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About the Institute

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

TABLE OF PERIODIC PROPERTIES OF THE ELEMENTS

Percent Ionic Character of a Single Chemical Bond

Difference in electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Percent ionic character %	0.5	1	2	4	6	9	12	15	19	22	26	30	34	39	43	47	51	55	59	63	67	70	74	76	79	82	84	86	88	89	91	92

GROUP IA

H	0.2	2.1
Li	1.0	0.108
Na	0.9	0.14
K	0.8	0.004
Rb	0.8	0.004
Cs	0.8	0.004

IIA

Be	1.5	1.12	73.9
Mg	1.3	0.31(+)	2.8
Ca	1.0	0.108	0.25
Sc	1.0	0.108	0.25
Y	1.0	0.108	0.25
La	1.0	0.108	0.25

Sub-Atomic Particles

Symbol	Electron		Positron		Proton		Neutron		Photon		Neutrino		Meson						Hyperon		
	e^-	e^+	p	n	γ	ν_e	ν_μ	ν_τ	π^+	π^0	π^-	K^+	K^0	K^-	Λ^0	Σ^+	Σ^0	Σ^-	Ω^-		
Mass*	1	1	1836.12	1836.65	0	-0	206.84	273.23	264.4	966.6	974.4	2181.4	2327.7	2343.2	2584	1686					
Charge**	-1	+1	+1	0	0	0	± 1	± 1	0	+1	0	0	0	0	+1	-1	-1	-1	-1		
Spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0	0	0	0	$\frac{1}{2}$	$\frac{1}{2}$	integral	integral	integral	integral	integral		
Magnetic Moment	1.00 B.m.	1.00 B.m.	2.793 n.m.	-1.913 n.m.	0	-0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Mean Life (sec.)	stable	stable	stable	1.11×10^8	stable	stable	2.22×10^{-6}	2.54×10^{-8}	-10^{-15}	-10^{-8}	-10^{-10}	-10^{-10}	-10^{-10}	-10^{-10}	-10^{-10}	-10^{-10}	-10^{-10}	-10^{-10}	-10^{-10}		
Decay Modes			$-p + e^+ + \nu_e$				$e^+ + \nu_e + \nu_\mu$	$e^+ + \nu_e + \nu_\tau$	$\gamma + \gamma$	$e^+ + \nu_e + \nu_\mu$	$e^+ + \nu_e + \nu_\tau$	complex	complex	$p + \pi^+$	$n + \pi^0$	$n + \pi^+$	$n + \pi^-$	$n + \pi^0$	$n + \pi^+$		

B.m. = Bohr magneton n.m. = Nuclear magneton *In units of 9.1083×10^{-31} kg. **In units of 4.80286×10^{-10} esu. †Exists as an antiparticle not listed.

VIIIA

He	0.93	0.020
Ne	0.9	0.005
Ar	0.9	0.003
Kr	0.9	0.003
Xe	0.9	0.003
Rn	0.9	0.003

Li	1.0	0.90	1.5
Na	0.9	0.31(+)	2.8
K	0.8	0.108	0.25
Rb	0.8	0.108	0.25
Cs	0.8	0.108	0.25
Ba	1.0	0.108	0.25

IIIB

IVB

VB

VIB

VII B

VIII

IB

IIB

K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
0.8	1.0	1.44	1.3	1.32	1.5	1.22	1.6	1.18	1.6	1.17	1.5	1.17	1.8	1.15	1.8	1.17	1.9
2.03	1.8	1.97	36.74	1.42	81	1.47	106.5	1.34	106	1.30	72.97	1.25	53.7	1.26	84.6	1.25	93
1.33(+)	0.55	0.99(+)	0.21	0.81(+)	3.8	0.90(+)	3.7	0.74(+)	4.2	0.69(+)	3.3	0.80(+)	3.50	0.76(+)	3.67	0.74(+)	3.64
45.3	0.23	29.9	0.3	15.0	0.015	10.6	8.35	7.23	0.16	7.39	0.18	6.7	0.16	6.6	0.22	7.1	0.94
100	0.177	141	0.149	151	0.13	158	0.126	156	0.11	171	0.115	182	0.11	181	0.099	176	0.105
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
2.16	0.8	1.91	1.0	1.62	1.3	1.45	1.4	1.34	1.6	1.30	1.8*	1.27	1.9	1.25	2.2	1.25	2.2
2.48	1.8	2.15	33.8	1.78	93	1.60	120	1.46	—	1.39	128	1.36	120	1.34	148	1.34	148
1.46(+)	0.55	1.13(+)	2.1	0.93(+)	2.7	0.80(+)	4.0	0.68(+)	6.6	0.64(+)	6.6	0.70(+)	6.1	0.86(+)	5.2	0.86(+)	4.0
55.9	—	33.7	—	19.8	0.035	14.1	—	10.8	0.125	9.4	0.35	8.3	—	8.3	0.21	8.9	0.17
96	0.080	131	0.176	152	0.071	160	0.066	156	0.065	166	0.061	167	—	173	0.057	178	0.059
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
2.35	0.7	1.98	0.9	1.69	1.1	1.44	1.3	1.34	1.5	1.30	1.7	1.28	1.9	1.26	2.2	1.27	2.2
2.67	16.3	2.22	35.7	1.87	96	1.67	155	1.49	180	1.41	185	1.37	152	1.35	162	1.36	152
1.69(+)	0.50	1.35(+)	2.1	0.93(+)	1.5	0.81(+)	5.2	0.73(+)	6.8	0.69(+)	6.4	0.86(+)	5.2	0.86(+)	4.0	0.92(+)	6.4
70	—	39	—	22.5	0.033	13.6	—	10.9	0.13	9.53	0.40	8.85	0.17	8.43	—	8.54	0.14
90	0.032	120	0.068	129	0.045	127	0.035	138	0.036	184	0.032	182	0.033	201	0.031	212	0.032
Fr	Ra	Ac															

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
1.65	1.1	1.65	1.1	1.64	1.2	1.63	—	1.62	1.2	1.85	—	1.61	1.1
1.81	95	1.82	79	1.82	69	—	—	1.81	46	1.99	42	1.79	72
1.11(+)	0.13	1.09(+)	0.15	1.08(+)	0.15	—	—	1.11(+)	2.1	1.12(+)	2.2	1.02(+)	3.70
21.0	0.026	20.8	0.028	20.6	0.031	—	—	19.9	—	28.9	—	19.9	0.021
159	0.042	133	0.048	145	0.045	133	—	129	0.042	131	0.039	142	0.071
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw
1.65	1.3	1.5	1.42	1.7	—	1.3	—	1.3	—	1.3	—	1.3	—
1.80	—	1.61	130	1.38	110	1.3	94.3	1.51	87.2	1.73	—	60.2	—
1.14(+)	4.6	1.12(+)	—	1.11(+)	2.7	1.09(+)	—	1.07(+)	—	1.06(+)	—	1.06(+)	—
19.9	—	15.0	—	12.5	0.064	21.1	—	20.8	—	20.8	—	20.8	—

NOTES:

- For representative oxides (higher valence) of group. Oxide is acidic if color is red, basic if color is blue and amphoteric if both colors are shown. Intensity of color indicates relative strength.
- Cubic, face centered; cubic, body centered; diamond; cubic; hexagonal; rhombohedral; tetragonal; orthorhombic; monoclinic.
- At room temperature. (4) At boiling point. (5) From 0° to 20°C.
- Ionic (crystal) radii for coordination number 6.
- Atomic radii for coordination number of 12.

CRYSTAL STRUCTURE (2)

SYMBOL

ACID-BASE PROPERTIES (1)

KEY

COVALENT RADIUS, Å

ATOMIC RADIUS, Å (7)

IONIC RADIUS, Å (6)

ATOMIC VOLUME, W/D

FIRST IONIZATION ENERGY (kcal/g-mole)

SPECIFIC HEAT (cal/g°C)

HEAT OF FUSION (k-cal/g-atom)

ELECTRICAL CONDUCTANCE (5) (microhms)⁻¹

HEAT OF VAPORIZATION (k-cal/g-atom) (4)

HEAT OF FUSION (k-cal/g-atom)

ELECTRICAL CONDUCTANCE (5) (microhms)⁻¹

THERMAL CONDUCTANCE (cal/cm²/cm²/sec) (3)

Zn	1.25	1.6
Li	1.38	27.4
Na	0.74(+)	1.76
K	0.167	—
Rb	9.2	0.27
Cs	216	0.0915

SARGENT-WELCH
SARGENT-WELCH SCIENTIFIC COMPANY
 7300 LINDER AVENUE, SKOKIE, ILLINOIS 60076
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28-X - IMMUNOLOGY: KOCH - PASTEUR
LADY MARY 1717 GWPY - SMALLPOX
 31 - STERILE TECHNIQUE - 1790-1800
 DILUTION METHOD - AGAR
 SOLID MEDIA
 47 SEMMELWEISS - CHILDED FEVER
 VIENNA
 1847 | BUDAPEST
 ETIMOBOTANY
 Background
 CULTIVATION OF PLANTS - HUNTING

2-XI - CONT'D - INTD. ETIMOBOTANY 1936
 SHAMANISM ONAHEA - WEITLANER
 DISCOVERY OF HALLURINOGENIC PLANTS
 WASSON 1957

4 - ETIMOBOTANY SLIDES -
 7 - CODEX VINDOBONENSIS || PEYOTL - LOPHOPHARA WILLIAMSI
 " MADRID
 " DRESDEN SIS
 POPOL VUH - KAKULJA (A. MUSCARIA)

9 - COMPLETE: TEONANACUHL
 SOMA KAKULJA
 BEGIN ASGUS

11 - ASGUS REVIEW: DEENAS & 75 / GARTH'S SURF.
 CYANOPHYTA - PHICOCYANIN POLLUTION DANGER
 CHAUSO - CHLORO - "ESSPOOL"
 PYRO - PHATE -
 PIGMENTS: CHLOROPHYLL, CAROTENE, XANTHOPH.
 + FUCOXANTHIN
 + PHYCOSANTHIN
 DIOXINS + D. EARTH FILTERS
 ASGUS DYNAMITE (TNT)

14 - NOBEL PRIZE WINNERS + BESSIE JACKSON
 PHILIP ANDERSON - sub atomic particles
 47 ROYER GUILLEMIN - SOMATOSTATIN
 ANDREW SCHALLY (TULANE) - RECOMB. E. COLI DNA
 C. WOESE - METHANOGENS
 26 - ALGAE - "NANNA" - "MAN HU" - QUE ES?
 RA - SAGASSO ISL 2 x 10⁶ sq. mi.
 RED - COOL ISLANDS

16 - EXAM NO 3
 18 - LICHENS - FOLILOSE, FRUTULOSE, CRUSTOSE
 DOCTRINE OF SIGNATURES
 MYCOBIONT
 PHYCOBIONT
 RESISTANCE TO ENVIRON.

21 - GEOLOGICAL HISTORY - CAMBRIAN
 BEGIN: MOSS METAGENESIS
 SPOROPHYTE - GAMETOPHYTE SILURIAN (LAND PLANTS)
 23 - DEMOS - LYCOPODIUM - FERNS - MOSS - METAGENESIS
 SPOROPHYTE
 GAMETO - FROND

TILLANDSIA USNEOIDES
 CILINDRARIA KANSICERINIA
 Plymouth Rock 1620

28 - METAGENESIS - MOSS - FERN
 EVOLUTIONARY TRENDS - H₂O → LAND
 EMBRYOPHYTES
 MONOECIOUS ARCHEGONIA
 ANTHRODIA
 MOTILE SPERM

30 - BROWN - 1931
 SCHEIDEN - SCHWANN - 1838-39
 PLEMMING - TRILL - MITOSIS
 BOYER - 1892 - MEIOSIS
 1859 - DARWIN
 1865 - MENDEL
 FLOWER STRUCTURE
 ♀ GAMETOPHYTE
 (SEED) 3N ENDOSPERM

DEC. 2 - REVIEW GYAND - ANGIOSPERMS
 VASCULAR TISSUE - XYLEM, PHLOEM
 PERICELLI VACUUM
 DES. N MITOSIS

MITOSIS - MEIOSIS
 MENDEL'S MONOHYBRIDS
 SEX DETERMINATION: XX XY
 ♀ ♂
 (BIRDS REVERSE)
 MOTHS
 SOMATIC VS GAMETIC

7 - COMPLETE MONOHYBRID: 3:1 1:1:1
 35) BISEN DIHYBRID: 9:3:3:1
 EVALUATION

9 - FINAL EXAM: 5:30 - 7:30
 100?

LEFT 15 MINUTES EARLY FOR KINSA TV
 7 (35)
 PENNEL 1931

Corlyk - 'evidence of Heaven
whether? - faith
know not, Jesus knows
not - - -

Colden : Que' e de Vida? Que
elusion, una sembla
et

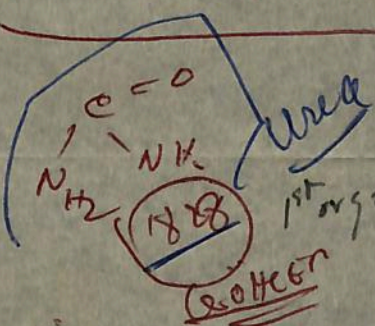
"AL PRINCIPIO" . . . LA TIERRA
ESTABA CONFUSA, Y VACIA Y LAS
TINIEBLAS CUBRIAN LA HAZ DEL

Hindu : eternidad ABISMO.
universo || No solo el
hombre!

→ Generación espontánea etc.
RECETA

- 92 Uranus - 1781 (Uranium también)
- 93 Neptun - 1846
- 94 Pluto - 1930

Khoshla-torium
Nº 104



1st organic compound
in vitro

Milayro → Ley
Natural or

UNIVERSE - DISC OF I ORIGINS
GALAXIES > 10⁶ LIGHT YRS. DIAM.

see: Life, Dec. 8, 1952. World We Live In.

AGE OF EARTH: Brahmin idea of ETERNITY to Irish Bishop Ussher (1654) who deduced from Scriptures that Creation occurred in 4004 B.C., Oct. 26, at 9 AM.

(PLUTO ± 3 x 10⁹ miles from sun)

RADIOACTIVE CLOCKS give us more reliable estimates.

Earth 5 x 10⁹ yrs. ie Pb/U ratio (fixed rate of disintegration of U into Pb; 1 gr. U > 1/7,600,000,000 gr. Pb/yr.)

Fossil Record.

AGE OF MAN: Homo sapiens about 1 million yrs. = 10⁶

Analogy of height of Empire State Bldg. with coin on top; ie bldg. is age of Earth; coin is life of Man on Earth.

ORIGIN OF LIFE: about 2 x 10⁹ yrs.

GREEK KNOWLEDGE: Pythagoras (530 B.C.) knew Earth was round.

Aristarchos of Samos (310-230 B.C.) knew earth revolved around sun.

HELIOCENTRIC
GEOCENTRIC

Eratosthenes (276-195 B.C.) computed circumference within 225 mi.!

6 planets known: M, V, E, M, J, S.

LIGHT YEAR = 26 x 10¹² miles
LIGHT: 186,000 mi/sec.
α CENTAURI ↓ 4 LIGHT YRS.
SERIUS 8 LIGHT YRS.
NORTH STAR 40 L.Y.

Uranus discovered 1781 by Herschel. (Uranium discovered same yr.)

Neptune " 1846 - ADAMS & LEVERIER

Pluto " 1930 by Tombaugh (Photographic plates)

(Humors)
BLOOD
PHLEGM
BILE Y-B
YOUNG
ATOMS, ELEMENTS

EARTH AIR FIRE WATER

MOLECULES;

(Earth: Baseball) ie magnify drop to size of Earth.

C H O N S P

PROTOPLASM (LIFE)

LIVING vs NON LIVING
ABIOTIC GENESIS ("RECIPE")

+ MAN MADE ELEMENTS
CALIFORNIUM
FERMIUM
AMERICANIUM
MENDELEVIUM
KURCHATOVIIUM - No. 106
ORGANISMS

CHLOROPLAST
CELLULOSE
MERISTEM

PLANTS vs ANIMALS & OTHERS

PAISTOUR 1864

VITALISM vs MECHANISM

CRITERIA
ANIMALS
VIRUS FUNGUS

BROWN - 1821 - NUCLEUS
SCHLEIDEN - 1838 - PLANT CELL
SCHWANN - 1839 - ANIMAL CELL

LEEUVENHOEK - 1676
HOOKE - 1665

DETERMINE OF SIGNATURES
CLASSIFICATION OF PLANTS

SPANNING NEARLY 3000 YEARS OF SCIENTIFIC HISTORY, *Theories of the Universe* is the first work to present in one comprehensive volume the growth of modern cosmology from its origins in primitive myth to its current development in the work of the great astronomers, mathematicians, physicists and philosophers of science of the twentieth century.

Drawing on the vast store of writings that have dealt with the fundamental cosmological questions of Space, Time and the Creation of the Universe, Milton K. Munitz, editor of the volume, offers 33 key selections from the largely unavailable, often out-of-print works of such major scientific figures as:

HERMANN BONDI	ARTHUR S. EDDINGTON	CHRISTIAAN HUYGENS
GIORDANO BRUNO	ALBERT EINSTEIN	JOHANNES KEPLER
NICOLAUS COPERNICUS	GEORGE GAMOW	E. A. MILNE
F. M. CORNFORD	THEODOR GOMPERZ	D. W. SCIAMA
J. L. E. DREYER	FRED HOYLE	THOMAS WRIGHT

Theories of the Universe, Lloyd Motz observes in his review beginning on the opposite page, is "an exciting panorama of the growth and development of cosmology" which provides "the background necessary to a genuine understanding of what is now going on in [this] extremely active field."

Publisher's price \$6.50, MEMBER'S PRICE \$4.95

Plus one Bonus Credit, equal to an added saving of \$1.00

Vol. III, No. 8

LIBRARY OF SCIENCE BOOK NEWS

May, 1957



THEORIES
of the
UNIVERSE

FROM BABYLONIAN MYTH TO MODERN SCIENCE

edited by Milton K. Munitz

Jup - 864,000 mi diam.

Jupiter - 88,000 $\pm 480 \times 10^6$ mi
 ± 12 yrs 1 REV. from Sun

Pluto - 1 Rev. Sun ± 250 yrs

SUMER - 5000 BC AKKAD } Tigris-Euphrates
ASSYRIA - 600 BC } MESOPOTAMIA
(IRAQ)

GAUTAMA | BUDDHA - 566-480 BC (Enlighten)

MUHAMMAD - 570-632 AD - ISLAM. (Prophet)
MUSLEM

PYTHAGORAS - d. 500 BC

SOCRATES - d. 399 BC

PLATO - d. 347 BC

ARISTOTLE - d. 322 BC

THEOPHRASTUS - d. ± 285 BC [TUT - 1325 BC]

EUCLID - d. ± 330 BC

ARCHIMEDES d. ± 210 BC

ERATOSTHENES d. ± 200 BC

SATURN - $\pm 886 \times 10^6$ mi
rings
PIONEER II }
} 172×10^8 mi/diam
} 29.5 yrs. Period
} 10 satellites

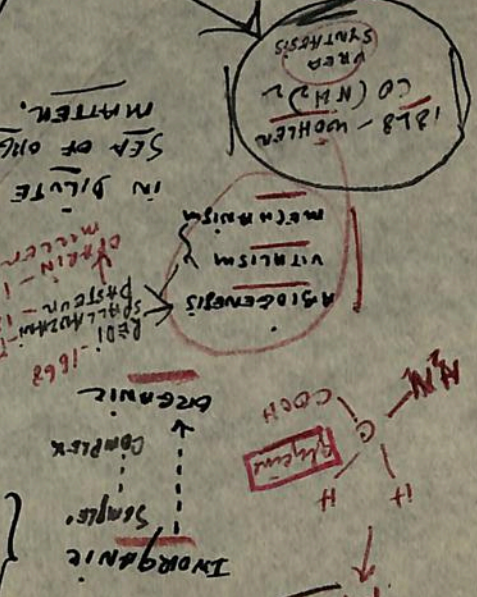
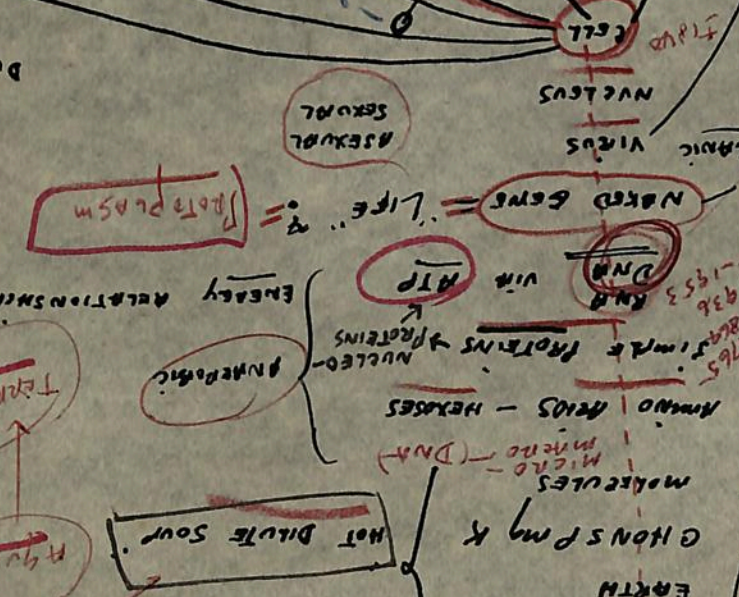
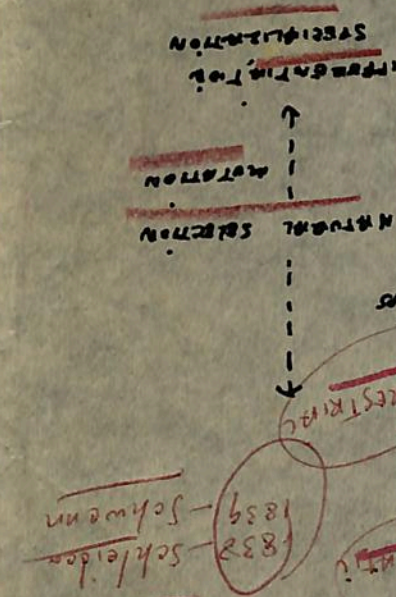
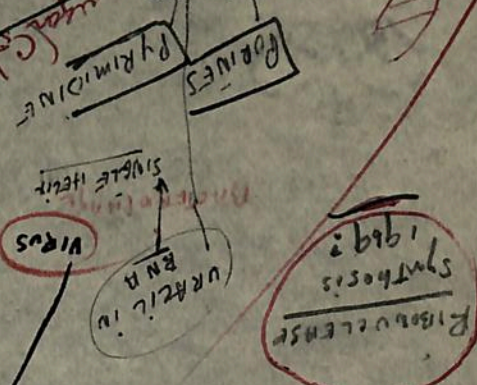
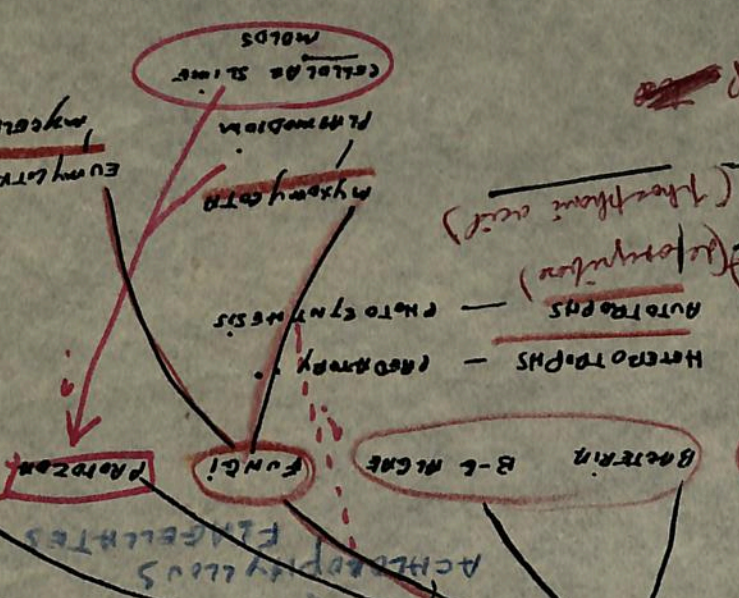
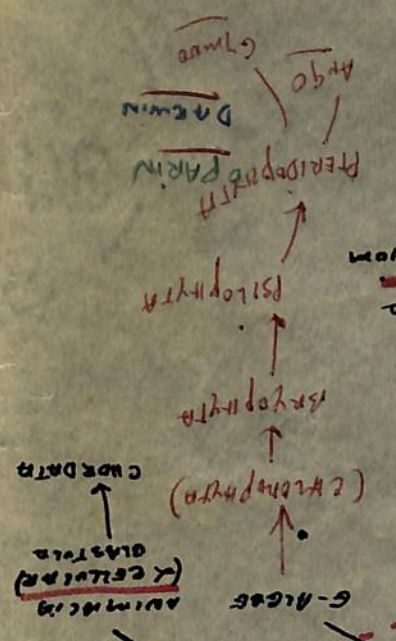
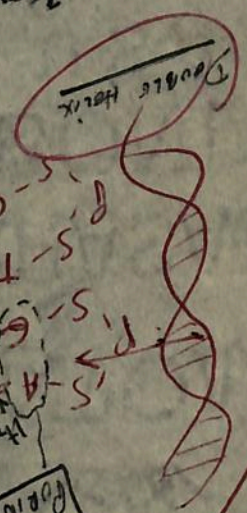
1
 * because of N. Cray
 * who passed to Eng.
 L. Pauling of Helix

Helix 20 Å diam.
 3.4 Å bet. paired bases
 34 Å → 1 complete "turn" of helix

1953 * WATSON & CRICK, WILKINS
 1962 Nobel
 NUCLEOTIDE BASES
 PYRIMIDINE
 PURINE

ADENINE - THYMINE
 GUANINE - CYTOSINE

GENE, ENZYME [GEOV. TAMM] 1958 Nobel
 in PYRIMIDINE - SUPP. - PROTEIN



Life is a logical consequence of known chemical principles operating on the atomic composition of the universe

My interest in chemical evolution began in the fall of 1949 when I read *The Meaning of Evolution*, by George Gaylord Simpson. I devised an experiment to test some of the ideas arising from that reading—namely, to determine whether or not an energy input into the collection of primitive molecules believed to exist on the surface of the original earth could lead to molecules of biological consequence. In 1951 such an experiment was performed, and it was indeed found that the beginnings of molecular growth could be demonstrated under prebiotic conditions.

