil their potential energy can be brought to the doorstep of the consumer, who then converts it into useful forms of energy like heat. The combustion products of hydrocarbons, CO_2 and water, are released into the atmosphere together with waste heat and other products. From these, vegetation produces fossil fuels again, but only after some millions of years, which means that the cycle is open in terms of human lives. Hydrocarbons are therefore not very good in the context of environmental pollution, as we can see from our towns and cities poisoned with exhaust fumes. The ideal fuel would be hydrogen, which only has water as a combustion product, and this can be reconverted, e.g., by hydrolysis, into hydrogen. The hydrogen cycle is closed on a human time-scale, and can be said to be in equilibrium.

Hydrogen - a common and versatile element

There is no doubt that the use of the primary and universal element hydrogen[3] is the most practical and versatile alternative, or possibly a back-up solution on which energy strategy can fall back in time to come. Produced by limitless nuclear energy from unlimited supplies of water in a closed cycle, hydrogen has excellent combustion properties. It is ideal as a motor fuel, being mixture-insensitive and producing very little else but steam as a waste product. It would be very suitable for use in industry, transport, heating and the home. In addition, energy can be transported over distances of over 400 km more cheaply in the form of hydrogen than in the form of electricity and existing natural gas pipes can be used, even though the transport costs for hydrogen are in this case higher than for natural gas or city gas (the lower calorific value of hydrogen means that greater quantities have to be pumped).

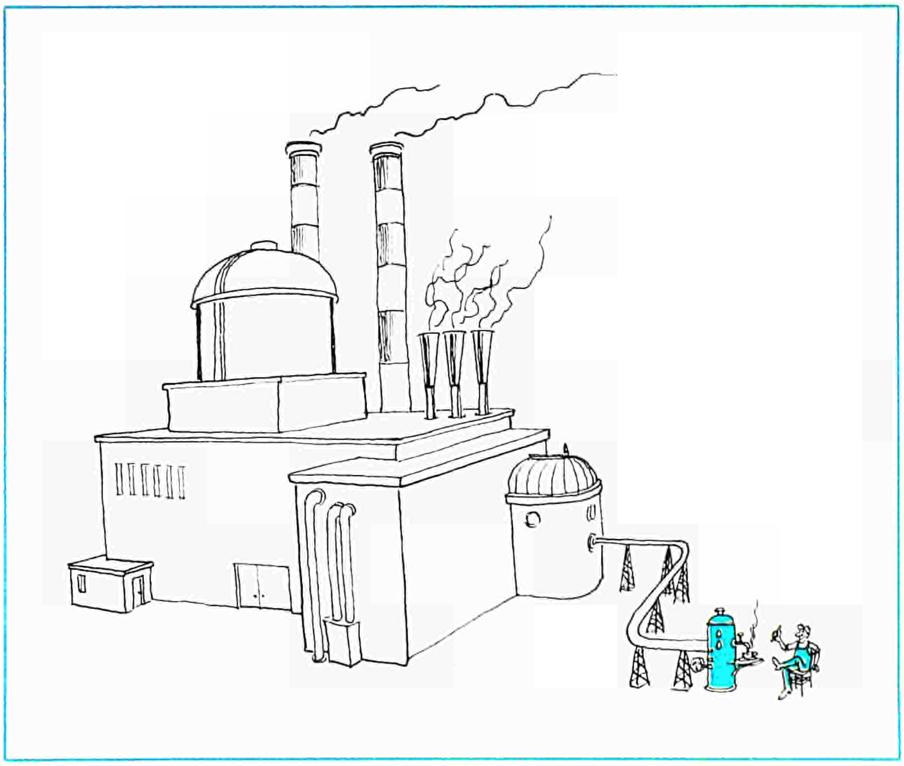
This and the possibility of storing hydrogen makes it an excellent source of energy. Its greatest drawback is its production cost, which is still high and is mainly due to the substantial consumption of electricity for electrolysis, which makes up about half of the total production costs. The price of liquid hydrogen produced by electrolysis in the USA in 1980 is estimated at $ 13.80/lb, $ 6.65/lb of this going towards the electricity consumed; the cost of hydrogen steam reforming is reckoned at $ 8.1/lb. Profits from the "waste products" of the electrolytic production of hydrogen, i.e., oxygen and heavy water, and a decrease in the cost of electricity could reduce to a minimum the difference between the price of electrolytic hydrogen and that of hydrogen from steam reforming. But price ought not to be, and one day will not be, the only criterion. Any method for producing hydrogen from hydrocarbons should in due course be replaced by processes using water as the raw material.