The first external publication from

Melvin Calvin is known for his scientific achievements in fields ranging from metal-organic chemistry to the chemical origin of life and for his contributions to the understanding of photosynthesis in green plants and, more recently, of chemical oncogenesis. Dr. Calvin obtained the Ph.D. in chemistry from the University of Minnesota in 1935. After two postdoctoral years at the University of Manchester, in England, in 1937 he joined the Department of Chemistry at the University of California, Berkeley, becoming a professor in 1947. He has served on the President's Science Advisory Committee, as chairman of the committee on Science and Public Policy of the National Academy of Sciences, and as president of the American Chemical Society. He is a member of the National Academy of Sciences, the Royal Society of London, the Japan Academy, and other distinguished societies. In 1961 he was awarded the Nobel Prize for Chemistry, in 1964 he received the Davy Medal of the Royal Society, and in 1975 the Virtanen Medal in Finland. The preparation of this paper was supported by the U.S. Atomic Energy Commission. It was originally presented, in slightly different form, as an address to the Mitsubishi Kasei Institute of Life Sciences, Asahi-Kodo Hall, Tokyo, on 18 May 1974. Address: Laboratory of Chemical Biodynamics, University of California, Berkeley, CA 94720.

our laboratory of a comprehensive view of the problem appeared in *American Scientist* (44:248-63, summer 1956) under the title "Chemical Evolution and the Origin of Life." At that time only a few laboratories throughout the world were engaged in experimental efforts to demonstrate the possible origins of life. These included experiments in the laboratory of Harold Urey, the preliminary results of which were published in 1955, and in the laboratory of A. I. Oparin in Moscow, who had published a comprehensive discussion of his point of view in English in 1936, as well as a few scattered photochemical experiments in England and India.

In the two decades since the original publication, the subject has evolved into a many-sided discipline. The demonstration of the formation of biologically important molecules under all sorts of abiotic conditions has been repeated many times in many places all over the world. Four international conferences on the origin of life have taken place, and the International Society for the Study of the Origin of Life was formed in 1971. Whereas the initial problem was simply whether or not organic molecules of biological consequence could be formed in a prebiotic environment, the questions now before us are far more sophisticated and difficult. Such things as the origin and evolution of the mechanisms of directed energy transfer and information storage and transfer now concern us.

The question of the origin of life on earth and the nature of chemical evolutionary processes that could have given rise to it has engaged

the minds of men since they first contemplated the nature of their place on the earth and in the universe (1). The most acceptable view in scientific terms today stems primarily from the concepts first carefully and clearly enunciated by Charles Darwin in his early writings. The basis for his discussion was the great variety of the morphological and functional forms of present living things, as well as knowledge of the vast array of extinct forms whose morphological features were preserved in the paleontological record in the rocks.

On that basis, Darwin was able to formulate his general hypothesis of biological evolution, which is perhaps best expressed by the title of a paper proposed by Wallace but never used—"On the Tendency of Varieties to Depart Indefinitely from Original Types." These words seem to me to express best the fundamental idea of Darwinian evolution—namely, that two species which exist today as independent species, if followed back in time, were originally two varieties of the same species. Thus, if we go forward in time, individual variations would gradually separate to become new species.

If we follow the reverse-time process sufficiently far back, we must arrive at a time, and a condition, when there was only one ancestral species—one type of organism—which included varieties that became today's separate species. If we go still farther back, reaching that point when the individual living thing was only one variety of many different kinds of molecular aggregations, we can see that the transition from molecules to a living

thing is a continuous one. Thus, we can reach back into the history of the earth to a period when the earth had no living things, only molecules. And we can go even farther back to that time when there were no molecules, only atoms, bringing us to the period of the evolution of the elements themselves.

As Darwin and Wallace realized—and expressed in the unpublished title—there was a continuity in evolution, ultimately arriving at a successful starting point whose descendants survived. That starting point is what we tend to mean by the “origin” of living matter. Darwin wrote a very interesting letter (2) about this idea in 1882 in response to a query, stating:

You expressed quite correctly my views where you said that I had intentionally left the question of the Origin of Life uncanvassed as being altogether *ultra vires* in the present state of our knowledge, and that I dealt only with the matter of succession. I have met with no evidence that seems in the least trustworthy, in favour of so-called Spontaneous Generation. I believe that

I have somewhere said (but cannot find the passage) that the principle of continuity renders it probable that the principle of life will hereafter be shown to be a part, or consequence, of some general law.

The statement to which Darwin refers, and which he had forgotten, was written earlier, in 1871:

It is often said that all the conditions for the first production of a living organism are present, which could ever have been present. But if (and oh what a big if) we could conceive in some warm little pond with all sorts of ammonia and phosphoric salts—light, heat, electricity, etc.—present, that a proteine compound was chemically formed, ready to undergo still more complex changes, at the present day such matter would be instantly devoured, or absorbed, which would not have been the case before living creatures were formed (3).

I propose to discuss a certain period in this time sequence—the period in which the molecules themselves were being formed and transformed and built up to reach, eventually, a size and complexity that could con-

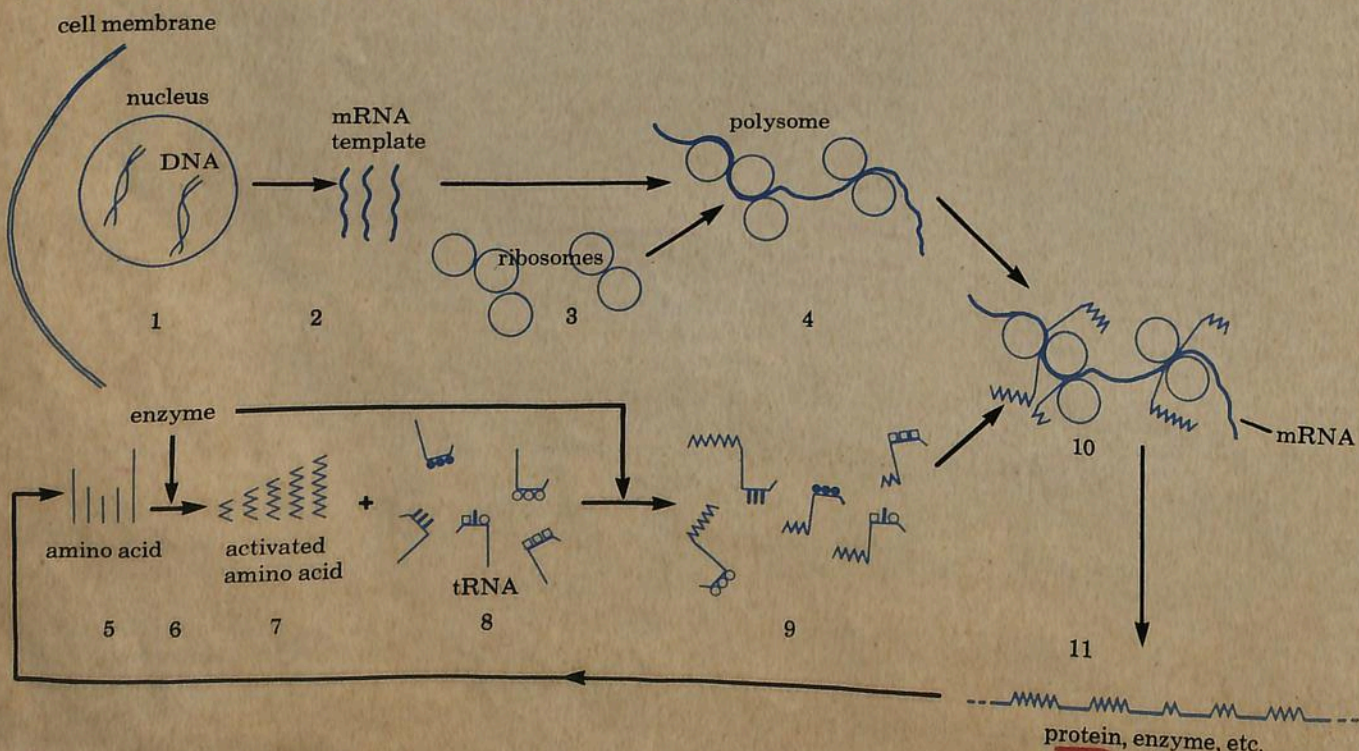
tain and sustain the living process leading to life as we now know it (4, 5, 6). We will begin by looking at the molecular nature of living things as we understand them today, to see, first, what it is we must arrive at by chemical means. It is not yet possible for us (and I am not sure it ever will be) to find a record in the rocks of the molecular events that may have taken place prior to the appearance of what we call a living thing. Therefore, we must try to reconstruct those possible processes from what we know about present-day chemistry and see how far we can carry them out experimentally in the laboratory.

Figure 1 is a diagrammatic representation of the essential principles of present living organisms and their construction. It contains all the elements that we must eventually describe in molecular terms—the appearance of small molecules (amino acids) and of polymers of those amino acids and nucleic acids which form large mole-

Figure 1. The mechanism of protein biosynthesis is illustrated by the reproductive process in a living cell. The genetic code of the cell—DNA—is located within the nucleus (1). In order to construct a new cell, the cell must first transcribe the information contained in the DNA to the messenger RNA (mRNA) templated on pieces of the DNA

(2). The mRNA combines with ribosomes (3) in the cytoplasm to form a polyribosome (polysome) (4). The simple amino acids present in the cytoplasm (5), after being activated by a chemical catalyst (6), become attached to transfer RNA (tRNA) (9). The polysome then unites the amino acids from tRNA, in an order designated by mRNA

(10), thus creating a protein (11). The process is a combination of information transfer and energy transfer. Steps 2, 3, 4, and 10 represent the cell-specific process of information transfer, while steps 5, 6, 7, and 9 represent the general biological information processing common to all cells. (After Calvin, ref. 7.)



cules that ultimately have specific structure, giving rise to specific shapes and sizes. Thus, there are four elements of molecular evolution that we must try to understand: the evolution of molecules themselves, the simple molecules of which living things are made; the evolution of macromolecules (polymers) and structure; the evolution of catalysis—the ability to make specific reactions occur with a high degree of efficiency; and the evolution of information-storage and information-transfer processes that allow the two systems to coalesce.

Evolution of molecules

Figure 2 outlines the time sequence in which results of evolution were and are being achieved. In the beginning, most of the elements of the universe were in the form of hydrogen, which eventually had to undergo fusion reactions, giving rise to the higher elements in the periodic table, particularly those important to living things: carbon, nitrogen, oxygen, sulfur, phosphorus, halides, and certain metals, particularly iron, which are important for catalytic functions in living organisms.

Then, the primitive (prebiotic, primeval) molecules were formed from the organogenic elements with which the earth was initially coated: methane, ammonia, carbon monoxide, water, carbon dioxide, hydrogen sulfide, and, of course, hydrogen. These first three stages present no chemical problem, since the first two are nuclear and the third is simply the result of the presence of carbon, hydrogen, nitrogen, and oxygen at a low enough temperature to produce the small, primitive molecules.

The next stage of chemical evolution—from the organogenic molecules to the biomonomers—does present a chemical problem, and it has been an area of major progress in the last twenty years (6, 7). The conversion of organogenic molecules into amino acids, sugars, nucleic acid bases, and other carboxylic acids (acetic acid and citric acid, for example) has been achieved in the laboratory under the influence of a wide variety of energy sources, ranging from the ultraviolet light of the sun to radioactive energy (in the form of ionizing radiation) to

Evolution of polymers

The transition from biomonomers to biopolymers is best illustrated in the formation of polypeptides and nucleic acids (Fig. 3). In each of these cases, in order to make the biopolymer from the biomonomer, it is necessary to remove a water molecule between the two monomers. The removal of the water molecule, the essential chemical reaction that must be achieved in the presence of water itself (10, 11), is sometimes very difficult. We know that it can be done if the conditions are correct, because that is what occurs today in every living organism. Proteins, polysaccharides, and lipids are all made by such a water-removal process, in the presence of water.

It was necessary to devise a special kind of chemical reaction that would allow the condensation polymerization with polypeptide or the nucleic acid formation to take place. We used a variety of chemical reagents that store the energy of ionizing radiation or ultraviolet radiation, agents which are formed very readily from methane and ammonia. These are reagents in which the carbon-nitrogen multiple bond is contained (either a double bond as in the tautomer of cyanamide in which one of the hydrogens has moved, or a triple bond such as in cyanide ion, HCN). These multiple carbon-nitrogen bonds are relatively stable high-energy sources for absorption of water, and they do not react very rapidly with water themselves; they react preferably with the sources of water. By mixing dicyandiamide with glycine in water solution we were able to make glycine polymers at least up to the tetrapeptide (12). The polymer thus formed is one in which the glycine loses a water molecule between the carboxyl group of one molecule and the amino group of another to form a peptide. This occurs, of course, in water, and the products are diglycine, triglycine, and tetraglycine.

We have thus demonstrated that it is possible to unite two amino acids to form a peptide link, even in water. In fact, that process takes place with some degree of specificity. When one mixes several amino acids in the same solution and in the same reaction, it is possible to

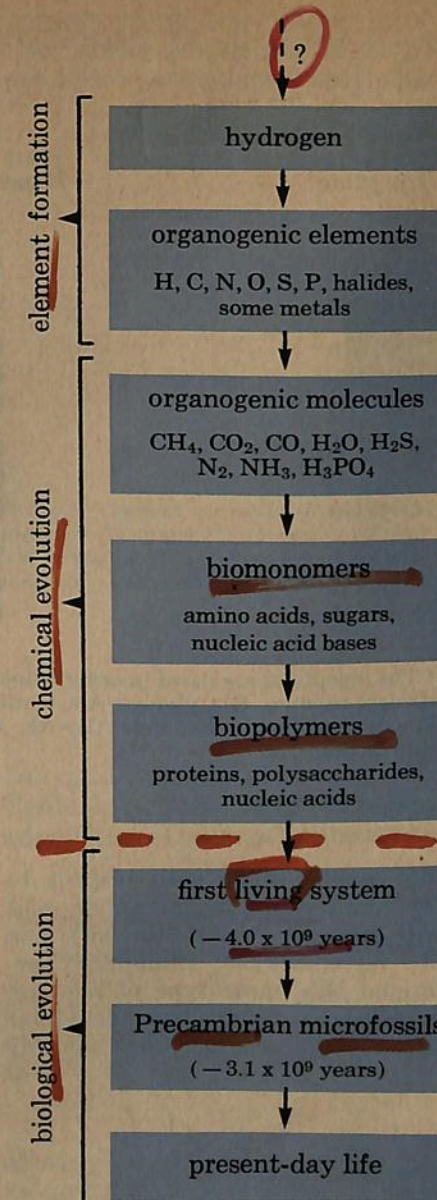


Figure 2. Time sequence of evolution from the formation of the elements to the present.

mechanical energy (in the form of meteoritic shock waves) (8). All these energy sources give rise to the transformation of the organogenic molecules to biomonomers.

The next stage—the transition from biomonomers to biopolymers—is more difficult to achieve in terms of chemical evolution (9), and most of the rest of the discussion will be concentrated in this area and on the formation of structure and function in the biopolymer region, which eventually gave rise to the first living organisms about four billion years ago.

BEGINNINGS etc.

ARISTOTLE - d. 322 BC

PTOLEMY - I 125 AD
GEOCENTRIC
 OF ALEXANDRIA

COPERNICUS - 1543
HELIOCENTRIC

GALILEO - d. 1642

NEWTON - b. 1642 -
 GRAVITATION 1727

KEPLER - d. 1630
 elliptical orbits

EINSTEIN - d. 1955

* 4004 BC
 3992 BC
 3113 BC MAYA

→ BEGINNING MIDDLE END

→ GEOCENTRIC

↓ HELIOCENTRIC

→ TELESCOPE - MOON etc.

→ GRAVITATION
 $F = G \frac{m_1 m_2}{d^2}$
particle moon

→ $E = mc^2$ RELATIVITY

↳ BUT HINDU IDEA OF ETERNITY etc.

↳ NATURE'S LAWS, etc. POPE

ATOM

← EARTH, AIR, FIRE, WATER

← MATTER (gas, liquid, solid)

← PROTONS, ELECTRONS etc.

→ MOLECULE etc.

Atomic THEORY

DEMOCRITUS ± 400 BC — Intuition is "ATOM" - indivisible

↓

DALTON - 1808⁽²⁾ — Law of DEFINITE Proportions (ie H₂O)

Experiment

MENDELEEV - 1869 | PERIODICITY Atomic WEIGHTS

↳ 63 elements

Three hundred years ago, few men were curious about the age of the earth. They took their Bible literally and saw little reason to question the claim of Archbishop James Ussher of Armagh, Ireland, who, in 1650, based upon Biblical references, calculated that all life had been created in 4004 B. C.



THE ORIGIN OF LIFE

by GEORGE WALD

REPRINTED FROM
**SCIENTIFIC
AMERICAN**
AUGUST 1954



PUBLISHED BY W. H. FREEMAN AND COMPANY 660 MARKET STREET, SAN FRANCISCO 4, CALIFORNIA

*A stimulating and provocative exploration of
a nonmythologic Genesis . . .*

THE ORIGIN OF LIFE

BY NATURAL CAUSES

by MARTIN G. RUTTEN, *Professor of Geology, State
University at Utrecht, The Netherlands.*

1972, 440 pages, 150 illus.

Price: \$34.50

ISBN 0-444-40887-8 LC 73-118255

Dealing with modern ideas regarding the possibility of life on earth (and elsewhere in the universe) originating from a lifeless environment without intervention of divine creation or other supernatural events, this volume considers when, where, and under what conditions life may have evolved. The subject is not only a very wide, but a controversial one, which has caught the interest of philosophers and theologians for the past two thousand years. It is only during the present century that a more general interest has been aroused in scientific circles.

The author is not here concerned with whether life was created or evolved, but rather with the scientific background relating to the possible development of life through natural causes. The study takes us back to the beginning of the geologic history of the earth, considering at all stages the role played by every discipline of the natural sciences. It will not only be of interest to theologians, philosophers and scientists, but to the layman as well. Although some sections delve rather deeply into theoretical aspects and background, they can be disregarded by the non-specialist without losing the general trend.

CONTENTS: Preface (by A. Oparin). Preface (M. Schidrowski). I. Introduction. II. The principle of actualism. III. Measuring time in geology. IV. The



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Age of Universe Now Estimated as 20 Billion Years

By WALTER SULLIVAN

Scientists at the University of Chicago have determined that the universe may be as much as 20 billion years old, considerably older than most current estimates.

The latter have tended to range from 10 billion to 15 billion years. The new finding suggests that the Milky Way galaxy of stars began forming at least 10 billion and possibly 20 billion years ago after the earlier, explosive birth of the universe.

For more than a century, estimates of the age of the earth and of the universe have tended to grow from a biblical few thousand years to millions and then billions of years. This latest development fits one more piece into the puzzle of forming its matter and its inhabitants evolved.

The estimate is based on calculations of how much radioactive rhenium 187 has decayed since that element was first formed early in the history of the galaxy. This form, or isotope, of that rare metal has an extremely long half-life of 40 billion years. That is, half of a given amount decays in that time.

It is assumed that rhenium 187 began to be formed from lighter elements during

stellar explosions early in the history of the galaxy whose billions of stars are partly visible as the Milky Way. Such explosions known as supernova, are thought to generate a number of the heavier elements.

The Chicago scientists, from laboratory tests at the Lawrence Livermore Laboratory of the University of California, have estimated how much rhenium 187 originally formed, relative to other isotopes of rhenium, notably rhenium 185, which does not decay.

The proportion of rhenium 187 remaining today, assuming relatively steady production of the isotope in subsequent epochs, could then be used as a stop watch to determine how much time had elapsed since rhenium synthesis began.

According to the announcement, issued jointly by the University of Chicago and the National Science Foundation, which funded the research, it is assumed that galaxies like the Milky Way began forming from 10 million to 100 million years after the great explosion, or "Big Bang," in which it is believed the universe was born.

As early as 1929 Sir Ernest Rutherford in Britain sought to measure the age of the universe by a similar method, based on uranium 238. The half life of the latter is 4.5 billion years, which means that

most of it formed by early stellar explosions has decayed.

According to one of the experimenters, Dr. David N. Schramm, the use of long-lived rhenium 187 for doing this calculation "is far superior" to the short-lived uranium 238 since that component of the isotope formed when heavy elements first began to be formed has largely disappeared.

Other estimates of the age of the universe include running backward its observed rate of expansion, with some correction for a slowing down in the past few billion years. This, according to the announcement, puts the time of the Big Bang at from 7 billion to 20 billion years ago.

Another age, derived from that of the oldest stars, is from 9 billion to 18 billion years.

The extent of slowing in expansion of the universe is of special interest because it bears on whether it will continue forever or ultimately will succumb to the gravity of all parts of the universe and fall back together. The most recent evidence points to continuous expansion, but is very tentative.

Working with Dr. Schramm was Dr. Kem. L. Hainebach. Both are at the university's Enrico Fermi Institute.

U.S. URGED TO RELAX CURB ON DNA STUDIES

Advisory Group Asks Exemptions for Most 'Gene-Splicing' Tests

By HAROLD M. SCHMECK Jr.

Special to The New York Times

BETHESDA, Md., Sept. 7 — A national advisory committee has recommended exemption from strict Federal guidelines of 80 to 85 percent of current studies with recombinant DNA, or "gene-splicing" research.

If accepted by the director of the National Institutes of Health, which is considered nearly certain, the action will result in a major relaxation of the guidelines promulgated in June 1976. They were a result of concern over possible hazards of this revolutionary and often controversial realm of scientific research.

Relaxation of the guidelines is likely to result in expanded and accelerated research. A member of the advisory committee said that his group now appeared to be operating on the principle that recombinant DNA research was safe unless a specific potential hazard was foreseen.

The major fear that has pursued such research is that it might produce some new and dangerous form of bacterial life.

No Change for Certain Tests

The recommended exemptions would still leave in place prohibitions against certain potentially dangerous experiments, such as those that would incorporate the genes for a known poison in bacteria. The exemptions, however, would greatly reduce the amount of paperwork for scientists before starting experiments.

The researchers would no longer be re-

Continued on Page 26, Column 1

Call toll-free to start home delivery of The New York Times: 800-631-2500. In New Jersey—800-932-0300. In Boston—1-800-532-6021.—Advt.

Exemptions From Are Urged for M

Continued From Page 1

quired to get Federal approval for experiments in the proposed exempt categories, or even approval from the biological safety committees of their institutions. Restrictions on how the experiments could be carried out would be relaxed to equal those of laboratory procedures in other areas of research.

The experimenters would be required to register their proposed experiments with their local safety committees, but could proceed without waiting for formal approval.

Debate On Since Mid-70's

The national group, known as the Recombinant DNA Advisory Committee, was set up to advise the director of the National Institutes of Health on policy matters concerning this complex area of biological science.

The Federal guidelines apply to all university research supported even in part by the Federal Government, and are considered binding on essentially all academic research. They are not binding on industry, but spokesmen for the Pharmaceutical Manufacturers Association said that all of its members who were doing recombinant DNA research had decided to conform voluntarily to the guidelines.

Since the middle 1970's there has been an almost continuous debate over the potentialities of recombinant DNA research. A committee member, Dr. Sheldon Krinsky, a specialist in social and environmental policy at Tufts University, asserted that the current revision would make the guidelines almost irrelevant.

Even under the sometimes restrictive guidelines, the research has been expanding. In recent years it has, among other things, demonstrated the possibility of using bacteria to grow large quantities of such human substances as insulin and a human-growth hormone.

Heredity's Master Chemical

DNA, for deoxyribonucleic acid, is the master chemical of heredity, the active substance of the genes, which determine all manner of inherited traits. New technology makes it possible to rearrange and transplant pieces of this genetic instruction material from animals or humans to bacteria. The bacteria are then used as factories to produce large quantities of specific genetic material for study or other use, such as the growing of large quantities of rare hormones.

Along with its potential usefulness, the new research is also viewed as a vehicle of great potential hazard, if bacteria endowed with novel and dangerous characteristics escaped from the laboratory. One original fear was of new kinds of infection that might spread among humans, animals or plants.

More recently concern has been expressed over the possibility of more subtle kinds of harm, such as contamination that would prompt humans or animals to react harmfully against some of their own tissues.

Experiments on the possibilities of harm have been termed reassuring by those who want the the guidelines relaxed. But some critics remain unconvinced.

Vote Taken on the Move

It was against this background that the Recombinant DNA Advisory Committee, made up of scientists and laymen, took up a proposal to exempt a large category of current experiments from the guidelines.

The issue was discussed at the committee's quarterly meeting, which ended here today at the National Institutes of

DNA: Industrial Interest Grows

By HAROLD M. SCHMECK Jr.

BETHESDA, MD.

THE horizons of recombinant DNA technology are rapidly expanding from pure research to industrial application with potentially important consequences for science, government and other areas of society.

The clearest expression of this accelerating change came last week when two industrial firms asked the National Institutes of Health for permission to

increase the size of production in some important experiments beyond the relatively modest limit set forth in current Federal guidelines.

The two requests are believed to be the first such industrial proposals put before the Federal panel, called the Recombinant DNA Advisory Committee, which advises the director of the institutes on policy in this rapidly expanding and often controversial area of science.

Recombinant DNA research, known popularly as "gene splicing," has been a subject of great excitement and con-

trovery among scientists and laymen alike in recent years. The research techniques make it possible to transplant segments of the genetic material DNA (deoxyribonucleic acid) from one species of cell to another and to induce common bacteria to manufacture genes, and sometimes the products of those genes, from almost any living creature, including humans.

The research has already produced a wealth of important new information on the chemistry of heredity and has demonstrated the possibility of growing, outside the human body, large amounts of important substances such as human insulin and the human growth hormone.

An increase of experimental volume by industry is a necessary preliminary to any commercial production of human insulin or other substances for which there would be a large market.

Scientists consider this area of research to be one of the most fertile to emerge within the past several decades.

Because of their potency, however, the new techniques aroused fears that great hazards might emerge from the research and its applications; for example, the production in the laboratory of bacteria with abnormal and dangerous characteristics unknown in nature.

The same advisory committee of scientists and laymen also took an important step on the issue of hazards last week by voting 10 to 4, with one abstention, to recommend exempting an estimated 80 to 85 percent of current recombinant DNA research from most of the Federal guidelines. The Federal rules govern virtually all nonindustrial research in this important new field. The committee's decision was based on evidence from several years of research by scientists throughout the world and on risk assessment experi-

Continued on Page C3

THE NEW YORK TIMES, TUESDAY, SEPTEMBER 11, 1979

Industrial Interest in

Continued From Page C1

ments designed to gauge the possibility of hazard.

The exemptions were limited to experiments employing bacteria and other organisms that do not readily pass genetic information between species. Prohibitions were retained on certain presumably dangerous experiments such as those that would endow common bacteria with the capability of producing dangerous poisons. Also retained was the standard limit of 10 liters (slightly more than 10 quarts) of biological material that can be produced in a given experiment. It is this limit that the commercial concerns wish to surpass.

There are still sharp divisions of opinion on the exemptions among the committee members, a few of whom believe the proposal to relax the guide-

lines was ill-advised and possibly even a grave mistake.

Although there has been voluntary compliance, industrial research is governed by the guidelines, a fact that has prompted several unsuccessful attempts in recent years to pass a Federal law making the guidelines mandatory. It was disclosed at the Recom- nant DNA Advisory Committee meeting that the staff of the Senate Commerce Committee's Science, Technology and Space Subcommittee has been asked by the subcommittee chairman, Adlai Stevenson, Democrat of Illinois, to draft a bill to require registration of all industrial research activities in this field. More sweeping mandatory controls on industry that would require adherence to the guidelines seem to have small prospect of passing Congress at present.

The types of industrial experiments for which approval for increased out-

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The authors suggest that hour of regular class time. a remedial program, but study skills, or productivity dents alike. They say the might taught as part of a such as English, social studies a home-room sideshow.

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Item: In teaching to lis following questions, expe

4004 BC OCT. 28 9 AM (SUNDAY) ORIGINAL

ARCHBISHOP USSHER 1654 KING JAMES BIBLE

KEPLER (IRELAND) 3992 BC

2 x 10¹⁰ yrs. 1970.
5 x 10⁹ yrs - EARTH - 1/10 MATTER
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Ptolemy 150 AD. CIPERNAOS - 1543
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SPONTANEOUS GENERATION } VIRUS

DNA - DEOXYRIBONUCLEIC ACID

CELL PROTOPLASM - LIFE (ACINORPHYCIOUS)

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3113 BC - MAYA
3992 BC - KEPLER d. 1630

PLANETS DIST FROM SUN
Mercury - ± 36 x 10⁶ mi.
EARTH - ± 93 "
Jupiter - ± 480 "
PLUTO - ± 3 x 10⁹

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ATTEMPTS TO DEFINE LIFE - ELUSIVE "ELAN VITAL"

MECHANISM VS VITALISM

F. REDI (1668) SPALLANZANI (1768) PASTEUR (1861)

Big Bang 1
QUASARS 2
12 x 10⁹ light yrs 3

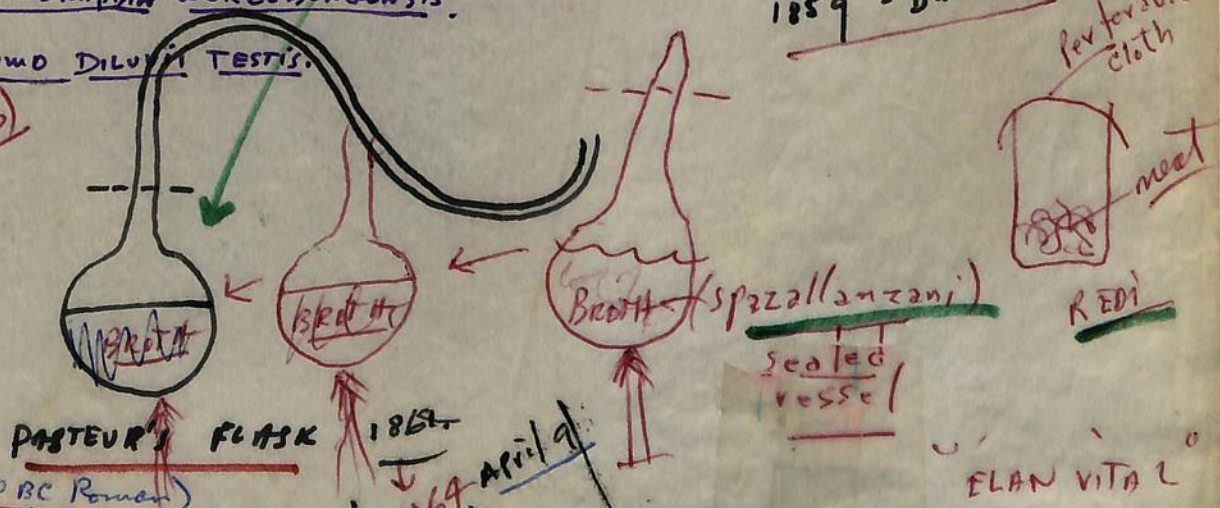
THE COOKBOOK ANALOGY - QUANTITATIVE VS QUALITATIVE
TWO WATER ANALOGY
S. MILLER 1953 NH3 CH4 H2 H2O

HOW TO CREATE A LIVING THING } MEDIEVAL RECIPES BREAD ETC.

PASTEUR'S CRITICAL EXP.

BIOGENESIS - HUXLEY 1870
1859 - DARWIN

J. BERINGER 1726. LITHOGRAPHIA WÜRTEMBERGENSIS.
J. SCHEUCHZER 1726. HOMO DILUVII TESTIS.



OPARIN - MILLER (1953)
Nothing from nothing ever got was born.
Lucretius (± 50 BC Roman)

Autotrophs vs Heterotrophs

Mechanism vs Vitalism
 ("élan vital")
abiogenesis

ATOM
 (Quark Quasar)

PROTON
 ELECTRON etc
 MOLECULE



4004 - Ussher - 1654
 3992 - Kepler d. 1630
 3113 - Maye

MATTER -- BIG BANG
 ± 20 x 10⁹ yrs.

Quasar
 ↓
 Quark

ATOMIC THEORY
 DEMOCRITUS + 400 BC

± 5 x 10⁹ yrs - EARTH

± 9 x 10⁹ yrs - LIFE

IF UNIVERSE 3 DAY
 OLD, THEN MAN
 ON EARTH ± 10 SEC.

DALETON 1808
 ATOMIC
 WGT'S.

EARTH
 AIR
 FIRE etc
 etc
 Electron
 Proton
 Neutron
 etc
 Quark

abiogenesis

REDI - 1668
 SPALL - 1768
 PAST. - 1864

± 3.5 x 10⁶ yrs
 Homo
 habilis

↓
 H. erectus
 H. sapiens
 ("élan vital")

SPONT.
 GENI.

[LEEUWENHOEK - 1683 - BACTERIA etc]

"Never will the doctrine of spontaneous
 generation recur from the mortal
 blow of this single experiment."

COPARIN + 1936

April 7, 1864
 Sarbonne

MILLER 1953

methane
 ammonia
 water + H₂
 elec. spark

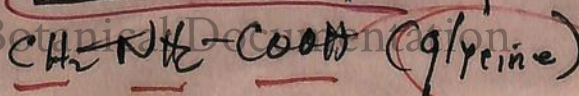
UNIV. ILL.
 "Methanogens"

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[Protobacteria]

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* amino acids



PETRI 1877

CHANCE where?

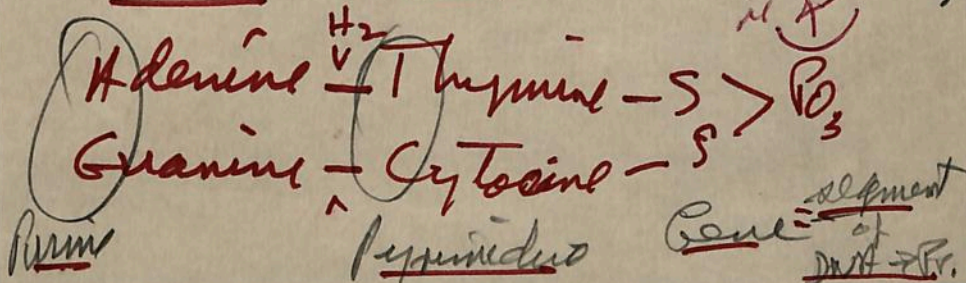
AIR
 N₂ - 77
 O₂ - 21
 Argon - 1
 CO₂ - .03
 + rare gases

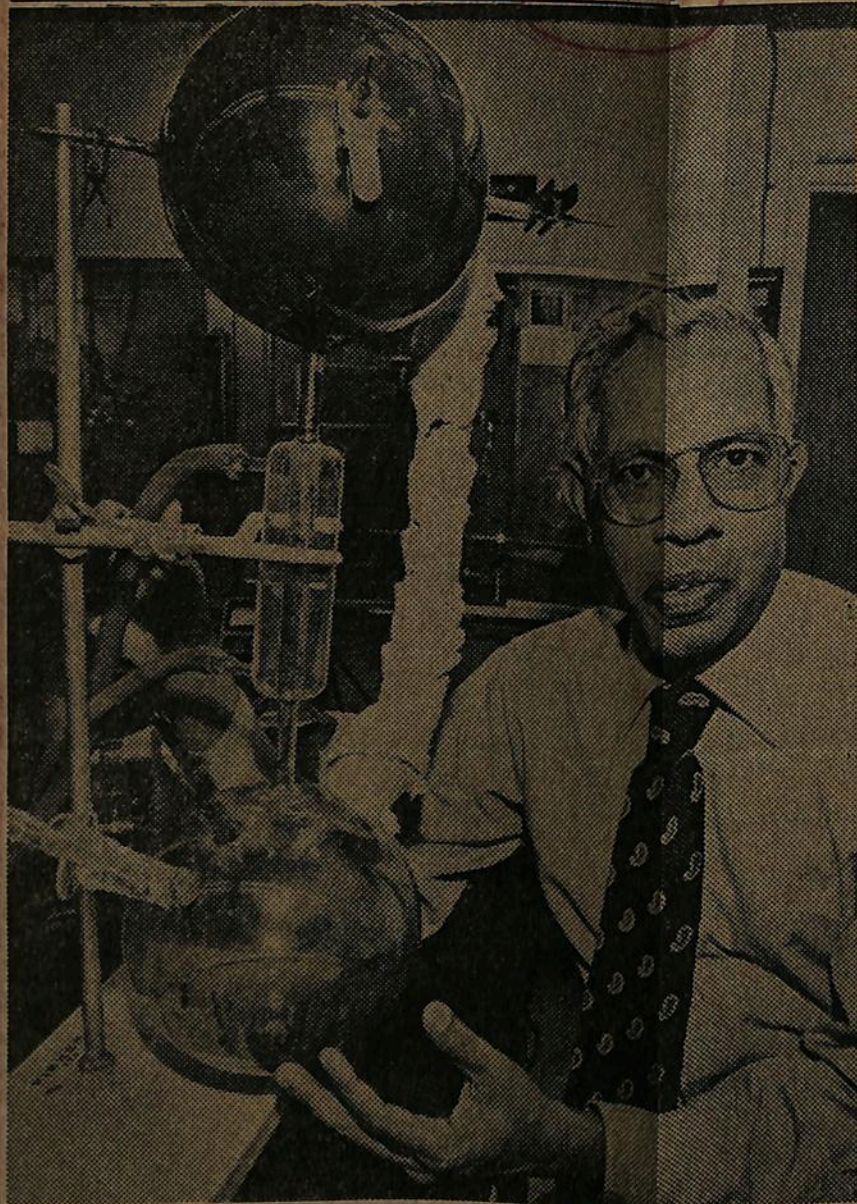
WATCH ANALOGY
 VITALISM
 vs
 MECHANISM

lightning
 in
 Nature

3 nucleotides → amino acid
(CODONS)

is triplet code. (64 possible combinations)





SOUP'S ON — University of Maryland scientist Cyril Ponnampereuma exhibits a sample of "primordial soup." Ponnampereuma and his colleagues are exploring the basic questions of the origin of life on Earth.

— Washington Post photo

Scientists Seek Key To Origin of Life

By BART BARNES
(C) 1979, The Washington Post
WASHINGTON — "How did life begin?"

In the search for an answer to mankind's most fundamental question, Cyril Ponnampereuma travels to Greenland every summer. In a place called Isua at the edge of the polar ice cap, he and his fellow scientists gather up piles of what look like ordinary rocks.

But the "rocks" are 3.8 billion years old — samples of the oldest known sediments in the world. With his staff, Ponnampereuma, who is director of the University of Maryland Laboratory of Chemical Evolution, carefully analyzes the sediments for traces of molecular fossils that might be similar to materials being produced synthetically in laboratories.

While some of Ponnampereuma's scientists are analyzing the sediments, others are working in the laboratories to produce a substance known only as primordial soup, described by Ponnampereuma as "the mixture of organic molecules from which we believe life evolved."

If the scientists discover a similarity between the molecules in the primordial soup and those in the Greenland sediments, "then our synthetic and analytical processes will meet at some point in the history of the Earth," observed Ponnampereuma, and he will be one step closer to unraveling the chemical interaction that first created life.

Ponnampereuma and his staff, to put it simply, are about the business of trying to duplicate in their laboratory that primitive chemical interaction that first formed a molecule capable of reproducing itself — the scientific definition of life.

As a corollary, they are probing the question, "Is there civilized life outside our solar system?" Ponnampereuma is convinced there is.

"In all science, the single biggest question we can ask each other is, 'What is the origin of life?'" said Ponnampereuma. "We are the only comprehensive laboratory of this kind that is addressing this question."

Tucked away on the third floor of the chemistry building at the College Park, Md., campus, Ponnampereuma and his staff — which varies from 15 to 25 scientists, researchers and students — have spent the better part of the last decade searching for an answer to the question of how life began.

"This is a question which has been for ages in the mind of the philosopher and the theologian," observed Ponnampereuma in a paper presented earlier this year at the annual meeting of the American Association for the Advancement of Science in Houston. "But today we dare to approach this subject in a strictly scientific and experimental manner."

A native of Sri Lanka, the soft-spoken Ponnampereuma began his academic career as a philosopher. In fact, his first academic degree was in philosophy, earned at the University of Madras in India.

"It's nice to think I couldn't find the answers in philosophy, so I turned to science," he says, "but that really isn't the case. I've always been interested in chemistry."

With a doctorate from the University of London, Ponnampereuma, 50, has spent the better part of his adult life probing the mysteries of the origin of life. Before going to Maryland he worked on the West Coast for the National Aeronautics and Space Agency.

Although his later training and research has been in science, his earlier work in philosophy is very much with him.

He is a student of various theories and myths about creation, and when asked how he squares what he is doing with the story of creation he is likely to answer, "Which one?"

In his Houston paper, he noted that theories of creation and spontaneous generation of life are as old as language itself. "The ancient philosophers of India described the oceans as the cradle of life. Aristotle, in his 'Metaphysics,' suggested that 'fireflies arose from morning dew.' Virgil describes 'a swarm of bees arising from the carcass of a calf.' There is a

reference to 'the crocodile of Egypt born of the mud by the action of the sun' in Shakespeare's 'Anthony and Cleopatra.'

"You have the Eastern religions and the beliefs in transmigration. That's not unlike the scientific fact that the carbon that is in you now was manufactured by the stars 10 billion years ago.

"People sometimes ask me what the impact of my work will be on religion. I say none. It is the job of the scientist to gather information. The burden of interpretation is on the philosopher. You cannot probe matters of the spirit in a laboratory. That would be like trying to find a square root with a spade."

In addition to his work in the lab, Ponnampereuma teaches an undergraduate course to non-science majors at Maryland and conducts a weekly seminar on extraterrestrial life. "Each star that we see twinkling in the night sky may have around it a planet suitable for life," he says. "If that is indeed the case, the number of sites for life in the universe is literally astronomical. According to the most conservative estimate, 5 percent of all stars in the universe must have planets suitable for life. By the latest count, it is estimated that in our galaxy alone there may be a million civilizations."

Ponnampereuma lives in Washington with his wife, a native of northern India, and their daughter. "My wife tells me I'm married to chemistry, but I am interested in art and music and I do a little gardening. Mainly, I like to do a little bit with my roses, but occasionally I try my hand at growing something else," he says.

He also is president of the Sri Lanka Overseas Foundation, an organization of expatriots working to help Sri Lanka in science and the humanities. In Washington, Ponnampereuma is a member of the Cosmos Club, where he "tries to take some part in the activities downtown," and at Maryland he chairs a program for international activities at the College Park campus.

By his own description, he "reads everything that comes my way."

But for the most part, he continues looking for the origin of life. "The moment somebody comes up with a replicating molecule in a laboratory, we'll have it," says Ponnampereuma. "It could happen soon. It could be a long way off."

Until that day comes, Ponnampereuma

and his scientists will continue their summer trips to Greenland and their brews of primordial soup.

To brew the primordial soup, Ponnampereuma attempts to simulate a primitive atmosphere composed mainly of methane gas and ammonia, then subjects it to electrical charges. After 24 hours, what he has left is a dark brown material that most chemists throw away as "goo or gunk." That's the stuff his chemists analyze for chemicals of biological significance.

When the Smithsonian Institution opened its Air and Space Museum on July 1, 1976, they decided to include Ponnampereuma's primordial soup in an exhibit on the origin of the universe. Since it is, after all, a soup, someone had the bright idea of having Julia Child explain how it's made, as if it were one of her recipes, and a film crew recorded her explanation.

"She did a rather good job," said Ponnampereuma.

ORIGIN AND EVOLUTION OF LOWER (PRIMITIVE) FORMS

ORIENTATION IN TIME AND SPACE

EARTH $4.5 - 5 \times 10^9$ yrs. (RADIOACTIVE DATING)
 (4004 B.C. OCT. 26, 9A.M.) (5966 yrs. - 1962)
 ARCHBISHOP USSHER 1650

MAYA
3113 BC

GEOLOGIC TIME TABLE:
 PRECAMBRIAN (500×10^9 yrs.)
 PROTEROZOIC } CAMBRIAN
 MESOZOIC } ORDVICIAN = 2.5×10^9 } Life } "BIRTHDAYS"
 CENOZOIC } SILURIAN
 etc. = 10^6 } Homo

LIFE ORIGIN THEORIES

SPONTANEOUS GENERATION (REDI, SPALLANZANI, PASTEUR) 1668 1768 1864

EVOLUTION OF INORGANIC & ORGANIC

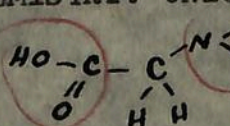
FOLL. FACTORS IN EVOLUTION OF LIFE

OPARIN
HALDANE 1936

OPARIN

1. PRIMITIVE SEA A "HOT DILUTE SOUP" OF 10% ORGANIC MATTER.
2. AMINO ACIDS, SIMPLE SUGARS, PURINES ALL PRESENT (POSTULATED)
3. CONCENTRATION OF ORGANIC MOLECULES BY POLYMERIZATION: COLLOIDS.
4. PROTEIN SYNTHESIS VIA ATP FOR ENERGY TRANSFER. IMPORTANCE OF PO₃
5. UV RADIATION FROM SUN A PRIMITIVE SOURCE OF ENERGY. NO OZONE IN EARTH'S ATMOSPHERE.
6. PROTEINS SURVIVED BECAUSE OF ABILITY TO REPRODUCE THEMSELVES. (AUTOCATALYTIC)
7. POLYNUCLEOTIDES ie PROTO DNA THE GENE. MENDEL RNA CHROMOSOME → CELL → FUNGUS PL ANIM
8. FREE LIVING NAKED GENE IN A DILUTE SEA OF ORGANIC MATTER WAS THE FIRST LIVING THING. NO NUCLEUS. BACTERIA (PURPLE)
9. DIFFERENTIATION & SPECIALIZATION. AUTOTROPHS & HETEROTROPHS COMPETITION. FERMENTATION CHEIF ENERGY SOURCE. NO O₂.

WÖHLER'S SYNTHESIS OF UREA 1828. $CO(NH_2)_2$. UPSET VITALISTIC VIEW. CARBON CHEMISTRY. UNIQUE PROPERTIES.



glycine 1953 MILLER

JOHANN BOHRINGER 1826
 "LITHOGRAPHIA WURTZBURGENSIS"
 MEANING OF FOSSILS

MOLECULAR BIOLOGY

EVOLUTIONARY TREND: H₂O → LAND

...CHON...

formation of H₂O, CH₄, NH₃

H ₂ O	}	}	monosaccharides
CH ₄			glycerin
NH ₃			fatty acids
			amino acids
			pyrimidines
			purines

monosaccharides + monosaccharides
 fatty acids + glycerin
 amino acids + amino acids proteins
 pyrimidines } + ribose + phosphate
 purines }
 nucleotides + nucleotides

polysaccharides
 fats, lipids
 enzymes
nucleotides
nucleic acids

nucleic acids + proteins

nucleoproteins
 reproduction
 mutation
 nutrition
 aggregation

DNA

nucleoproteins + organic shells

protoviruses, early cells

synthesis
 growth
 development
 division
 internal control
 fermentation

protoviruses, early cells

parasites

animals
saprophytes
chemosynthesizers

chlorophyll
 photosynthesizers:
 plants

CO₂
 byproduct
 ↓
 CO₂
 +
 H₂O

sugar,
 O₂ byproduct

oxygen revolution:

O₂ + methane
 O₂ + ammonia
 O₂ + oxygen
 O₂ + metals
 O₂ + organisms

CO₂
 N₂
 O₃, ozone
 ores, rocks
 aerobic respiration

Sociobiology

Establishment of Space Colonies Inevitable, Scientists Told Theory That Genes Affect Behavior Evokes Vehement Clash at Parley

By WALTER SULLIVAN

WASHINGTON, Feb. 15—A foreign affairs specialist, a physicist, a designer of space stations, a communications specialist and others looked as far out and as far ahead as possible today in assessing the destiny of the human race.