An alternative to the expensive method of electrolysis is that of the direct decomposition of water, which is quite feasible at temperatures of 2 500-3 000 °C. Such temperatures are, however, technologically prohibitive, and so the option open at present is to use much the same way that nature does when it splits up water catalytically using the energy from the sun. To produce hydrogen industrially the catalysts provided by nature are insufficient and have to be replaced by "manageable" ones, which can be done in a multistage chemical process at working temperatures attainable by modern technology. A process of this type has been developed at the JRC Ispra, the MARK I Process, which is carried out at the outlet temperatures of high-temperature gas-cooled reactors, i.e., around 800 °C. Admittedly, this process is uneconomic, but it does show basic feasibility and points the way for the future. In various laboratories all over the world the search is going on for more economic processes for making hydrogen readily available to us as an "all-purpose" raw material.

Solar energy

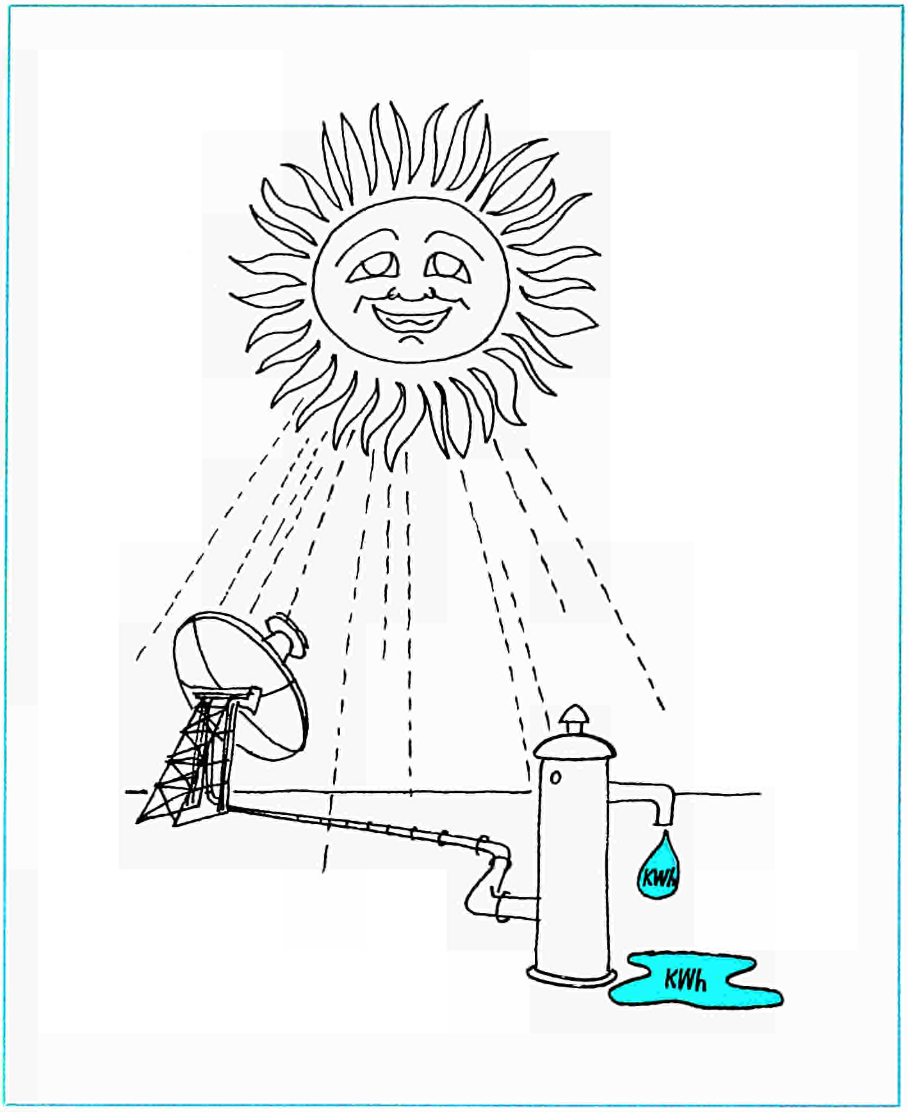
In studies of the sources of energy available to man, solar energy is generally dealt with right at the end, almost in passing, and is regarded as something exotic and futuristic whereas in fact the sun is, in some form or other, directly or indirectly our energy supplier. Instead of waiting for some millions of years for photosynthesis and incomplete combustion to do their work to give us coal and oil, and instead of waiting for weeks for water to evaporate from the sea and come down as rain to give us water power, why not make direct use of solar energy and dispense with all the other types of energy transformation which pollute the environment? The reason is the intermittent nature and the relatively low power intensity of sunlight, coupled with its dependence on cloud formations.

A lot of successful work is being carried out lately on the direct or thermal conversion of solar energy, with the purpose of increasing the feasibility and efficiency of conversion. An American project is under way which aims at a total efficiency of around 30% for the conversion of solar energy into electricity. With a power intensity of approx. 1 kW/m² at sea level with the sun in azimuth, which gives an intensity of about 250 W/m² averaged over a day and a year, and a conversion efficiency of 30%, about 80 W/m² of electrical energy can be obtained in cloudless desert regions like Arizona and New Mexico. Even if the power intensity of 1 kW/m² is not very high, nevertheless the solar energy



[3] See also *"euro-spectra"*, Vol. IX (1970), Nr 2, p. 46-50 and *"euro-spectra"*, Vol. X (1971), Nr 4, p. 117-129 (ed.).

impinging on 1 km² in one day is equivalent to that of a medium-sized atom bomb (10^{14} joules). The power yield from 15% of the uninhabited desert of Arizona and Nevada could therefore supply a large proportion of American energy and fresh water needs—some 10^6 MW—in the year 2000. The process is not based on direct conversion but on thermal conversion by means of selective surfaces, which allow the visible solar radiation to pass through and retain the reflected long-wave radiation. The "fuel" comes free of charge, but it must be said that the investment costs are still enormously high—about $ 2/kW. After the system had been in operation for 40 years the cost of the electricity would, however, return to normal. Basically, therefore, there is nothing to prevent the direct harnessing of the sun's radiation, a practically unlimited and unfailing source of energy which is not likely to necessitate more than a bare minimum of expenditure for repairing any damage caused to the environment.



Paradise or apocalypse?

It is not a question of a choice between paradise or apocalypse. As we have seen, man has at his disposal a variety of sources—nuclear fission, nuclear fusion and solar energy in the long term, oil, coal, natural gas and nuclear fission in the short and medium term—to provide him with energy potentially for millions of years, adequate to cover his energy needs as such and in consequence indirectly his requirements for raw materials as well. But there is, and must be, also the exponentially growing phenomena of environmental pollution, the population explosion and booming industrial production, with their salutary effect on the rhythm of life as we saw at the beginning in the "parable" of the bacterium and the virus.

Despite reprocessing, some reserves of raw materials are limited. Pollution is bound to increase as the world's population increases, in spite of the measures being applied more and more as man becomes increasingly aware of the problem, but which in fact use up energy themselves and therefore also create thermal or chemical pollution through energy transformation. Moreover, the above considerations are of a general, world-wide nature, and it is quite possible that locally, for a particular country or a continent, energy shortages arising from delays in distribution and poor strategy can have catastrophic effects.