They said that the limits to mankind's growth were not the finite resources of the earth but, as Dr. Gregg Edwards of the National Science Foundation put it, "The ultimate limits to growth are hope, heart and chutzpah."

His thesis and that of several other participants in a symposium on "Humans in the Cosmos" was that mankind, sooner or later, must propagate the species far beyond the earth and, perhaps, the solar system.

They were taking part in one of several conferences dealing with the possibility of intelligent life beyond this planet at the annual meeting of the American Association for the Advancement of Science, being held at the Sheraton Park and Shoreham Hotels here.

Some Visionary Concepts

The participants were from a number of institutions and government agencies that, with one exception, normally do not concern themselves with such visionary concepts as the colonization of space. That exception is the National Aeronautics and Space Administration, which has conducted a couple of studies of that possibility at its Ames Research Center in Mountain View, Calif.

However, the space agency's man, who, perhaps more than any other, has confronted the problems of large-scale space construction, warned that there seemed to be little public support now for such enterprises. He is Dr. Jesco von Puttkamer, NASA's program manager for space industrialization.

While it is possible that a lunar colony will exist by the year 2000, he said, a more ambitious effort, such as the construction of an independent space colony, seems to lie "pretty far in the future." But, in the long run, he added, mankind's expansion beyond the earth is inevitable.

Much of the discussion had its roots in a 1960 proposal by Freeman J. Dyson of the Institute for Advanced Study in Princeton, N.J., who also took part in today's meeting. He suggested that some civilizations that have evolved on planets orbiting stars other than the sun had developed engineering capabilities far beyond those achieved so far on this planet.

'Dyson Civilizations'

Driven by population pressures, such

president of the newly formed Space Studies Institute there, has promoted the concept of a space colony at the L-V position, a site of relative orbital stability equidistant from the earth and the moon.

At today's meeting, Dr. Brian T. O'Leary, who also is a Princeton physicist, said such a colony might come "sooner than we all think," adding that the transition to a steady, no-growth situation, thus relieving population pressure, "may be socially impossible."

Dr. William A. Gale of the Bell Telephone Laboratories carried the colonization concept to its ultimate extreme. He envisioned its extension throughout the Milky Way galaxy, formed of more than a hundred billion stars, and then possibly to other galaxies.

Expansion to Be Expected

Such dynamic expansion must be expected of any intelligent life form, he said, transforming a galaxy and perhaps even a cluster of galaxies. Since there is no evidence of any such transformation nearby, he suggested that the nearest intelligent life form must be very distant.

Dr. Gale, a physicist, served with Bellcomm, the Bell system's contribution to the Apollo moon-landing project, before joining Bell Telephone Laboratories. He envisioned an average population growth of half a percent annually, leading to a billionfold increase in a few thousand years.

This would saturate the solar system and migrations to other stars would become necessary. By then, he suggested at a press briefing before the meeting, technology would be able to develop habitats to orbit a star regardless of whether Earth-like planets exist there. For such a construction, he added, "we will take whatever is available."

'Unprecedented Educational Effort'

In this way, the galaxy could be fully colonized in one to 10 million years—a short time, geologically speaking, and comparable to that in which the human race has inhabited the earth. If travel speeds in excess of one-tenth the speed of light can be achieved, he said, colonization of other galaxies will become possible.

Michael Michaud, acting director of the

Security Policy Bureau of the State Department's Office of Politico-Military Affairs, said that "an educational effort on an unprecedented scale" would have to set the stage for any large-scale effort in space construction. Like the others, he spoke as an individual rather than as an official.

Mr. Michaud warned that national governments might find themselves increasingly embroiled in contests for the world's limited resources. If a space effort is undertaken that draws on the moon, asteroids and other planets for raw materials, it would by necessity be international in nature, he said, adding that national stakes would "become less relevant."

Dr. Edwards, a programmer officer in the National Science Foundation said that mankind would eventually be forced to leave the Earth because of such catastrophes or threats as a new ice age, radical climate change or, far in the future, the moon's dropping out of orbit or the sun's expansion.

"Eventually we must move," he said. "The only question is when."

RECOMBINANT DNA

New Gene-Splicing Bill Criticized at Science Meeting

By HAROLD M. SCHMECK Jr.

Special to The New York Times

WASHINGTON, Feb. 15—A new attempt to frame Federal legislation to regulate gene-splicing research is encountering serious difficulties that have appeared here at the annual meeting of the American Association for the Advancement of Science.

All last year, Congress was unable to agree on legislation to govern this controversial and important research technology. It was widely agreed that legislation was needed to bring all research and development in this field under controls, but legislative efforts failed in the face of lobbying by the conflicting views of scientists and environmentalists.

Efforts began again as soon as Congress reconvened this year. The prime objective has been to bring all industrial research and development in this field under Federal regulation. Rules published by the National Institutes of Health are already binding on all Government-supported studies involving gene-splicing.

A new draft bill from the Health and Environment Subcommittee of the House Commerce Committee was unveiled at the meeting here and has been criticized sharply on several points by environmentalists.

nedy, Democrat of Massachusetts, had seemed likely earlier, this now seems questionable.

The draft was defended by others as a workable interim measure to achieve the regulation of research and insure safety.

DNA, short for deoxyribonucleic acid, is the active substance of the genes of all living things and is thus the master chemical of heredity. Recombinant DNA techniques, developed in the last five years, have made it possible to splice together genetic materials from diverse species—genes of humans and bacteria, for example—so that individual genes of higher organisms can be grown in copious quantities in bacterial cultures.

It is almost universally agreed that the techniques constitute a powerful research tool with extraordinary potential, but some critics have charged that there are also potential dangers.

New vaccines and important biological products have been cited among the possible benefits; new and potentially dangerous disease-causing organisms have been cited among the potential risks.

Federal vs. Local Laws

A key issue in the legislation has been the question of whether Federal laws

research in their midst.

The draft bill described at the meeting here contains a strong Federal pre-emption provision and gives discretion to the Secretary of Health, Education and Welfare in authorizing some exemptions from the rules and in making other decisions concerning their application. The bill also exempts the research from regulation under the National Environmental Policy Act.

A statement from the subcommittee said that Representative Harley O. Staggers, Democrat of West Virginia, and Representative Paul G. Rogers, Democrat of Florida, planned to introduce soon a two-year interim bill for control of recombinant DNA research. The draft of such legislation was described in detail at the meeting here by Dr. Bert Zimmerman, science consultant to the subcommittee.

The draft was criticized by Representative Ottinger, who said that he would fight the pre-emption provision and some other key points and described the bill as "miserable." It was also criticized by Pamela Lippe, spokesman for Friends of the Earth, an environmentalist group, who charged that its provisions omitted most of the safeguards that environmentalists

By BOYCE RENSBERGER
Special to The New York Times

WASHINGTON, Feb. 15—Proponents and critics of sociobiology, a controversial new field of scientific investigation, clashed today in a debate over whether there is any evidence that human social behavior is influenced by genes inherited from animal ancestors.

The debate, a series of papers presented here at the annual meeting of the American Association for the Advancement of Science, was interrupted briefly by shouting demonstrators who charged onto the platform just as the best known advocate of sociobiology, Dr. Edward O. Wilson of Harvard University, started to speak.

The dozen or so demonstrators departed after pouring water over his head and chanting slogans linking sociobiology to racism, sexism, genocide, Fascism and Nazism. Although the packed auditorium at the Sheraton-Park Hotel gave Dr. Wilson a standing ovation as a form of apology, it was clear that a deep division remained among the scientists present as to the validity and implications of sociobiology.

Evolution of Behavior

The controversy began in 1975 when Dr. Wilson, an authority on the behavior of social insects, published "Sociobiology," a major book gathering together the evidence that social behavior had evolved in similar patterns in many animal species. Dr. Wilson suggested that since human beings evolved from lower animals, some of the same genes that seemed to govern animal behavior might still influence the way people interact.

Sociobiologists have suggested that human behavior such as male dominance, homosexuality and xenophobia, or fear and hatred of strangers, appeared to resemble similar behavior in animals. Dr. Wilson has speculated that some day sociobiology would subsume sociology, anthropology, psychiatry and other efforts to understand human behavior.

Dr. Stephen J. Gould, a Harvard paleontologist and a leading critic of sociobiology, assailed the suggestions about human behavior as "unsupported speculations with political clout." He said there was no evidence that human behavior was genetically determined and argued that sociobiologists, seeing such traits as male dominance and xenophobia in their own cultures, concluded without evidence that they must have a genetic base and therefore be "fixed."

not the rule in all human societies. She contended that sociobiologists were ignorant of anthropological findings that in existing hunting and gathering cultures, presumed to be typical of the kind in which mankind lived for 99 percent of its existence as a species, women played at least as important a role as men, providing from 50 to 80 percent of the food and often enjoying as much social and sexual freedom as the men.

The sociobiologists, on the other hand, contended that their critics often failed to understand what the controversial field is about. "Sociobiology is not a theory that human behavior has a genetic base," Dr. Wilson said, but a scientific discipline exploring the roots of social behavior in all animals.

He added, however, that he believed the evidence leaned toward a genetic influence on human behavior, though its strength is as yet undetermined. Dr. Wilson said that while the variations in human cultures over the past few thousand years might seem to be wide and were clearly the product of cultural and not genetic evolution, they still fell within boundaries that were probably genetic.

He forecast that it would soon be possible to identify within human chromosomes the specific genes governing certain behavior—not such details as mode of dress or sexual preference, but rather such things as "readiness to learn" and the strength of emotional responses.

Dr. David P. Barash, a sociobiologist from the University of Washington, said it was his hope that the new field would permit people to move beyond the classical "nature-nurture" debate. He noted that it was apparent long ago, even among many animals, that both environment and heredity shaped behavior. He conceded that the genetic influence among human beings was undoubtedly much smaller than the environmental influence.

About Education

How to Study: Guides Focus On Basics

By FRED M. HECHINGER

AS millions of youngsters return to their classrooms, most of them want to learn as much as possible in as little time as feasible. In industry, this is called productivity, and much effort goes into time-and-motion studies to improve the workers' skills. In education, according to some experts, similar skills are largely neglected, to the students' immediate disadvantage and possibly lasting detriment.

In an attempt to correct this neglect, a group of educators from Harvard University and Milton Academy, a private college-preparatory school near Boston, next week will publish the first in a series of "how to" programs. Known as the "HM (for Harvard Milton) Study Skills Program," the initial workbook (plus teacher's guide) is for grades 8 to 10. It will be followed next year by two similar guides aimed at grades 5 to 7 and college freshmen.

The program has been officially endorsed by the National Association of Secondary School Principals, which will also handle publication and distribution. In explaining this unusual cooperation between a leading university, a prominent independent school and the public school establishment, Owen B. Kieran, the NASSP's executive director, says that he and his associates have become increasingly concerned that lack of these skills, particularly as students move on to secondary school, "make it increasingly difficult for them to succeed."

In the editors' view, the present push for stress on the "basic skills," meaning writing and computation, omits some more basic — study skills. Many parents assume that such skills are required in passing and that they require little common sense and a measure of self-direction.

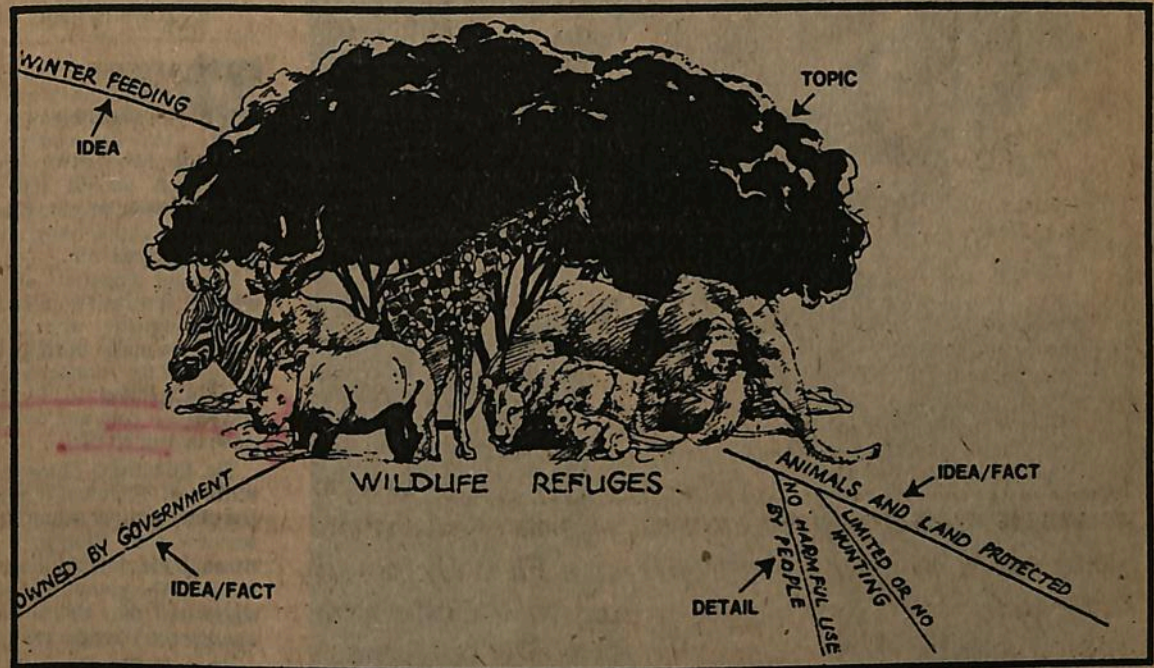
Not so, say the editors. Like any other skill, it can be taught, and teaching them effectively is not time, frustration and wasted effort.

David Marshak, of Harvard's Business School and author of the program's guide, says that, though currently neglected in preparation of study skills has remained constant throughout this century. He considers it important precisely because of "the tremendous changes in American education which often seem to be a good deal of ill-considered change."

Marshak now therefore is not to invent a new set of skills but to bring back the time-tested ones. He says students learn through practice how to use them.

What has gone wrong, Mr. Marshak says, in his eight years' observation of classes in various states, is lack of focus and organization in teaching study skills. The tendency is for each teacher to assume that somebody else has taken care of it, with the result that actually nobody has.

The 95-page student work book, accompanied by a 36-page teacher's guide, deals with 12 units:



Michael Ng

The workbook suggests 'mapping' of paragraph as a way of note-taking.

5. A Way to Read a Textbook.
6. Vocabulary (Literal and Figurative Meanings).
7. How Do You Study?
8. Improving Your Memory.
9. Preparing For and Taking Tests: Objective Questions.
10. Organizing a Paragraph.
11. Organizing a Paragraph (cont.) and Answering Essay Questions.
12. Using Your Time

all but nine died. How many does he have left? (Answer: 9).

Is it legal in California for a man to marry his widow's sister? (Answer: A man who has a widow is dead.)

Other "learning to listen" exercises include reading aloud a passage containing a number of irrelevancies and then asking students to identify them; let students close their eyes for five minutes and then have them describe all the sounds they have heard;

"All the News
That's Fit to Print"

The New York Times

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—NEW YORK, MONDAY, SEPTEMBER 3, 1979—

Spacecraft Takes Close-Up Photos Of Titan, Saturn's Largest Satellite

5 Pictures Transmitted by Pioneer 11 Reveal Greater Variation in Color Than Scientists Had Expected

By JOHN ROBERT WILFORD

Special to The New York Times

MOUNTAIN VIEW, Calif., Sept. 2 — Pioneer 11, outbound from Saturn, cruised within photographic range of Titan today for the first close-up examination of what is believed to be the largest moon in the solar system.

Five pictures of Titan, reconstructed from unprocessed data, showed a fuzzy ball of light with apparently more variation in color than had been expected. Titan is the only moon known to have a significant atmosphere, which appears to be primarily methane and includes a stratospheric layer of orange smog.

Project scientists at the Ames Research Center here said that the Titan pictures showed not only the smog but also evidence of a blue coloring along the moon's edge and some other faint variations and coloring elsewhere.

This indicated that Titan's atmosphere must be a fairly heterogeneous mix of gases and molecules and that, in places, the pictures may be revealing the atmosphere beneath the smog and clouds. Titan's smog is believed to be somewhat similar to smog on Earth. It could be formed when such gases as methane are converted by sunlight into more compli-

cated chemical compounds that create an opaque haze.

The Titan pictures, which were displayed today in raw form, must be enhanced through computer processing before a more detailed analysis will be possible.

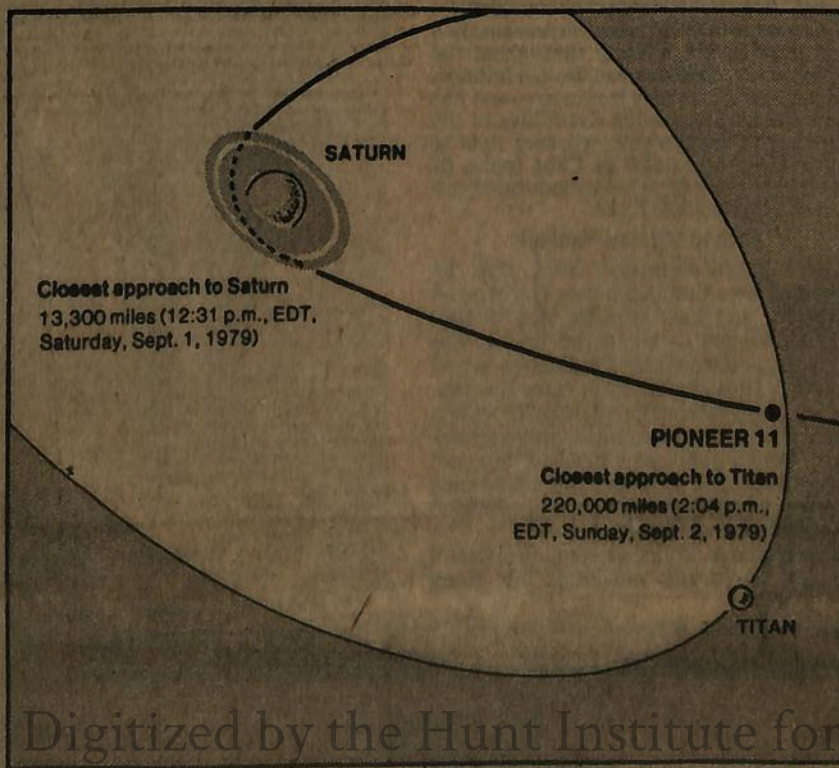
The American spacecraft made its closest approach to Titan, at a distance of 220,000 miles, at 2:04 P.M. Eastern daylight time. The pictures were taken before the closest encounter, at a distance of about 260,000 miles.

Organic Molecules Possible

Titan's 3,600-mile diameter makes it larger than Mercury and almost as large as Mars. Its atmosphere of methane and other molecules is thought to be similar to the primordial atmosphere of Earth and may well have produced organic molecules, the building blocks of life. Pioneer 11, however, is not equipped to provide any definitive answers to the question of probable life on Titan.

Pioneer 11 also collected ultraviolet and infrared data as it flew by Titan in an effort to learn more about its atmosphere.

Continued on Page D6, Column 1



Pioneer 11 Craft Gets Close View Of Solar System's Largest Moon

Continued From Page A1

and temperatures. These measurements have not yet been analyzed.

Titan was the eighth of Saturn's 10 known satellites to be observed during the Pioneer mission. Before the rendezvous with Saturn yesterday, Pioneer 11 gathered some data about Iapetus and caught sight of the innermost moon, Janus. At the closest approach to Saturn, Pioneer 11 passed Dione, Mimas, Tethys, Enceladus and Rhea before reaching Titan. The others are generally much less than 1,000 miles in diameter and thus were not good targets for photography.

Tonight, Pioneer 11 was more than one million miles away from Saturn, traveling 25,000 miles an hour. Flight controllers said that the spacecraft was operating well and showing no ill effects from its trip beneath the rings of Saturn and deep into the region of radiation magnetically trapped around Saturn.

As Pioneer 11 sped away from both Saturn and Titan, project scientists began reporting some of the mission's preliminary findings about Saturn, which is about 963 million miles from the Earth.

Temperature measurements by the spacecraft's infrared sensor indicated that the outer atmosphere of Saturn is somewhat warmer than had been expected on the basis of Earth-based observations. Dr. Andrew Ingersoll of the California Institute of Technology reported temperatures of more than 100 degrees above absolute zero, or more than 279 degrees below zero Fahrenheit.

Heat Flow May Be Complex

This is some 10 or 15 degrees warmer than expected, Dr. Ingersoll said, which suggests that the mechanics of heat flow from the interior of the planet may be complex. The primary source is believed to be heat left over from the collapse of the gas cloud that formed the planet billions of years ago, plus energy released by Saturn's continuing gravitational contraction.

But Dr. Ingersoll said that there must be "some other processes going on" to account for the slightly higher temperatures. Additional heat could be caused by the separation of dissolved helium from the metallic hydrogen thought to exist in Saturn's interior.

Pioneer 11's ultraviolet photometer discovered a tenuous cloud of particles well beyond the upper atmosphere of Saturn. Dr. Darrell L. Judge of the University of Southern California, the chief ultraviolet experimenter, said that atomic hydrogen was "an excellent candidate" as one constituent of the cloud.

Dr. Judge said that the particle cloud was apparently caused by interactions between charged particles and Saturn's

rings and inner satellites. A similar cloud, though much more heavily populated with matter, exists around Jupiter in the region of Io, one of the Jovian satellites.

Dr. James A. Van Allen of the University of Iowa reported that the radiation trapped by Saturn's magnetic field was comparable in intensity to the radiation in Earth's magnetosphere. The Saturn radiation is much less — by a factor of 50 to 1,000 — than that found in the "much more wild and woolly magnetosphere" of Jupiter, Dr. Van Allen said.

Earth's radiation belts, the first major discovery by a spacecraft, are named after Dr. Van Allen.

Moreover, Dr. Van Allen said, when Pioneer 11 flew under the rings of Saturn during its close encounter yesterday the radiation detected by spacecraft instruments dropped nearly to zero. The icy material in the rings acted as an umbrella against the electrons and protons. Dr. Van Allen said that nowhere in the Saturnian magnetosphere were the radiation intensities sufficient to cause damage to visiting spacecraft.

Two Voyager spacecraft, which flew by Jupiter earlier this year, are to explore Saturn with even more sophisticated cameras and scientific instruments in 1980 and 1981.

Dr. John A. Simpson of the University of Chicago said that the properties of the magnetosphere appeared to be remarkably the same going toward Saturn and going away from it. This indicated, he said, that the region was "very stable."

EARTH → SATURN PIONEER 11
(w. message fr. earth)
 $\pm 960 \times 10^6$ mi

10 MOONS - JANUS smallest

NEW RING ± 125 mi DIAM.

F? TITAN LARGEST
SATELLITE SOL. SYST.
 ± 3600 mi. DIAM.

PIONEER TRAVELED $\pm 6\frac{1}{2}$ YRS
TO REACH SATURN ↘

1-IX-'79

{ AMES RESEARCH CNTR. } DAVID MARRISON
{ MOUNTAIN VIEW, CAL. } UNIV. HAWAII
{ A.T. YOUNG DIR. } A. INGERSOLL
CAL. TECH.

RADIO SIGNAL SATURN → EARTH
TAKES $\pm 1\frac{1}{2}$ HRS. PERIOD ± 29.5
YRS.

PIONEER TO CONTINUE
INDEFINITELY.

SUN AT SATURN $\pm \frac{1}{400}$
INTENSITY SEEN AT EARTH.

Pioneer 11 spacecraft closing in on Saturn

By GEORGE ALEXANDER

(c) 1979, The Los Angeles Times

Pioneer 11, a spacecraft that all but a handful of scientists have forgotten during the more than six years it has been sailing on the high seas of space, will sweep past the ringed planet of Saturn this week.

And when it does — and trains its camera and scientific instruments on Saturn's rings, its yellow-and-white striped clouds and eight of its 10 moons — the images it gathers will far surpass any that have ever been taken of the planet through ground-based telescopes and sensors. Still another new world will stand revealed to the people of Earth.

Indeed, so many new planetary worlds have been opened by space probes in the recent past — Jupiter by the two Voyagers in July and March of this year; Venus by two other Pioneers last December; Mars by a quartet of Vikings three years ago; Mercury five years ago by a Mariner, and the moon some 10 years ago by a succession of astronaut expeditions and unmanned rangers, surveyors and lunar orbiters — that some scientists wonder if the general public will appreciate this latest American achievement, which is costing taxpayers some \$60 million.

Scientists are awed by the fact that all this has been accomplished in less than a generation. Contrast that with the more than 200 years it took Vasco de Gama, Ferdinand Magellan, Christopher Columbus, Sir Francis Drake and other 15th-century and 16th-century explorers to stumble on the "new worlds" of the Americas,

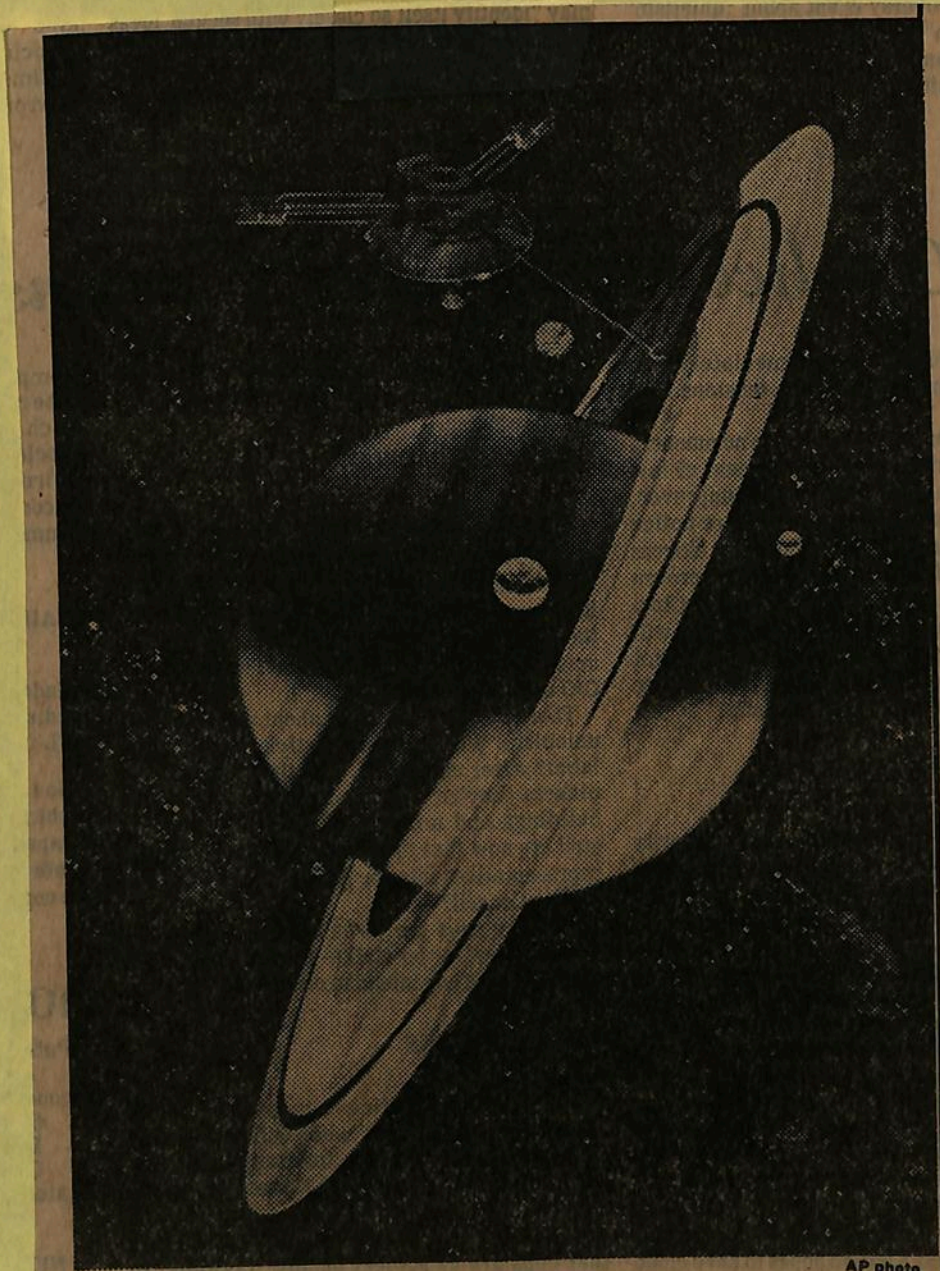
Polynesia, the Orient and Antarctica and report their findings back to an incredulous Europe.

Moreover, those findings of 400 and 500 years ago were fragmentary and often fanciful descriptions of the land forms, flora, fauna and people found on those continents and islands. Compare that with the unambiguous pictorial evidence and precise measurements captured by spacecraft on the "new worlds" of Mercury, the moon, Venus, Mars, Jupiter — and now Saturn.

Saturn, the sixth planet from the sun, is second only to Jupiter in size. It is a great gaseous sphere with a polar diameter of about 67,000 miles and an equatorial diameter of almost 75,000 miles, compared to a diameter of about 3,000 miles for the earth.

But it is Saturn's rings that are the planet's glory and puzzle. There are three, the inner or "crepe" beginning at about 11,000 miles above the planet's cloud tops and extending out to about 20,000 miles; a middle ring that starts at 20,000 miles and carries out to a distance of 36,000 miles from the clouds; and, after a 1,600-mile gap known as Cassini's Division, an outer ring that begins at about 38,000 miles and extends out to nearly 48,000 miles above the Saturnian clouds.

Saturn has 10 natural satellites, or moons, and, like its sister planet Jupiter and its 13 or 14 moons, forms a miniature solar system all by itself. Pioneer 11 will take passing glances at eight of Saturn's moons as it rushes through the system between Monday and Sunday.



AP photo

PIONEER NEARS SATURN — An artist's conception shows Pioneer 11 emerging from Saturn's shadow after passing within 13,300 miles of the planet's banded cloud tops. The spacecraft is expected to send back 50 photos of the planet and some of its moon, Titan. 10 moons

MORNING ADVOCATE, Baton Rouge, La., Mon., Aug. 27, 1979

Sat. 1-IX-79

See TV

July 20, 1969
MOON

Pitdown Fossils Stir New Debate

By MALCOLM W. BROWNE

NEW evidence concerning one of the most far-reaching April Fool's hoaxes in the history of science — the bogus "Pitdown Man" — has stirred up a dispute in which some scientists are questioning the integrity of their own profession.

The bones purporting to be fossils of Pitdown Man began to be "discovered" in 1912 in a gravel pit in the English county of Sussex. They were soon accepted by most scientists as the "missing link" between apes and man that had been postulated by the evolutionary theory of Charles Darwin. In honor of the lawyer and amateur geologist who found them, the new species was named *Eoanthropus dawsoni*, or Dawson's Dawn Man.

The fragments of two skulls found at the site suggested that the creature's jaw bone was similar to that of an ape, while its brain case was closer to that of modern man. Dawson turned up stone tools at the site as well as an object strikingly resembling a modern cricket bat, lending Pitdown Man a peculiarly British character.

Darwin's monumental theory appeared to have been confirmed at one dramatic stroke, and the world recognized in Pitdown Man a discovery of the first magnitude. Dawson and his collaborator, the anthropologist Arthur Smith Woodward, achieved immediate fame.

Real Fossils Different

But in the 1920's, real fossils of early man began to be discovered in Africa, and they were entirely different from the Pitdown bones. Their jaws were human and their brows simian — the reverse of the English fossils. Increasing numbers of the real fossils were found, and because none of them resembled Pitdown Man doubts began to stir about the authenticity of *Eoanthropus dawsoni*.

In 1953, modern analysis, including dating techniques using the decay of radioactive carbon, were applied to the Pitdown fossils. Pitdown Man was finally and devastatingly proved to be a forgery in which human and simian bones had been skillfully blended and artificially aged. One of the three investigators who exposed the fraud, J.S. Weiner, described the achievement in a book, "The Pitdown Hoax." The circumstantial evidence was that the hoax had been perpetrated by Dawson himself, who died in 1916.

All that was scandal enough, and many scientists were angry and embarrassed that the scientific establish-

Continued on Page C3

Pittdown Fossils Stir New Furor

Continued From Page C1

ment could have been fooled so completely and for so long.

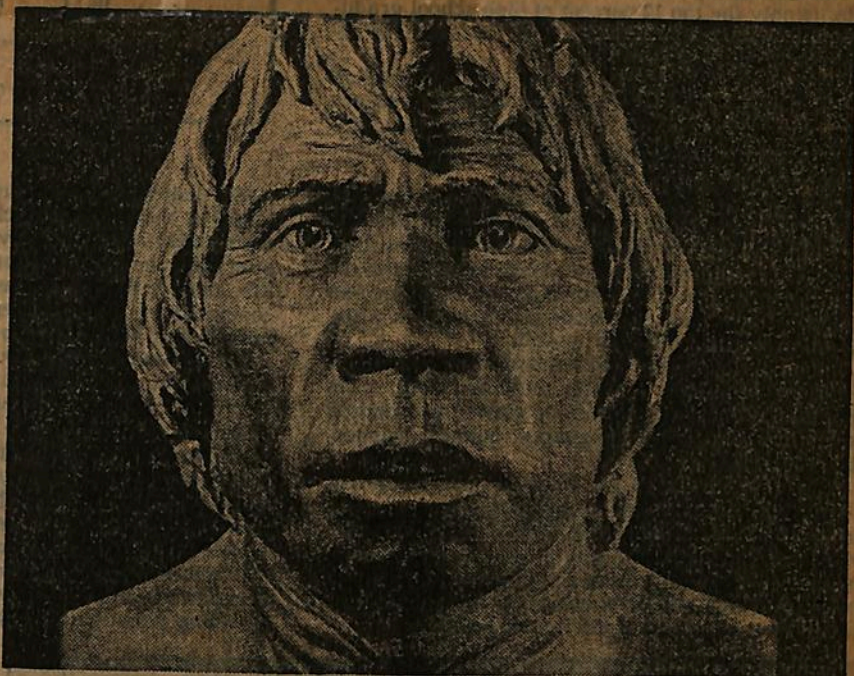
But just before his death last fall, Dr. James A. Douglas, professor of geology at Oxford University from 1937 until 1950, made a tape recording in which he disclosed new and even more disturbing evidence.

Earlier Hoax Recalled

Dr. Douglas said he believed the Pittdown hoax had been perpetrated by his world-famous predecessor at Oxford, Professor W.J. Sollas, as a way of making an inept but pretentious academic rival look ridiculous. The rival was Dawson's collaborator, Smith Woodward.

Dr. Douglas disclosed that Professor Sollas had assisted in an earlier hoax in which some schoolboys presented Smith Woodward with a purportedly prehistoric drawing of a horse on a piece of bone. That hoax also fooled Smith Woodward, according to Dr. Douglas, and may have given Professor Sollas the idea for the much more elaborate Pittdown hoax, including the bogus prehistoric cricket bat.

The revelation has prompted a lively and sometimes heated exchange in leading scientific journals. In the journal *Nature* last month, for example, L.B. Halstead, a University of Reading geologist, commented that the Pittdown hoax went far beyond a practical joke and deeply affected scientific, philosophical and even theological thinking.



American Museum of Natural History

A reconstruction of Pittdown man

The scientific establishment found it easier to accept the idea that Dawson, a nonscientist, had acted alone, he said, preferring not to believe that one of its own respected members could do such a thing.

Academic Involvement

"Inferring the guilt of the amateur Dawson, is far the most acceptable" to scientists, Dr. Halstead said, "as it absolves the academic world from any involvement." He added: "The other view is that Dawson was the scapegoat and the hoax was part of a conspiracy on the part of the scientists to delude the public into accepting the anti-religious idea of human evolution."

But while Dr. Halstead believes the scientific establishment has been proved by the Pittdown hoax to be vulnerable to criticism, his views are not shared by all scientists.

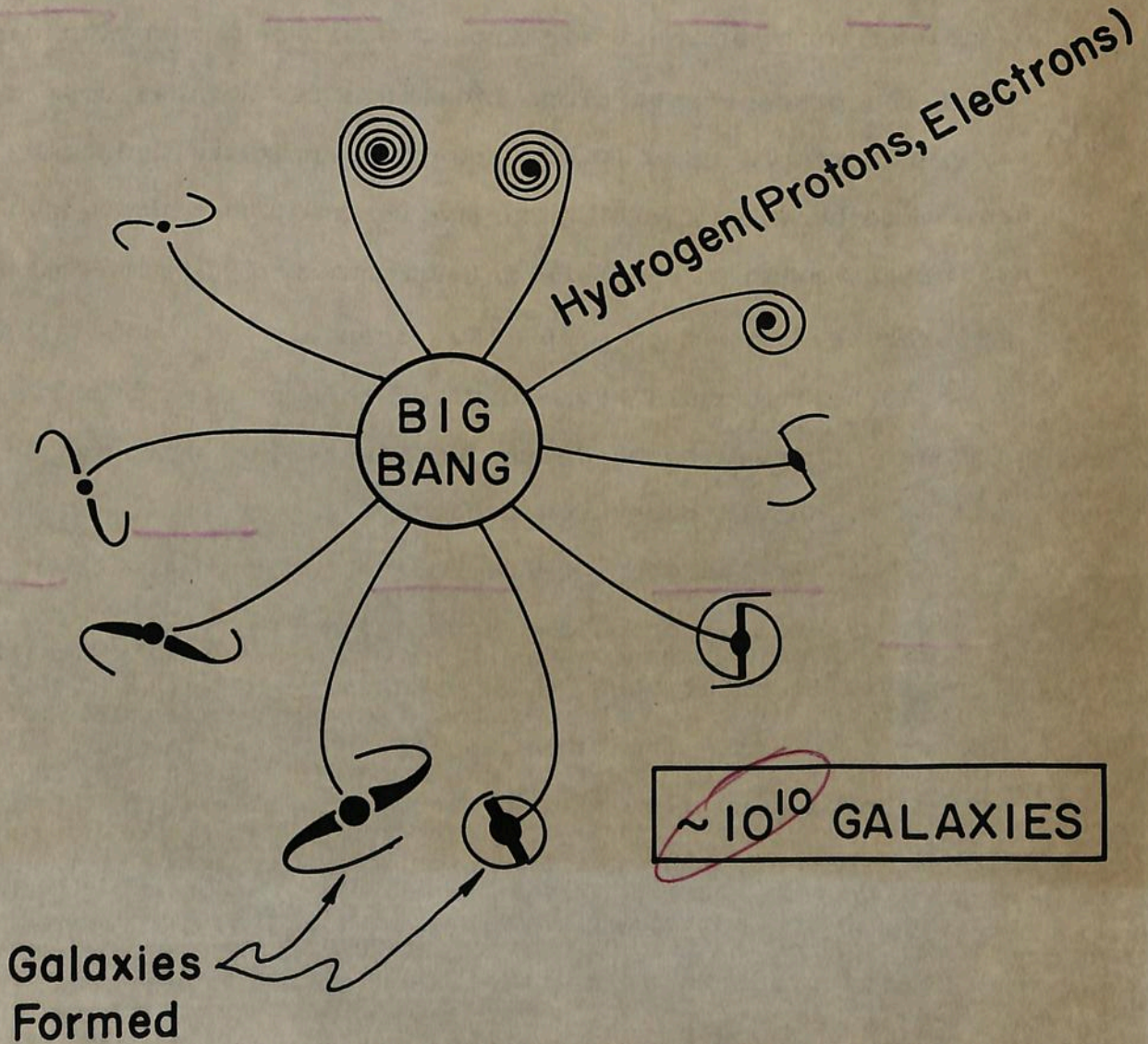
Nature also published a letter from

Dr. Weiner himself, discounting the evidence presented in Dr. Douglas' tape recording, including "Douglas' recollection of 68 years ago of a packet of potassium bichromate" allegedly used by Sollas to stain the bone fragments and make them look old.

"One thing the late Professor Douglas has succeeded in doing," Dr. Weiner said. "He has certainly added a mystery of his own devising to the Pittdown saga — why should Douglas on such incredibly weak evidence take the trouble to besmirch Sollas' reputation?"

The debate continues, but those who had direct knowledge of the Pittdown hoax are now dead. The ultimate truth may never be known, most interested scientists agree. But there is a nagging suspicion among some of them that the spirit of April Fool's Day dies hard, and science may not have suffered its last stupendous hoax.

IN THE BEGINNING..... ?!!!?
[15-20 Billion B.C.]



cosmological events in which they were created.

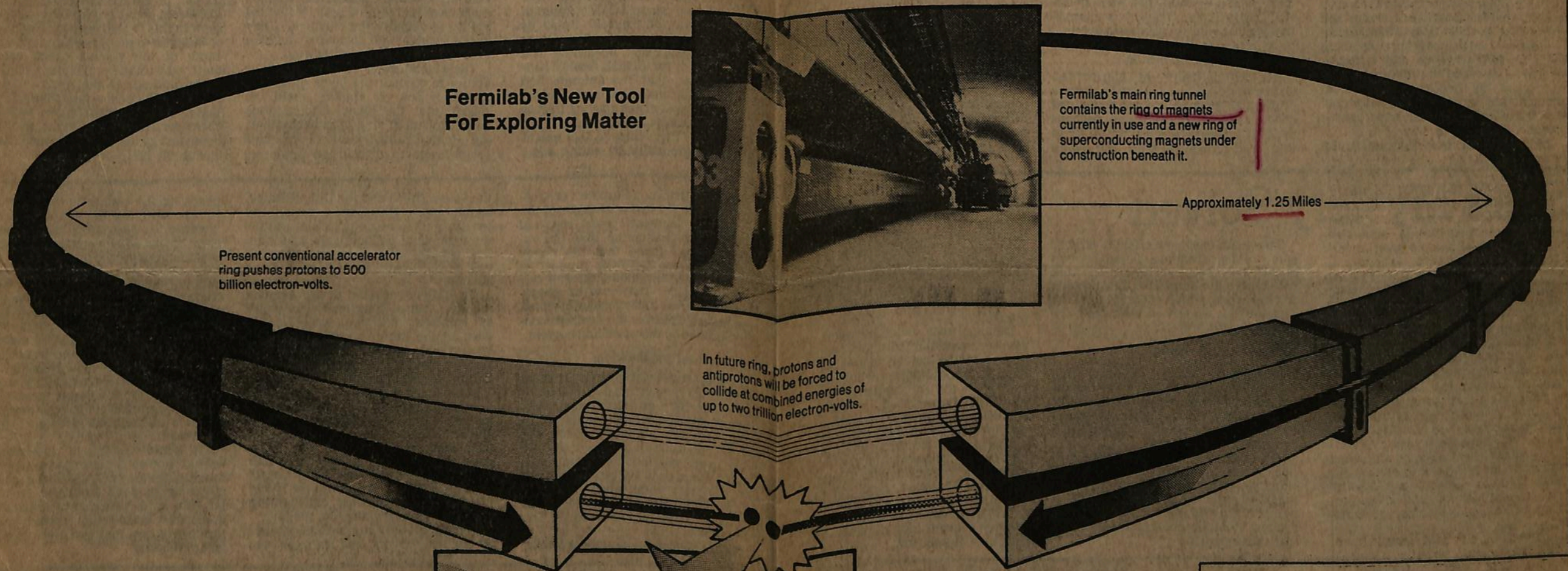
Present evidence suggests that the universe is evolving from a "big bang" which occurred 15-20 billion years ago. See the schematic illustration in Fig. 1. According to a "standard" theoretical model,⁴ we imagine a great primeval fireball of matter and radiation with a very high density and a temperature of perhaps 10^{10} °K. At first there were only protons, neutrons, electrons, positrons, and neutrinos, - all independent particles. Within a few minutes the temperature dropped to $\sim 10^9$ °K and the particles combined to form some heavier nuclei. During the next few hours about 20% of the mass of the material formed into helium and the temperature dropped to $\sim 10^8$ °K. Scarcely any nuclei heavier than helium could have survived this nuclear building process. However, some deuterium, depending on the fireball mass, should have been created. The fireball composition of mostly hydrogen, \sim 20% helium, and a trace of deuterium gradually cooled and expanded during the next million years to about 3000 °K and a density of about 1000 atoms/cm³. During this time the fireball was opaque, with radiation passing from atom to atom, but afterwards it was transparent, and the radiation was able to pass freely throughout the universe. After about one billion years this model predicts that matter should have condensed into galaxies and stars.

Although we shouldn't take our ideas concerning details of the big bang too seriously, it seems beyond doubt that

quarks
quasars
black holes
etc

←

Researchers Race to Find Particle Vital to Atom Theory

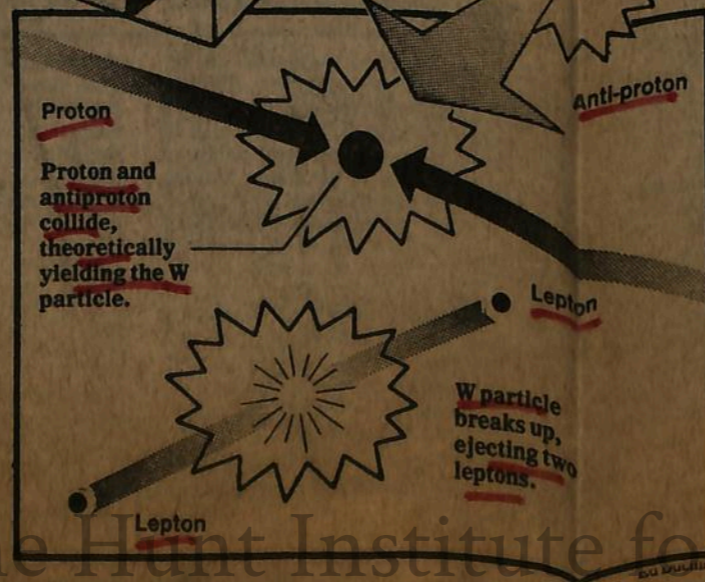


Studies Relate Physical Causes To Delinquency

By VIRGINIA ADAMS

WHILE most behavioral scientists favor sociological or psychological explanations for juvenile violence, four researchers at Yale University have found evidence suggesting that some such cases actually have biological underpinnings.

The Yale researchers found that violent offenders, when compared with nonviolent delinquents, more



Because Fermilab's new "doubler" ring is based on superconducting magnets, it is expected to consume only half the electricity required by the present accelerator. By using such magnets and hurling one beam of particles at another beam coming from the opposite direction, the particle collision energy will increase fourfold. This will take scientists into a new realm as they investigate the atom.

NASA Revises Predicted Date Of Skylab's Fall

By JOHN NOBLE WILFORD

THE latest prediction is that Skylab will fall to earth between July 11 and July 21, the National Aeronautics and Space Administration announced yesterday. There is a 50 percent probability that the re-entry will come before July 16.

NASA said that the 77.5-ton space station is dipping nearer to earth at the rate of 1.1 miles a day. The spacecraft is now traveling an orbit ranging in alti-

often had psychiatric symptoms such as paranoia, hallucinations and delusions. They also had more frequently suffered from neurological symptoms, such as blackout spells, falling and other indications of psychomotor epilepsy. In general, the more violent youngsters had the more serious symptoms.

The extremely violent delinquents also had more serious and more extensive medical histories than their less violent and nonviolent counterparts. A significant proportion of the violent youngsters had suffered head injuries early in life. They also were more likely to have endured physical abuse violent enough to damage the central nervous system.

The findings appear to have important social implications, according to the researchers, who say that violent children with psychiatric and neurological disorders can be treated.

The Yale scientists are Dr. Dorothy Otnow Lewis, clinical professor of psychiatry at the university's Child Study Center; Dr. David A. Balla, a research psychologist at the center; Dr. Jonathan H. Pincus, professor of neurology at the Yale School of Medicine, and Shelley S. Shanok, a public health researcher at the center. Some of their findings were reported recently in the *Journal of the American*

Continued on Page C3

EDUCATION

Boyer Reviews Term in Office

By EDWARD B. FISKE

ON Saturday, Ernest L. Boyer will step down as the United States Commissioner of Education. Since April 1, 1977, Mr. Boyer, the former Chancellor of the State University of New York, has been the principal educational spokesman for the Carter Administration and the chief administrator of the Office of Education's \$12 billion budget, which covers areas ranging from compensatory reading programs to Indian education.

In a recent interview, he was asked about his thoughts on Federal educational issues and what it was like to spend more than two years in a high Government post. Following are excerpts from that interview:

Q. Is there any such thing as a Carter education policy?

A. Definitely. The gains for education at the Federal level under the Carter Administration have been greater than at any time in the nation's history. The budget has increased from \$7 billion to \$12 billion, and that is a quantum leap. There's also been a clarification of the Federal role in education, with aid at the elementary and secondary level now

Continued on Page C4

By MALCOLM W. BROWNE

BATAVIA, Ill.

HOBbled by chronic money shortages, scientists at the Fermi National Accelerator Laboratory here are in a race against a wealthy European scientific consortium to find a hypothetical but vitally important nuclear particle called the W.