The blissful superabundance of energy resources by no means precludes catastrophe for this planet, if man is going to tangle things up for himself more and more until he suffocates. Energy will play a vital part in man's attempts to stabilize his planet.

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Detection of histidine and threonine in complex mixtures of amino acids

PHILIPPE RUELLE

THIN-LAYER CHROMATOGRAPHY is a sensitive technique, but in complex biological solutions it gives rise to a large number of uncertainties because of the small migration distances usually employed.

There are already several specific dyes with various substrates and solvents for the detection of amino acids.

A method for the detection of histidine and threonine is described below which is valid at least on silica gel and with the following three solvents:

A	methyl alcohol 96 %	70 vol.
	distilled water	30 vol.
B	n-butanol	4 vol.
	acetic acid	1 vol.
	distilled water	1 vol.
P	pure phenol	75 vol.
	distilled water	25 vol.

The developer consists of a solution already described (1) made up of:

ammonium acetate	15 g
glacial acetic acid	0.3 cm^3
acetyl acetone	1 cm^3
n-methanol	100 cm^3

This solution is vaporized at laboratory temperature (20 °C) on dry plates.

Amongst the amino acids, aspartic acid, glutamic acid, alanine, arginine, asparagine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophane, tyrosine and valine, this vaporization enables histidine and threonine to be clearly identified, since they take on a pale yellow colour in visible light, while the others remain colourless and turn yellowish-green UV light much more violenty than the other stains.

The detection limit is about 1 µg in visible light and 0.1 µg in UV light.

A comparison of the theoretical (2) and experimental Rf values for histidine and threonine are given in the following table for information pur-purposes.

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AMINO ACID	SOLVENTS A Rf exp. (1)	A Rf theor.	B Rf exp. (2)	B Rf theor.	P Rf exp. (3)	P Rf theor.
Histidine	34.5	33	13.5	6	36.5	24
Threonine	52.5	50	30	25	30	18

(1) average of 13 determinations
(2) average of 16 determinations
(3) average of 8 determinations

PHILIPPE RUELLE is on detachment to the Entomology Department of the Ispra Establishment of the *Joint Research Centre*, of the Commission of the European Communities.

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FOURTH SYMPOSIUM ON
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The Commission of the European Communities will hold a Fourth Symposium on Microdosimetry, from September 24-28, 1973, in Verbania Pallanza (Lago Maggiore), Italy.

1. Programme

The preceeding Symposia on Microdosimetry in 1967, 1969 and 1971 revealed the rapid development of microdosimetry, which is of considerable practical significance as regards health physics measurements, neutron therapy, and the broadening of our knowledge concerning the biological effects of radiation. The purpose of the Fourth Symposium is to obtain a comprehensive exchange of views on the progress made since the last meeting, on the relation of microdosimetry, and on its application to health protection and radiation therapy. Sufficient time for discussion will be provided.

2. Provisional subjects

Among the subjects to be dealt with at the Symposium, the accent will be on the physical, biological and chemical aspects of the spectral and spatial distribution of energy transferred to irradiated tissue, in particular to cells, cell components and biomacro-molecules. In this respect attention will be given especially to the energy transfer by neutrons, ions, and secondary electrons. Ample time is also foreseen for the discussion of technical problems related to the measurements with microdosimetric counters and for the presentation of new experimental and theoretical concepts.

3. Participation

Scientists wishing to attend the Symposium or to receive further information are requested to contact the conference secretariat as soon as possible. In order to facilitate a detailed discussion the number of participants may have to be restricted.

4. Papers

Preliminary notice of papers to be presented should be given as soon as possible. Papers can be read in English, French or German. Simultaneous interpreting facilities in these three languages will be provided.

5. Scientific secretaries

Dr. J. BOOZ and Dr. H. G. EBERT, Commission of the European Communities.

6. Correspondence

Please send your preliminary notice and all other correspondence to the:

Secretariat of the Fourth Symposium on Microdosimetry
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DG III — Biology Division
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