Laboratories on both sides of the Atlantic are currently spending tens of millions of dollars to build sufficiently powerful research machines to detect the W particle. To its discoverer will go the prize of clinching a major theory about the fundamental nature of matter.

Europe, which is outspending the United States two to one on this research, is the odds-on favorite to find the particle within a few years. But scientists here believe they can recover the lead in this area of research after 1983, moving into energy levels far beyond European capabilities and probing the atom even more profoundly.

W particles (and some close relatives called Z particles), if they exist, are believed to serve as messengers, carrying force between various particles embedded in the nu-

clei of atoms, and translating one kind of force into another. Proof that two different kinds of force, such as electromagnetism and the "weak" force that is involved in the radioactive decay of some atoms, are related to each other through the intermediary W particles would sweep away much of the uncertainty that has clouded the theory of nuclear particles in recent decades.

Particle physicists note that progress in all branches of science, from astronomy to human behavior, depends on detailed knowledge of the structure of atoms and the particles that comprise them.

The elusive particles that are the object of the current quest are so much heavier than any hitherto detected that no machine powerful enough to knock them loose from their nuclear environment yet exists. Therefore, atomic particle smashers are being built or improved here and in Europe. The most powerful American instrument is here at Fermi National Accelerator Laboratory (better known by its official acronym "Fermilab") and other powerful machines are at Brookhaven National Laboratory on Long Island and Stanford University in California. The governments of West-

Continued on Page C2

of earth every 89.5 minutes. Over the weekend, a series of computer commands radioed to Skylab in the wrong sequence caused the vehicle to wobble out of its previously stable orientation. Skylab's automatically controlled maneuvering rockets fired to stabilize the vehicle. The maneuvers used up about 1,000 pounds of jet thruster gas, leaving about 6,200 pounds on board. NASA said that is sufficient to exercise control over the station in the final hours, if necessary.

When Skylab disintegrates during re-entry into the atmosphere, about 500 pieces of metal are expected to reach earth. The odds are one in 152 that someone will be injured.

Beginning this week, NASA will be issuing daily bulletins on the latest tracking data and on the most likely re-entry dates. In an advisory last Friday, NASA said that when Skylab is coming down it may be "slightly safer to be indoors than outdoors" but did not recommend that people change their plans or make special attempts to seek shelter.

According to Skylab's orbital paths, if the debris falls on land, the pieces could hit in this hemisphere anywhere between southern Canada and southern Argentina.

Mystery of Bering Sea Solved

By BAYARD WEBSTER

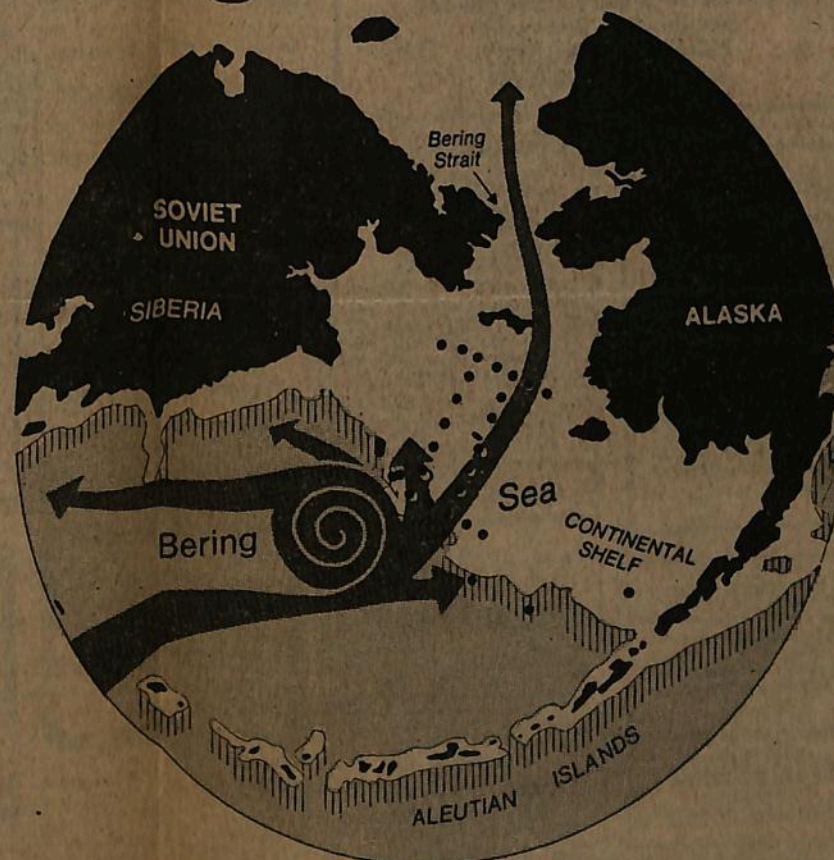
A joint scientific expedition by the United States and Soviet Union has solved the mystery of why the Bering Sea — the forbidding, cold and stormy body of salt water separating the two nations — produces fish in greater abundance than almost any other oceanic body.

A two-year analysis of data gathered during the expedition in 1977 has revealed that the rich quality of the Bering's sea life stems from a previously uncharted current that flows northward from the depths of the Pacific.

As the current moves through the Bering, it rises to the surface along the continental shelf in the northeastern half of the sea. This upwelling of water brings a full measure of the nitrates, phosphates, silicates and trace elements at the bottom of the food chain that are needed for the growth of phytoplankton, which provide nourishment for small marine animals, the research has shown.

The findings were reported at a recent meeting at Fordham University's Calder Conservation and Ecology Center in Armonk, N.Y., by six Soviet and American scientists who participated in the expedi-

Continued on Page C2



U.S.-Soviet mission traced nutrient-laden ocean current entering Bering Sea. Dots indicate areas where water samples were taken.

THE DOCTOR'S WORLD

Treating Appendicitis

By LAWRENCE K. ALTMAN, M.D.

APPENDICITIS pain in the right side of the lower abdomen is a condition familiar to most people, even if they have not experienced it, since it is so common.

And because surgeons have had such success in curing appendicitis and dramatically lowering its death rate, many people falsely assume that it involves a straightforward diagnosis. But that is often not the case. Its pain can be felt virtually anywhere in the abdomen, and many other conditions can cause pain in the lower right side.

Presumably, appendicitis has always been a problem (a perforated appendix was found preserved in the mummy of a young Egyptian princess), yet it was just 93 years ago that doctors discovered that immediate surgical removal of an inflamed appendix could cure the condition and prevent its lethal complications.

The appendix is a wormlike pouch three to six inches long that extends from a part of the large intestine called the cecum. Only humans, certain primates and the wombat have an appendix, which has no known function.

Blockage and inflammation of the appendix causes it to swell, burst and leak feces and bacteria. This can lead to gangrene, abscesses and deadly peritonitis, an inflammation of the lining of the abdominal cavity. Deaths from appendicitis now are rare — 0.3

Continued on Page C4

ARTS: Spain awaits arrival of Picasso's 'Guernica' with uneasy emotions, page 7/**BOOKS:** 'Time of the Turtle' by Jack Rudloe, page 9

STYLE: On cook's day off, a picnic for chefs/For teen-age scientists, the energy shortage sparks the imagination, page 16

REDI, F. - 1688 - Abiogenesis
 SPALLANZANI - 1767
 R. HOOKE - 1665 - "CELL"
 LEWENHOEK, A. - 1674 - PROTOZOA
 1676 - BACTERIA
 T. SCHWANN - 1839 - CELL THEORY
 H. VON MOHL - 1846 - PROTOPLASM
 R. VIRCHOW - 1858 - OMNIS CELLULA
 DARIUS - 1859 - origin of CELLULA
 M. SCHULTZE - 1863 - PHYSICAL BASIS OF LIFE
 L. PASTEUR - 1861 - abiogenesis

Introduction: Review of
 Integrated picture of plant world
 in relation to animals
 including Man.
 ± 350,000 plants
 ± 1,000,000 animals

2.

Since concept of disease associated with NATURE OF LIVING

ORGANISM, this should be considered:

CRITERIA FOR "LIFE" (get a class response to this).

Examples of definitions: "sum total of vital functions"

"continual adjustment of internal relations to external relations" (Spencer). "a series of definite and successive changes both in structure and in composition, which take place in an individual without destroying its identity"

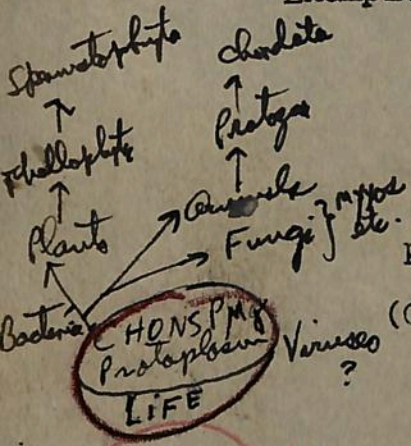
(G.H. Lewes). How would you define it?

VITALISM vs MECHANISM controversy.

PROTOPLASM AND LIFE. LATTER "defined" in terms of the former.

ie reproduction (asexual, sexual)
 growth (accretion vs intususception)
 metabolism (all energy transformations in organism)
 irritability } S → R
 adaptability
 organization (the watch analogy)
 chemical & physical properties (C?H?N?O?S?P?K,Mg, etc.)

polyphasic emulsoid-colloid; sol-gel idea. H₂O.



alveolar
 reticular
 granular

CRITERIA →

Spontaneous generation
 Abiogenesis
 "formulae" 'RECIPES'
 2.

Difficulty in arriving at "definition" of LIFE.

DNA
 WATSON & CRICK
 1953

"Boderline" organisms; virus, bacteriophage. Modern revival of vitalism. (see Science) Englera.

NOW: Since we are here concerned with plants (mostly), we should know what one is! (get a class response)

Characteristics of the Plant world; contrasted with animal and fungus.

CHONS Fe
 Haemoglobin
 chlorophyll
 (CHONS Mg)
 55 70 6 4

Indeterminate growth (meristems) (age of some plants)
 Cellulose
 Chlorophyll (exceptions: Harveyella mirabilis, Monotropa, Orobanche, Ophiomeris etc.)

SYNTHESIS OF VITAMINS
 AMINO ACIDS.

NEGATIVE CHARACTERISTICS
 NERVOUS SYST

Digitized by the Herbarium Institute for Botanical Documentation

CELL STRUCTURE
 VACUOLES
 CENTRIOLES

EXCRETION

Observatorio astronómico pone hoy en órbita EE. UU.

Cabo Kennedy, agosto 20. (UPI). — Un gran laboratorio espacial que orbitará la Tierra, llamado Copérnico, será lanzado antes del amanecer de mañana, en la última misión planeada en esta década para estudiar las remotas nubes de gas y polvo donde nacen las estrellas.

La plateada nave espacial fue emplazada en la gran nariz de plástico colocada en un cohete Atlas-Centauro.

Funcionarios del proyecto informaron hoy que todo estaba pronto para que el lanzamiento se produzca a las 6.28 (1028 GMT).

El cohete de 41 metros fue programado para propulsar al observatorio a una velocidad superior a los 26.000 kilómetros por hora, dentro de una órbita a 740 kilómetros de altura de la superficie terrestre.

Desde ese ventajoso punto, sus telescopios tendrán una ini-

gualable visión del universo. Sólo una pequeña porción de la luz que brilla en el espacio llega a los observatorios de la superficie. El resto es rechazada o empañada por la atmósfera terrestre.

El satélite astronómico es el observatorio espacial más complejo construido y costó 82 millones de dólares.

El director del proyecto, Joseph Purcell, señaló que el observatorio deberá funcionar durante cinco años, suministrando respuestas a los científicos sobre algunas de los grandes interrogantes acerca del origen del universo.

Su principal telescopio astronómico tiene un lente de 813 milímetros de diámetro, el cual fue diseñado por la Universidad de Princeton para estudiar las luces ultravioletas de las estrellas, que no se ven desde la superficie terrestre.

4004 2-26, 94-1

How Life Began

A Chance Chemical Union Which Could Not Occur Again

The theory that life on earth may have begun spontaneously through the chance chemical union of organic compounds floating in prehistoric seas well over a billion years ago was expounded by Dr. G. W. Beadle, geneticist of the California Institute of Technology, at a recent Mills College Centennial Symposium on evolution. Because there are no longer masses of organic compounds from which such life may have sprung, he thinks the process cannot be repeated again.

It may have taken as long as thousands or even millions of years for the first "living molecule" to produce a second like itself, in Dr. Beadle's opinion. "But somewhere, somehow," he said, "a chance combination of compounds must have acquired a new property it never had before—the ability to duplicate itself and to undergo mutation. This presumably was the precursor of all present living things."

Development of this first bit of life to even the simplest alga perhaps represents a greater step in evolution than the development from amoeba to man. The process may have take a billion years.

Viruses, according to Dr. Beadle, are at both the beginning and the end of the scale of living things. Not only are they like the first probable form of life, but they are also the final stage of degeneration of higher forms of living things under conditions of parasitism.

"All during the process during which living things have been evolving to give increasingly complex forms, evolution has been going on in the other direction as well," he said.

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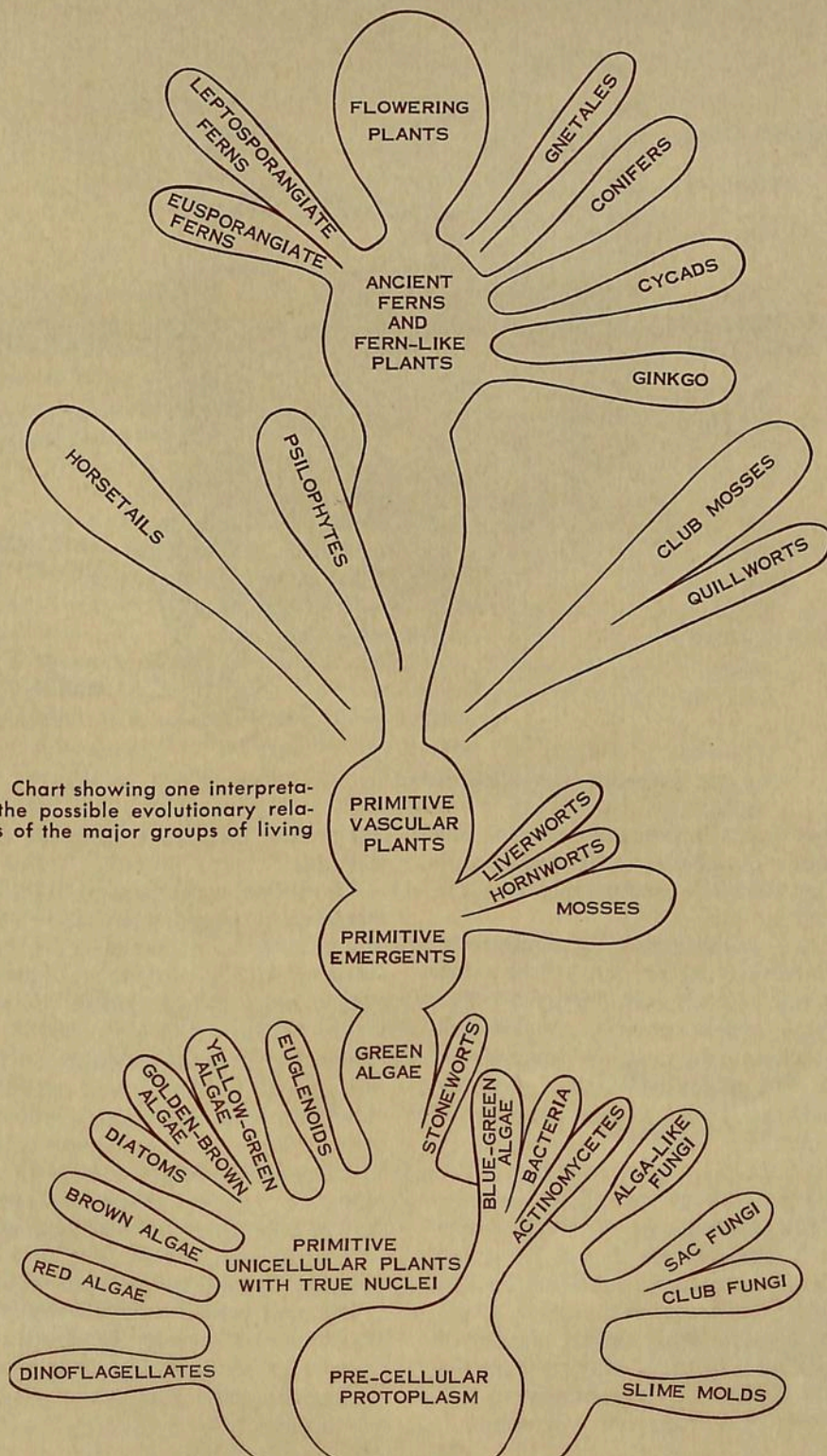


Fig. 8.1. Chart showing one interpretation of the possible evolutionary relationships of the major groups of living plants.

In this chapter a brief résumé of the major groups of living plants is presented. A comparison of two contemporary classification systems is undertaken and a chart shows the possible evolutionary relationships of the major groups.

C.

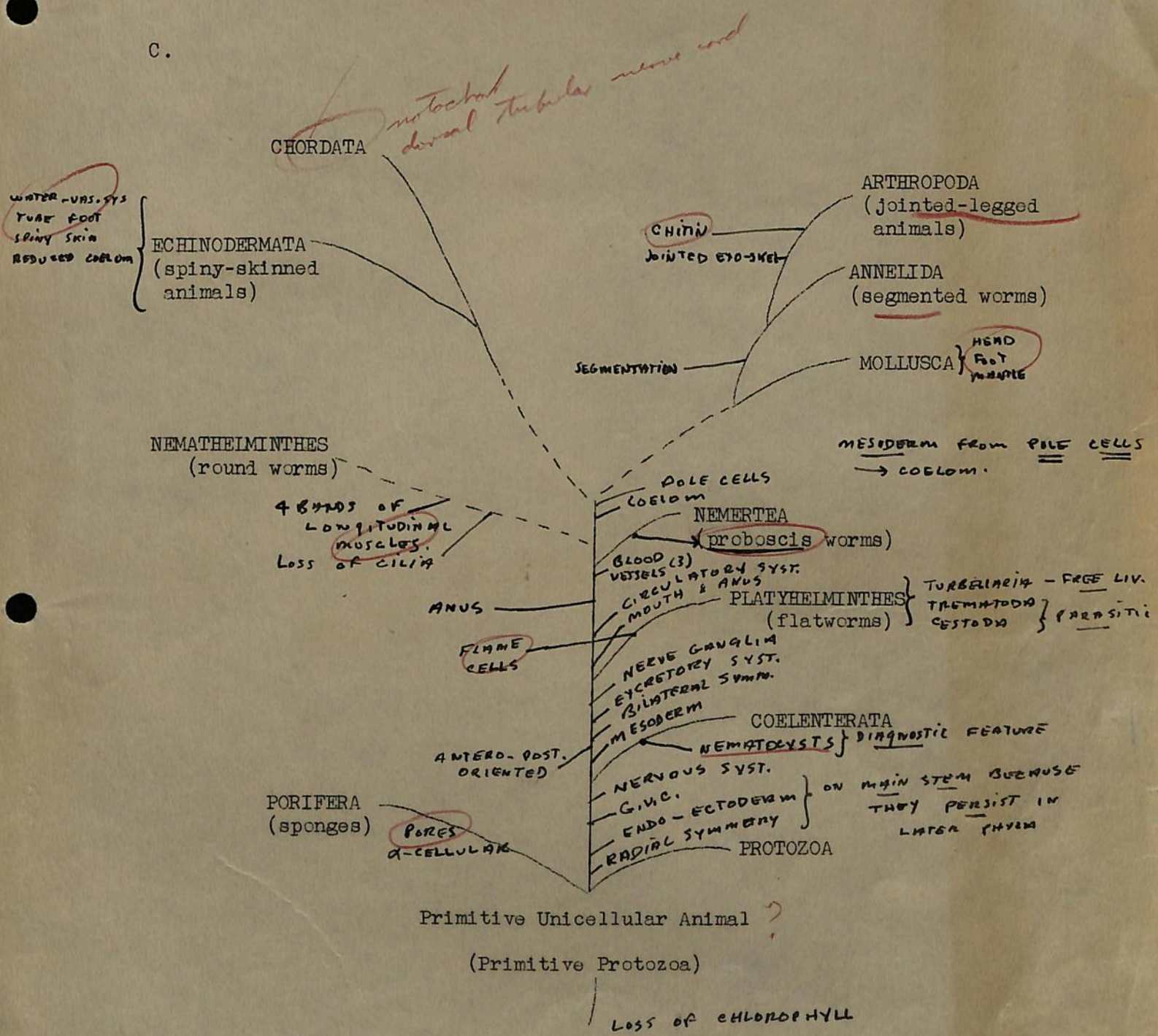
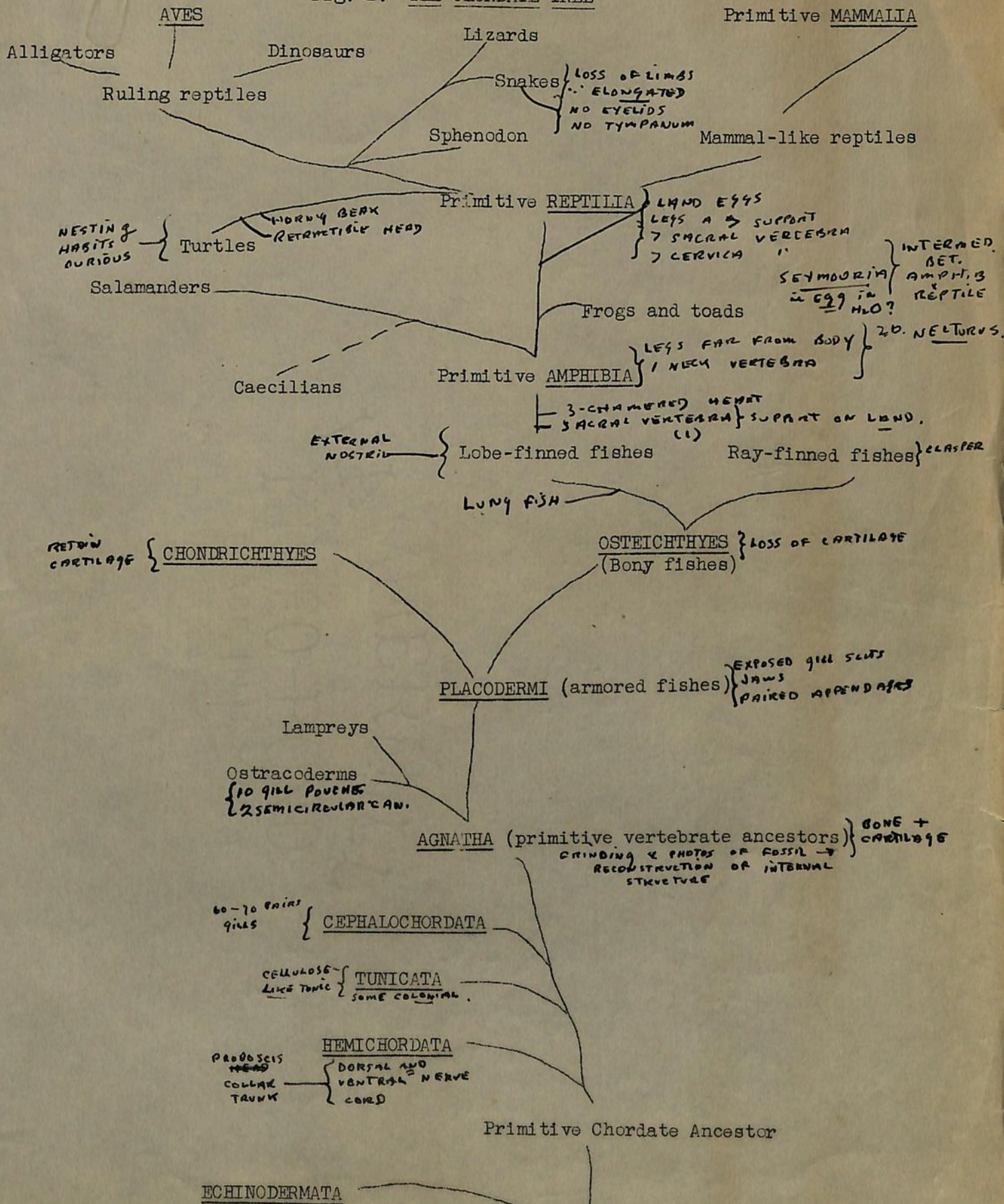


Fig. 1. PRIMITIVE PLANT or PLANT-ANIMAL } CHLOROPHYLL

Fig. 2. THE CHORDATE TREE



Toward the Margin of Life

Vers la lisière de la vie

W. H. COOK, F.R.S.C.

LE Président de la Société royale du Canada doit prononcer, à chaque année, un discours présidentiel. C'est une tâche rendue très difficile par la variété et l'étendue des disciplines représentées dans cet auditoire distingué.

Le choix du sujet est laissé au Président, et j'ai cru bon de vous parler des réalisations des autres, pour élargir le sujet et le rendre plus intéressant. Plusieurs d'entre vous ne sont probablement pas tout à fait au courant des recherches qui se poursuivent aux frontières des sciences biologiques. J'ai cherché à tenir compte de cette situation.

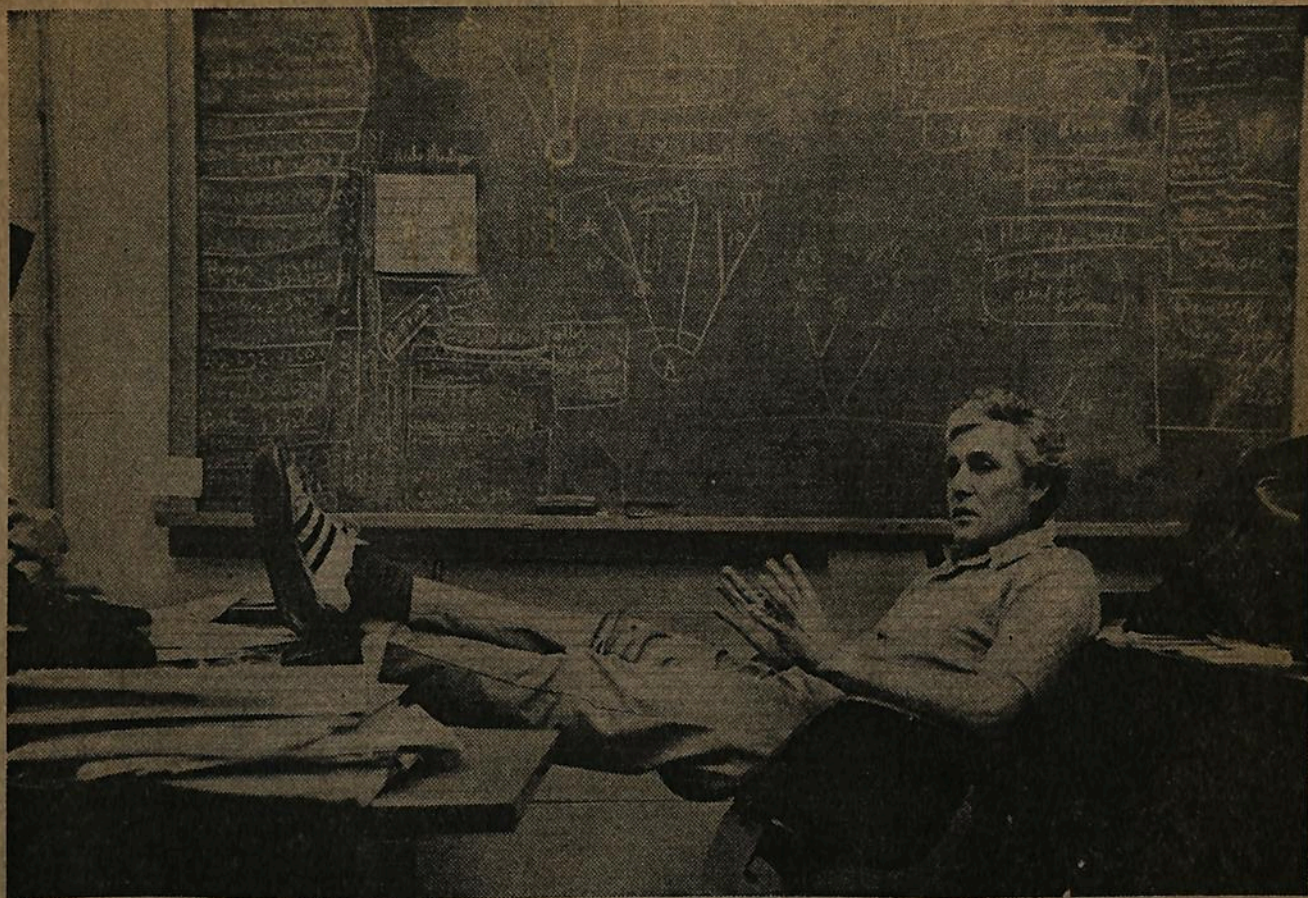
For some this presentation may serve as an introduction to tomorrow's symposium dealing with biology at the molecular level. May I now request the forbearance of the specialists who have carried the study of biology to its present margin.

Historically, physical science started with a study of matter *en masse* and gradually moved to units of progressively smaller dimensions until it reached the particles in the atomic nucleus. The first world-wide scream of the new-born atomic age broke through the barriers of secrecy in 1945, and society has been trying to control this infant ever since. About the same time life science entered the wonderland of diminishing dimensions and hastened down past the size of Mr. Carroll's Alice to the level of Mr. Maxwell's demon, who played handball with hot molecules.

This new branch of biological science, called molecular biology, is conducting studies on the borderline between the animate and the inanimate. It has grown up quietly, does not threaten human existence, requires a comparatively modest level of financial nutrition, and nature is its only security officer. In consequence, molecular biology has made little impression on society, but it has been well recognized in scientific circles. During recent years the number of individuals who have been awarded Nobel Prizes for their work on molecular biology matches or outnumbers those awarded to individuals working in any other comparable branch of science. In 1962 alone the Nobel Prizes in both biology and chemistry were given to five individuals for their contributions to this subject.

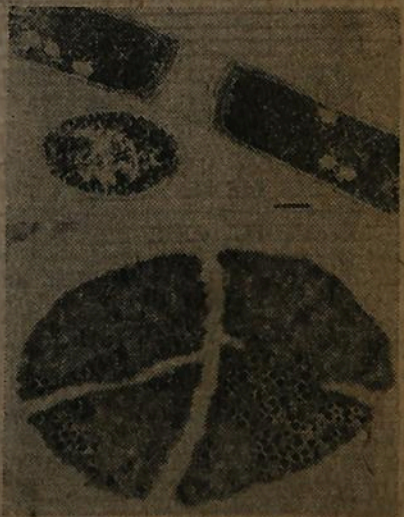
CONCEPTUAL BACKGROUND

The difference between living and non-living things seems simple when we compare a horse and a car. The obvious differences shrink to the level of



The New York Times/Phil Greer

Dr. Carl R. Woese, leader of research team, in his office at the University of Illinois. Photo at right shows the newly discovered microorganism: top, a chain of two organisms, each one-thousandth-of-a-millimeter long; center, a cross section of the chain; bottom, an organism dividing into four cells.



Scientists Discover a Form of Life That Predates Higher Organisms

By RICHARD D. LYONS

Special to The New York Times

METHANOGENS

URBANA, Ill., Nov. 2—Scientists studying the evolution of primitive organisms reported today the existence of a separate form of life that is hard to find in nature. They described it as a "third kingdom" of living material, composed of ancestral cells that abhor oxygen, digest carbon dioxide and produce methane.

The research group working here at the University of Illinois reported that this third form of life on earth is genetically distinct from the higher organisms that evolved from it—bacteria and, finally, the plant and animal world.

Believed to have evolved 3.5 billion to 4 billion years ago, these organisms have yet to be named but are being referred

years, were made public today by two of the Federal agencies that supported the research, the National Aeronautics and Space Administration and the National Science Foundation.

The work is described in detail in the October and November issues of the Proceedings of the National Academy of Sciences.

Asked for their evaluation of the results of the team at the University of Illinois, two other scientists familiar with the genetics of microbiology described the reports as "important" and "exciting," adding that it would further what is known of the basic processes of evolution.

Dr. Woese and his colleagues conclude

SCIENTISTS DISCOVER DISTINCT LIFE FORM

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practical value of the research probably was nil.

But he added that, if the efforts of his group were confirmed by other researchers, the findings would enhance man's knowledge of his genetic heritage and perhaps explain some of the mysteries of evolution and puzzles of the solar system.

One flight of fancy advanced by Dr. Woese, with an accompanying smile, is that the presence of this class of organisms might explain why life evolved here and not on the earth's sister planet, Venus.

The rationale goes as follows: Clouds of carbon dioxide originally enveloped both planets, but methanogens developed on earth and digested much of the cloud

and in turn produced the hydrocarbons that developed into higher forms of life. But on Venus, according to this line of speculation, the lack of methanogens allowed the carbon dioxide to accumulate to the point that the so-called "greenhouse effect" took over the Venusian surface, in turn making it too hot for life to evolve.

Dr. Woese, a slightly built biophysicist who has an unruly shock of graying hair, expounded on the research of his group in a three-hour interview in his sparsely furnished office here. Nearby rooms are filled with such gadgets as electron microscopes and X-ray machines that are the basic tools used in deciphering the genetics of microorganisms.

'Genealogy of Organisms'

"For years I've wanted to understand how life evolved," he said, "and five years ago my colleagues and I set about looking into the genealogy of organisms."

Dr. Woese, who is 49 years old, said that only in the last 10 years had it been feasible to explore the genetics of such rudimentary organisms. Elaborating, he cited the existence of only an elementary

knowledge of molecular genetics a decade ago, the development of more powerful electron microscopes, and the discovery of more sophisticated techniques for examining the molecular structures of microorganisms.

At first the group examined DNA of bacteria, that is, the deoxyribonucleic acid molecules that contain the coded information needed for the function and development of the cell. The team also studied bacterial ribosomal RNA, the ribonucleic acid that is a major constituent of the ribosomes. These are the units within cells where the messages from the genes are received and read in order to make the appropriate proteins.

The ribosomal RNA's are believed to be extremely old and represent parts of the ancestral replicating systems of both primitive and advanced organisms. As they are found in both higher and lower orders of cells, their genetic history can be compared by using the right tools.

Examining the parts of either an animal cell or a plant cell is relatively easy as compared with a bacterial cell, which is perhaps 1,000 times smaller. Also, the bacterial cell does not have a clearly de-

finied structure that the higher forms of life possess.

According to Dr. Woese, the early research on the evolution of microorganisms focused on their structural differences, rather than their genetic differences.

Ever Simpler Forms Studied

By examining ever simpler forms of bacteria, the University of Illinois scientists arrived at what then were believed to be the simplest forms, which the scientists have now found not to be bacteria at all.

"The methanogens themselves are new to science," Dr. Woese said. He noted that 10 different forms had been examined in the course of the research here and that their total number was unknown because "scientists have just begun to isolate them in earnest and there could be millions of them."

To be examined, the methanogens must be cultured under extremely difficult conditions since they will not exist in the presence of oxygen.

Various forms of methanogens have been found in mud at the bottoms of

San Francisco Bay and the Black Sea, in deposits in Carioco Bay off the coast of Venezuela, and in deep, hot spring waters such as those at Yellowstone National Park.

They generally are found in what are called anaerobic niches, or areas free of the presence of oxygen, which are relatively uncommon on the earth's surface.

The technique used here cultured the methanogens in the presence of radioactive phosphorus, which in turn made the RNA radioactive. The radioactive RNA then was separated from the genes through the use of acrylamide gel electrophoresis.

Molecular Sequences Compared

The RNA then was digested with enzymes into smaller pieces and their molecular sequences, or messages as they are called, were compared with the RNA messages of either higher or lower organisms.

"Somewhere along the line in evolution a mistake is made and a mutation results," Dr. Woese said, adding that by studying these mutations it was possible to compare the ages of different RNA's.

Parentetically, he noted that one scholar had dated old Southern cookbooks by the misspellings in the volumes that were included in later editions.

By deciphering the mutations of the genetic material, the scientists were able to identify methanogens as being distinctly different from bacteria.

Dr. Woese credited the name "methanogen" as having been coined by a colleague on the project, Dr. Ralph S. Wolfe, a professor of microbiology.

Other collaborators included Linda J. Magrum, a research assistant, William E. Balch, a graduate student, and Dr. George E. Fox, the senior author of the paper in the October issue of the proceedings, who is now an assistant professor of biophysical sciences at the University of Houston.

Asked for comment about the University of Illinois work, Dr. Sol Spiegelman, now a professor of genetics at Columbia University, said that "the research results look O.K."

"Dr. Woese is a substantial scientist of international reputation who has contributed a number of ingenious ideas to science," he added.

Cosmology: Man's Place in the Universe

In which we review the history of the Universe and explore the relationships between its properties and the presence of life

What I want to try to do in the next few pages is to review the history of the Universe from the earliest times for which we have any evidence down to the present day, with special emphasis on how conditions favorable for life seem to have arisen, and then to explore the extent to which this history is dependent upon the Universe having roughly the properties it does, and finally to inquire into the implications of varying those properties.

A Cook's tour of the universe and its early history

Let's start by taking a look (Table 1) at the scales of the things we will be discussing. Notice that the human scales in each case are close to the geometric means of the astronomical and atomic scales. Thus, we should not be surprised to find that our presence here is dependent both on

Virginia Trimble is grateful to the Aspen Center for Physics, where much of this was written, for hospitality, and to the Alfred P. Sloan Foundation for a Research Fellowship (1972-74). The author's thoughts on the Universe and its contents have inevitably been influenced by more people than can conveniently be mentioned, but those from whom she first heard some of the ideas discussed here, and whom she would therefore like to thank especially, include Dave Arnett, William A. Fowler, Jim Gunn, Philip Morrison, Paula Moddel, Bohdan Paczyński, Martin Rees, Bill Saslaw, Starling Trimble, and (last only in this deliberately alphabetical list) Joe Weber. Address: Department of Physics, University of California, Irvine CA 92717 (January to June); Astronomy Program, University of Maryland, College Park MD 20742 (July to December).

the large-scale phenomena of astronomy and on the details of atomic physics.

The largest phenomenon of all is, of course, the Universe itself. It is important to be sure we agree about what we mean by "the Universe" and the various other terms we will be using. The earth and eight other planets, about 34 moons, and a variety of smaller objects are in gravitationally bound orbits around a star called the sun. We refer to this grouping as the Solar System. It has a total mass of about 2×10^{33} grams (virtually all in the sun, though most of the angular momentum is in the planets), a diameter of about 2×10^{15} cm, and an age of about 5×10^9 yr. The sun is a perfectly typical star, having a mass of 2×10^{33} g (the solar mass, abbreviated M_{\odot} , is often used as a unit for other stars), an electromagnetic radiation energy output of 4×10^{33} ergs/sec (one solar luminosity, L_{\odot}), a spectrum approximately that of a 5700 K black body, a radius of 7×10^{10} cm ($1 R_{\odot}$), and a composition by weight (at least in its outer, visible layers) about 73% hydrogen, 25% helium, and 2% everything else (about half of it carbon and oxygen).

The sun, in turn, is one of about 2×10^{11} stars that are gravitationally bound in a rotating, roughly spherical system (although the most conspicuous members are concentrated in a plane considerably flatter than the proverbial pancake) called the Milky Way Galaxy (or just the Galaxy). It has a mass of at least 3×10^{44} g (but see Ostriker et al. 1974 for evidence that it may be ten times more massive than this) and a diameter of about 10^{23} cm. It is at least 10^{10} yr old.

The Milky Way, in turn, is bound in a small cluster of about 30 galaxies (all but one much less massive than ours) called the Local Group. It is not certain whether higher-order structures are gravitationally bound, but there does seem to be some clustering of the clusters (Hauser and Peebles 1973). The clusters range from small ones like the Local Group up to much richer ones containing thousands of galaxies and having masses of $10^{15} M_{\odot}$. Completely isolated galaxies are probably rare (Tifft and Gregory 1976). The properties of the medium between the galaxies (except within the rich clusters, where a hot intracluster gas is often a strong source of X rays; Kellogg et al. 1973) are very poorly known. The average density could be anywhere from 0 to 10^{-5} particles cm^{-3} , the intergalactic medium comprising anywhere from 0 to 90% of the total average density over large regions of space. If the density is high, the matter must also be rather hot ($\sim 10^6$ K) or exceedingly clumpy to prevent detection. A preponderance of the evidence (as summarized, e.g., by Gott et al. 1974) now seems to favor an intergalactic density at the low end of the possible range.

The clusters of galaxies (or perhaps the superclusters) appear to be distributed at random through space, with separations such that they contribute an average density of at most 10^{-31} g cm^{-3} (Ostriker et al. 1974). There is no detectable falloff of the density of clusters of galaxies out to the largest distances at which they can be seen with present telescopes. This is about 10^{23} cm or 3000 Mpc (Megaparsecs; one parsec = distance at which an object has a parallax of one second of arc = 3×10^{18} cm), corresponding to a light travel time of

several billion years. We probably observe quasi-stellar objects (quasars) at much larger distances, but their properties are so poorly understood that they add very little to our knowledge of the large-scale structure of the Universe.

The volume surveyed is sometimes called the observable universe, and it is the region for which we have direct observational evidence. Spectra of the vast majority of galaxies within this region and outside the Local Group show red shifts which are proportional to their distances from us. These are normally interpreted as Doppler shifts, implying that all the objects within the observable universe are receding from one another at speeds proportional to their separations. The proportionality constant is generally called the Hubble constant. Its value (at the present time in the history of the Universe and of astronomical research) is about 57 km/sec/Mpc (Sandage and Tamman 1975). This proportionality (Hubble's Law) is our chief evidence that the Universe is expanding.

Within the framework of some reasonable theory of gravity, like General Relativity, we can extrapolate beyond the observable region and try to learn something about the entire four-dimensional space-time volume that can, in principle, be connected to us by light signals. The word Universe properly refers to this entire volume and, in this sense, is not much more than 50 years old, dating back to the realization that certain bright, fuzzy patches in the sky are, in fact, galaxies like our own (Curtis 1919; Hubble 1925).

Efforts to model the Universe go back just about as far and always involve a variety of simplifying assumptions. The simplest possible set of such assumptions has proved remarkably successful. We assume (1) that General Relativity is the right theory of gravity (probably without the arbitrary additional repulsive kind of gravity, the cosmological constant, introduced by Einstein to permit a static universe), (2) that the expansion implied by Hubble's Law is isotropic and would be seen to be isotropic by any observer moving with the galaxies, (3) that the Universe is homogeneous on a sufficiently large scale, and (4) that pressure is presently unimportant and that the

mass-energy of the Universe is now mostly in the form of matter rather than radiation or other zero-rest-mass particles. Under these assumptions, the Einstein field equations yield a two-parameter family of models, called the Friedmann models, and the problem of deciding what the Universe is like reduces to finding values for the two parameters. These turn out to be the present value of the Hubble constant, H_0 , which we know quite well, and the present value of the local average density of mass-energy (in all forms), ρ_0 , which may be uncertain by a factor of 100. Given values of these, we can answer a variety of interesting questions, like: How old is the Universe? Is it finite or infinite in volume? Will the present expansion continue forever or will gravity cause the galaxies to slow down and eventually fall back together? Roughly, a low-density ($\rho_0 < 10^{-30} \text{ g cm}^{-3}$) universe has infinite volume, is 16-20 billion years old, and will expand forever; while a high-density universe ($\rho_0 > 10^{-30} \text{ g cm}^{-3}$) has finite volume, is less than 16 billion years old, and will eventually (in a hundred billion years or so) turn around and recontract. With many ifs, buts, maybes, and other caveats, evidence now available seems to indicate that our universe is a low-density one (Gott et al. 1974). Notice that if the universe is to be a high-density one, then $\geq 90\%$ of the mass-

energy is neither visible nor in galaxies.

Under the same assumptions, there are some questions that we cannot answer or even ask in a meaningful fashion. One of these is Where is the center of the Universe? The assumed homogeneity and isotropy of the expansion imply that all the matter was arbitrarily close together a finite time ago in the past, so that the center of the expansion exists only in four dimensions and is something like the instant of creation; while the geometry of space-time within the framework of General Relativity is such that space is either infinite (and so can have no center) or uniformly curved, so that all points are equivalent (rather like the curved surface of the earth, only in three dimensions). It will become clear shortly that "what came before the present universe?" is another of these unanswerable questions.

With this background, we can now say that the earliest event for which we have any evidence is a time about 15-20 billion years ago when the Universe was much hotter and denser than it is at present. The evidence for the time scale comes from (1) running the Hubble expansion backwards in time and asking how long ago would all of the galaxies have been arbitrarily close together ($H_0 = 50 \text{ km/}$

Table 1. Scales of phenomena being considered

Atomic scale	Human scale	Astronomical scale
T I M E		
Nuclear decays 10^{-14} seconds	Attention span of physics undergraduates 1 minute = 60 seconds	Age of the Universe 6×10^{17} seconds
M A S S		
Hydrogen atom 2×10^{-24} grams	Typical Sigma Xi member 140 lb = 6.5×10^4 grams	Solar mass 2×10^{33} grams
L E N G T H		
Diameter of atomic nucleus 10^{-13} centimeters	Height of dean at prestigious university 18 feet = 546 cm	Distance from sun to next star 1 parsec = 3×10^{18} cm
R A T E O F E N E R G Y O U T P U T		
Atomic decay 10^{-3} erg/second	Output of large electricity generating plant 200 megawatts = 2×10^{15} ergs/second	Luminosity of the sun 4×10^{33} ergs/second

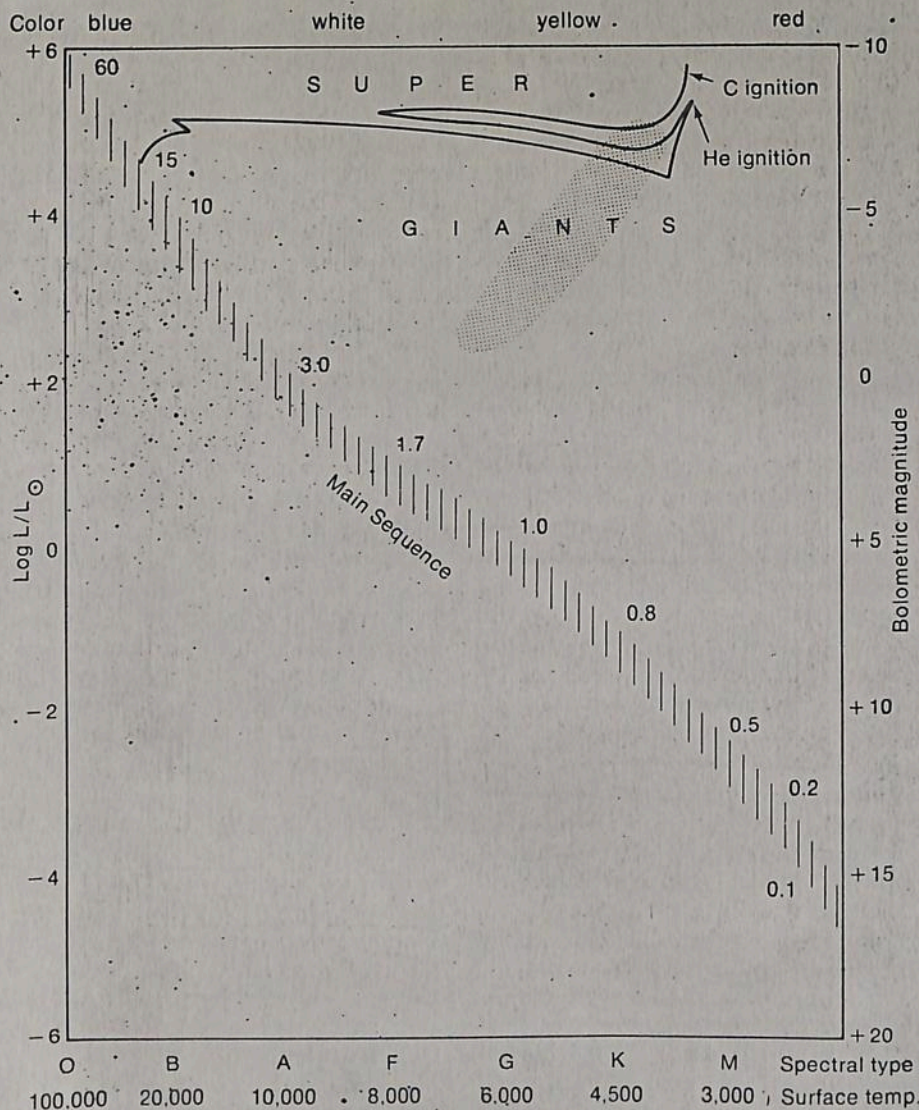


Figure 1. Hertzsprung-Russell (HR; color-magnitude) diagram for a representative group of stars young enough that the entire Main Sequence is still populated: Notice the curious scales always used by astronomers. The vertical scale is the logarithm of total luminosity in solar units, or magnitudes which are logarithms (base $100^{1/5}$) of the reciprocal of the luminosity in fairly arbitrary units. The horizontal scale is surface temperature (though neither exactly linear or logarithmic) or color or spectral class (an ancient and honorable way of dividing up the stars which somewhat predates the realization that temperature is the most important determinant of spectral line intensities) and

runs backwards. Masses in solar masses are given at representative points along the main sequence. The evolution of a typical massive star through the supergiant region is shown, along with the points at which helium and carbon burning start. Most of the time is spent close to the main sequence and in the red supergiant region. The stars in the stippled region of the diagram are generally or always variable in luminosity with regular periods of 3-30 days. They are called Cepheid variables, after the prototype, Delta Cephei, and are important distance indicators for nearby galaxies, because their periods are correlated with their total luminosities.

sec/Mpc = $1.67 \times 10^{-17} \text{ sec}^{-1}$, or $1/H_0 = 2 \times 10^{10} \text{ yr}$), (2) the ages of the oldest stars in our Galaxy, probably 12-18 billion years, and (3) the ages of the radioactive elements in the Solar System, which tell us that the earth and meteorites solidified about 4.65 billion years ago, and that synthesis of these elements had been going on for 7 to 13 billion years before that (Gott et al. 1974). The evidence for the high temperature and density comes (1) again from running the

Hubble expansion backwards, conserving mass-energy and the numbers of various kinds of particles, including photons, and (2) from the existence of two relics of the hot, dense phase. These relics are an isotropic background of microwaves having a blackbody spectrum corresponding to a present temperature of 2.7 K (Peebles 1971) and the seemingly universal presence of helium, with an abundance of 20-30% by weight (Trimble 1975). Thus, if we run a

picture of the Universe backwards about 20 billion years, we see it at a temperature $T \gtrsim 10^{10} \text{ K}$ and a density $\rho \gtrsim 1 \text{ g cm}^{-3}$. Under these circumstances, many kinds of matter and radiation come into equilibrium, and the relative numbers of various kinds of particles (protons, neutrons, electrons, positrons, neutrinos, photons, and perhaps others) depend only on T . As the Universe expands and cools, unstable particles decay or annihilate; and others undergo nuclear reactions, resulting in about 25% He⁴ and traces of H² (deuterium), He³, and Li⁷, as well as about 75% ordinary hydrogen (Wagoner et al. 1967) in the standard cosmological models.

Unfortunately, this hot, dense phase (sometimes called the Big Bang) also wiped out any evidence of what (if anything) went before. Hence the question What happened before the Big Bang? belongs to the realm of pure speculation (philosophy?) rather than that of physics. It is rather like putting a car into a steel blast furnace and asking the trickle of molten metal that comes out whether it was a Pinto or a VW before. You just can't tell, because the evidence has been destroyed.

Galaxies and stars

Coming out of the hot, dense early universe we therefore see some radiation (which continues to cool, down to 3 K by the present time) and some matter, in the form of hydrogen and helium. Luckily this is not all that happened, because the chemistry of H and He is not very interesting! The matter at this stage was not perfectly smooth but was concentrated in lumps. This is also fortunate for us, because, as we have already seen, the average density of matter in the Universe is exceedingly low. Thus, in the absence of local concentrations of matter, the average hydrogen atom would not have encountered another hydrogen atom for the last 10 billion years or so, and would be very lonely. The cause of the lumps is not well understood, though they are not unexpected, since, when the Universe was very young, there had not yet been time for interactions and smoothing to have occurred across large distances. But they must have been there, because we see galaxies and clusters now. There has been

§ 2. Redi (1621-97), Needham (1713-81), and Spallanzani (1729-99)

The first scientific treatment of the question was made toward the end of the seventeenth century. Francesco Redi of Florence, at once poet, antiquary, physician, and naturalist, proved by experiment that, if living causes be excluded, no living things arise. Using no microscope, his work failed to convince those who based their belief in spontaneous generation on microscopic appearances. Nevertheless, Redi's experiments are faultless so far as they go, and his arguments unanswerable so far as they apply to flesh-eating flies. He checked his operations by what are now called 'controls'.

In his Esperienze intorno alla generazione degli insetti ('Observations on the generation of insects', Florence, 1668), Redi tells that he

'began to believe that all worms found in meat were derived from flies, and not from putrefaction. I was confirmed by observing that, before the meat became wormy, there hovered over it flies of that very kind that later bred in it. Belief unconfirmed by experiment is vain. Therefore I put a [dead] snake, some fish, and a slice of veal in four large, wide-mouthed flasks. These I closed and sealed. Then I filled the same number of flasks in the same way leaving them open. Flies were seen constantly entering and leaving the open flasks. The meat and the fish in them became wormy. In the closed flasks were no worms, though the contents were now putrid and stinking. Outside, on the covers of the closed flasks a few maggots eagerly sought some crevice of entry.

'Thus the flesh of dead animals cannot engender worms unless the eggs of the living be deposited therein.

'Since air had been excluded from the closed flasks, I made a new experiment to exclude all doubt. I put meat and fish in a vase covered with gauze. For further protection against flies, I placed it in a gauze-covered frame. I never saw any worms in the meat,

2613.3

C. SINGER. A HISTORY OF BIOLOGY.

REDI → SPALLANZANI → PASTEUR

[July 20, 1969 - Apollo 11 - Lunar Landing]
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Voyager 2 Set to Start Billion-Mile Trip Today

CAPE CANAVERAL, Fla. (AP) — The Voyager 2 spacecraft begins its billion-mile journey Saturday to gather data about the outer reaches of the solar system. But it's also taking along information about earth — just in case anyone's out there.

Voyager 2 was to begin its journey toward Jupiter and Saturn at 10:25 a.m. (EDT) aboard a Titan Centaur rocket. Space officials predicted good weather for blastoff.

The spacecraft's twin, Voyager 1, isn't scheduled for launch until Sept. 1 but will fly a faster route and be first to reach the two planets, the largest in the solar system.

→ The Voyager mission will be carried out in the tradition of Galileo when he first looked through a telescope in 1610. Dr. Edward Stone, a project scientist, said Friday.

“In a sense, the Voyager mission is in the tradition of the step Galileo took. The

spacecraft will continue our observation into deep space,” he said.

Both Voyagers will carry television cameras and sophisticated instruments for scientific studies, but they also will carry gold-plated records with information about earth for any extraterrestrial beings who might exist.

The records, called “The Sounds of Earth,” contain both video and sound, including a message from President Carter, music from classical to rock, sounds of people kissing, and a picture of a modern American supermarket. The records are mounted on the side of each spacecraft. There are two Voyagers to give project controllers more flight options and increase the chances of success.

Scientists hope to use the spacecraft to find out more about the solar system by studying the similarities and differences between planets. They say the outer planets are particularly fascinating

because they may contain primordial material from which the universe was formed.

One of the most prominent features on Jupiter to be studied is the Great Red Spot, which appears to resemble an immense hurricane on earth.

Both Voyagers also are programmed to approach Titan, a moon of Saturn with a thick atmosphere that scientists hope will provide clues about the infant earth.

Titan's methane-hydrogen atmosphere interests scientists who have shined ultraviolet light through such mixtures in the laboratory and produced the hydrocarbons such as acetylene, the common welder's gas, or ethane and ethylene.

Those complex hydrocarbon molecules are considered to be the most likely precursors of life. Many scientists believe they probably were formed long ago on earth when our atmosphere was similar.

→ Voyager 1 will make its closest approach to Jupiter on March 3, 1979 and fly on to photograph Saturn on Aug. 24, 1980. Voyager 2 will be closest to Jupiter on July 10, 1979 and to Saturn on Aug. 27, 1981.

Project planners say that if both craft are intact after passing Saturn, Voyager 2 would be aimed toward Uranus, nearly two billion miles from Earth. Its closest approach would be Jan. 31, 1986; it might then go on to Neptune, arriving in September 1989.

Evidence Mounting Earth, Planets Were Formed from Star

By THOMAS O'TOOLE

(c) 1978, The Washington Post

WASHINGTON — Evidence is mounting that the earth and planets were formed when a nearby star 20 times the size of the sun exploded and showered our neighborhood with the seeds of creation.

The evidence says that at the precise time the solar system was born almost 4.6 billion years ago there was a massive nuclear explosion in the not-too-distant heavens that scattered radioactive debris across billions of miles of space and into the vicinity of what is now our solar system.

The evidence places the birth of the solar system and the stellar explosion no more than 5 million years apart, which, in cosmological terms, is insignificant.

"Something went off with a hell of a big bang just before the solar system was born," said Dr. Gerald J. Wasserburg of the California Institute of Technology, where much of the recent evidence has been gathered. "We're talking about a difference in time that is almost instantaneous, a difference so close that it's almost zero."

Scientists believe the exploding star sent such a strong shock wave through space that it forced the gas and dust swirling in the neighborhood of what was to become our solar system to come together and begin to form planets.

The vast quantity of radioactive debris thrown into space by the blowup of the star is also believed to have had a strong role in

the formation of the planets and possibly the formation of the sun. It was, Wasserburg said, the "last salting of the soup."

The evidence lies in two meteorites that fell from space to earth in the last 10 years. One, the Allende meteorite, dropped several tons of debris onto Mexico, and the other, known as the Santa Clara meteorite, scattered a few hundred pounds of iron across Mexico.

Bound up inside the Allende meteorite were "marbles" of radioactive elements in abundance unlike any seen on earth or even in moon rocks. Scientists found in Allende strange mixtures of barium, calcium, strontium, neodymium and samarium. Dr. Robert Clayton of the University of Chicago found an odd mix of an isotope of oxygen known as oxygen-16, all of which made it appear as if Allende was the leftover of a hydrogen bomb explosion rather than the workings of Mother Nature.

"There are some objects in Allende which did not come from any normal solar mix," Wasserburg said. "Every element in some of those little marbles in Allende looks like it was made in Oak Ridge," the U.S. atomic energy facility in Tennessee.

Most of all, the Allende meteorite contained huge excesses of an isotope called magnesium-26 that could have only come from the radioactive decay of another isotope known as aluminum-26. This isotope has all but vanished from the solar system because its half-life of

700,000 years is short enough to have long ago made it extinct.

Never before had scientists seen evidence that aluminum-26 was bound up in such large abundances in the rock being formed at the birth of the solar system. Among other things, it told them that a nuclear event was responsible for the original production of aluminum-26 and that enormous heats were being generated inside the rocks from the radioactive decay of elements like aluminum-26.

"At the levels we measured, there was enough radioactivity in the dust and gas cloud at the birth of the solar system to melt a planet," said Wasserburg, who found the first evidence of aluminum-26 with Drs. Typhoon Lee and D.A. Papanastassiou of Cal Tech. "If the whole solar system had aluminum-26 as abundant as our numbers said, there was more energy present than the binding energy of the sun," Wasserburg said.

Even fresher evidence has come from the Santa Clara meteorite, which produced an unexpected abundance of an isotope of silver known as silver-107. Again, the large excess of the silver isotope meant it had been put there by the radioactive decay of another extinct isotope — in this case, an isotope of the noble metal palladium called palladium-107 whose existence in nature has never before been confirmed.

"People have thought about palladium-107 and looked for palladium-107 for 30 years," Wasserburg said. "We claim to have found it." The claim appears in the current issue of Geophysical Research

Letters under the names of Cal Tech's Dr. William R. Kelly and Wasserburg.

The evidence that palladium-107 existed in large quantities in a meteorite whose origins go back 4.6 billion years is the strongest evidence yet that the solar system was seeded with "stardust" at the time of its birth. Palladium-107 is only made in a nuclear furnace. The suggestion of its existence means the nuclear furnace had a hand in the process that formed the planets.

The discovery of aluminum-26 in the Allende meteorite told scientists there was enough heat around in the beginning to melt rock. The finding of the palladium-107 in the Santa Clara meteorite meant there was enough rock being melted to make planets.

"It's confirmation," Wasserburg said, "that there was some big nuclear event making a wide spectrum of radioactive elements across the whole periodic table."

In finding the Palladium-107, Kelly and Wasserburg also put a date on its formation, a date no older than 5 million years beyond the 4.5555 billion years assigned from the analysis of the moon rocks to the formation of the solar system. The date for the palladium-107 also matched the date for the aluminum-26. Two separate meteorites, identical dates for the two extinct isotopes.

It was no accident that Kelly and Wasserburg went looking for palladium-107 in a meteorite rich in iron. Kelly suggested they look for the extinct palladium in the Santa Clara meteorite

because real palladium metal had already been found mixed in with the iron in the meteorite. Why not palladium-107?

In discovering the palladium-107, Kelly and Wasserburg literally stumbled on the relics of a planet no bigger than a few miles across as it melted in the process of formation. The iron and palladium in the Santa Clara meteorite could have been the core of a planet in its first few million years of life.

Among the isotopes of the heavy metals, palladium-107 is unique because its life is so short. For instance, uranium-235 is still in the earth's crust. Palladium-107 is not. Its half-life is 6.5 million years, meaning it almost disappeared 12 million years after it fell from a star and arrived in the regions of our solar system and began to make planets.

"You don't make iron meteorites with little dust grains. You've got to have a planet and you've got to have the planet melting iron out from rock," Wasserburg said. "To get the palladium-107, you've got to strip out the iron at the same time you've still got some radioactive palladium left. This is a very short time scale."

In the current issue of Geophysical Research Letters, Kelly and Wasserburg describe some of the details of their experiment to find the ghosts of palladium-107. Kelly worked 3 1-2 years preparing the experiment. Wasserburg describes it as "nontrivial."

The experiment involved methods of analyzing fractions of the meteorite so small they measured out as "nanograms,"

meaning they were so tiny they had to be handled under a microscope. It involved extending methods of analyzing "moon dust" to meteorite pieces. It involved precisions that doubled the accuracy of any meteorite analysis previously done.

Most scientists believe the aluminum-26 and the palladium-107 could only have come from an exploding star not too far from where our solar system rests. The remnants of the explosion can't be seen. Its first identifiable relics are the extinct isotopes of aluminum and palladium.

The idea that a supernova explosion gave birth to the solar system fits nicely with another theory of stellar evolution gaining more scientific acceptance. This theory says that stars are formed in clusters as they pass through the spiral arms of the galaxy. The largest stars grown out of this passage burn up their nuclear fuel in just a few million years, then blow up to seed the universe with their radioactive-decay products.

The only other source of the exotic mix of elements found in Allende and Santa Clara could be the sun, but scientists say it would have had to be a lot more violent than it is today to have produced such a mix. There is little evidence that the sun ever went through a hyperactive phase.

That leaves the supernova theory, which says that the exploding star scattered the first seeds of evolution all over the garden of space that is now our solar system. Without those seeds, the solar system may never have bloomed and life may never have thrived.

Neptune to Become Farthest From Sun

NEW YORK (AP) — After Sunday, and for the next 20 years, the planet Pluto will no longer be the farthest planet from the sun.

Astronomers at the Hayden Planetarium here said Pluto's highly elliptical orbit will carry it inside the nearly circular orbit of Neptune at three seconds before 4:58 p.m. EST Sunday.

At that moment, both planets will be 2.816 billion miles from the sun, said Dr. Mark Chartrand, planetarium chairman.

Neptune will remain the outermost planet until March 1999, when Pluto's orbit carries it back outside Neptune's, he said.

Despite their intersecting orbits, there is no chance of a collision. Pluto's orbit is sharply inclined to that of the rest of the solar system and the two planets will remain far apart.

Pluto, which takes 248 years to complete one revolution around the sun, now is approaching the closest point in its orbit — 2.8 billion miles. At its farthest point, Pluto is 4.6 billion miles from the sun.

Neptune, which circles the sun once every 165 Earth years, is always about 2.8 billion miles out.

Astronomers Report Seeing the Edge of Universe, at a Distance That Light Takes 12 Billion Years to Cover

Continued From Page 1, Col. 4

have originated in an enormous explosion of matter—a "big bang"—some 13 billion years ago, and the earliest quasars should be visible far enough away for their light to have been on its way here for that long.

But looking across vast distances — and, hence, far back into time—man can see out only to 12 billion years (in the most distant quasars).

Hence, in the words of Dr.

For quasars to be used for this purpose, they would have to be roughly uniform in intrinsic brightness. As astronomers put it, for such a determination they need a "standard candle" — something whose intrinsic brightness as against apparent brightness at an unknown distance, is known so that they can determine the extent to which the light has been dimmed by the distance it has traveled.

This is not proved to be

the case with quasars. Their intrinsic brightness seems to vary by wide margins. Hence, Dr. Sandage, who is one of the world's leading specialists in this field, believes that, for this search, astronomers will have to depend on certain galaxies whose intrinsic brightness is more uniform.

By cataloguing large numbers of such galaxies according to rate of recession and relative distances, determined from the dimming of their light, it should become

evident to what extent the rate of expansion was faster in the past—that is, extent of the slowing down.

The speed of recession is determined by measuring the extent to which certain known wave lengths of light from the object have been shifted toward the red, or long-wave, end of the spectrum. Rapid motion away from the observer stretches the wave lengths of light much as the pitch of a horn is lowered when a vehicle is moving away.

The extent of this "red shift" is an indicator of the speed of recession and has become the standard yardstick for distances to other galaxies.

There are some astronomers, apparently a minority, who have questioned the applicability of this yardstick to the quasars. They note that, if the yardstick is valid, the intrinsic brightness of the quasars must vary by remarkably large margins.

They also note that two of the quasars seem linked by

a gaseous bridge, although their radically different red shifts would indicate they should be flying apart. Other astronomers have questioned the reality of this bridge.

The yardstick has also been challenged because of its implication that certain very distant objects are flying apart faster than the speed of light—on theoretical grounds, an impossibility. If the red shift yardstick is misleading and these objects are relatively close to earth, estimates of their motion would

shrink to more reasonable rates.

In reply, it is argued that these objects may not really be flying apart at all, the observations being an optical effect unrelated to motion.

Attempts have been made to attribute the red shifts to effects other than rapid motion away from the earth—for example, by extremely strong gravity fields. The new observations are cited to challenge this on the ground that the red shifts now being seen are so great that

their production by anything other than motion is improbable.

Finally, there is the argument that, in some parts of the universe, or at some times in the past, the laws of physics were different and atoms emitted their characteristic light at wave lengths other than those of today.

This runs so counter to all other observational evidence that scientists tend to consider this the explanation of last resort.

Planets beyond Mars beckon with mystery

By Robert C. Cowen
Staff correspondent of
The Christian Science Monitor

Washington

Venus has been fascinating. Mars is a challenge. But for space scientists, the giant outer planets have the kind of magnetism which drew 16th-century explorers to America.

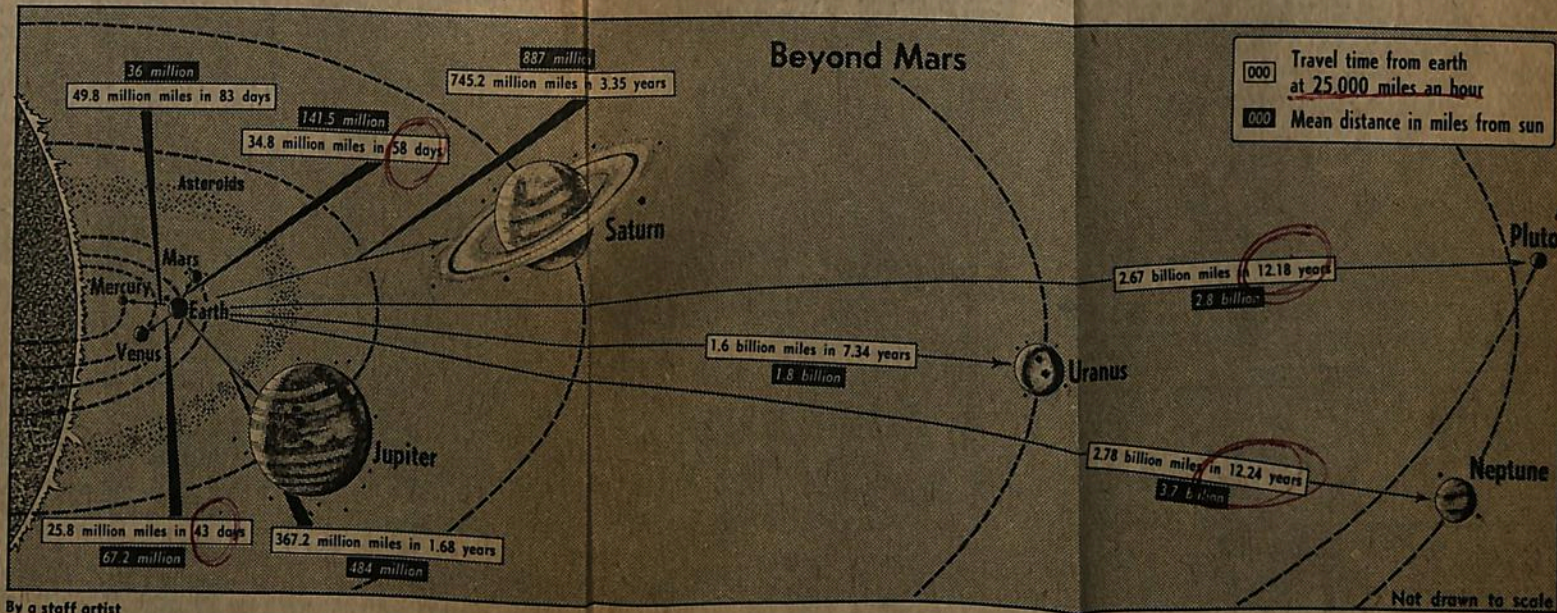
They know just enough about the realm beyond Mars to sense a wholly new planetary "world."

Even the first probes could overturn today's concepts of the origin and evolution of the solar system.

Indeed, scientists know so little about the flight hazards, they can't be sure their spacecraft would survive the journey.

Yet American space engineers now have the technical ability to probe the unknowns and try the dangers.

★ Please turn to Page 10



By a staff artist

New space venture: Earthcraft start for Jupiter next March and in April, 1973

December 1, 1971

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Evolution in the Microbial World

Edited by M. J. Carlile and J. J. Skehel

Microbiologists and all biologists interested in evolutionary studies will find these sixteen papers covering the major aspects of evolution in micro-organisms of great importance. The mechanisms of evolution and the evolution of molecules, processes and groups of organisms are considered. This is the first work to be devoted wholly to the evolution of micro-organisms, a topic until recently neglected in comparison with the evolution of plants, animals and man.

CONTENTS:

P. H. A. Sneath: *Phylogeny of micro-organisms*

J. W. Drake: *The role of mutation in microbial evolution*

M. H. Richmond and B. Wiedeman: *Plasmids and bacterial evolution*

K. Esser: *Breeding systems and evolution*

H. E. Kubitschek: *Operation of selection pressure on microbial populations*

J. H. Subak-Sharpe, R. A. Elton and G. J. Russell: *Evolutionary implications of doublet analysis*

B. S. Hartley: *Enzyme families*

Patricia H. Clarke: *The evolution of enzymes for the utilisation of novel substrates*

R. Y. Stanier: *The origins of photosynthesis in eukaryotes*

H. D. Peck, Jr.: *The evolutionary significance of inorganic sulfur metabolism*

J. R. Postgate: *Evolution within nitrogen-fixing systems*

W. K. Joklik: *Evolution in viruses*

J. J. Skehel: *The origin of pandemic influenza viruses*

J. R. Baker: *The evolutionary origin and speciation of the genus Trypanosoma*

D. H. Lewis: *Micro-organisms and plants: the evolution of parasitism and mutualism*

C. Ponnamperna and N. W. Gabel: *The precellular evolution and organization of molecules*

M. J. CARLILE is Senior Lecturer, Department of Biochemistry, Imperial College, London and J. J. SKEHEL is Research Scientist, National Institute for Medical Research, Mill Hill, London.

1974 440 pp. 9 plates/41 Tables/68 Line diagrams

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The Society for General Microbiology Symposium 24

Theory of an Expanding Universe Dealt a Blow by Two New Studies

By WALTER SULLIVAN

After several years in which various observations seemed to indicate that the universe is infinite and destined to expand forever, two studies have revived the possibility that it is finite and predestined to collapse.

The new observations, looking at the problem in separate but related ways, suggest that expansion has already slowed enough to end in a falling back together of all the galaxies and stars billions of years hence.

One study used quasars and the other used brilliant, distant galaxies as "standard candles" to see if the expansion rate was considerably greater long ago. In both tests, this appeared to have been the case. But in each case the findings were tentative.

The term "standard candle" is applied to astronomical objects believed to be of uniform intrinsic brightness. This makes it possible to estimate an object's relative distance by the dimming of its light in its journey to an observatory.

For example, if at night one tried to estimate distances to many houses by the brightness of lights in their windows, it would help to know that the brightest light visible in each was a "standard candle," such as a 100-watt bulb.

In a search for such "100-watt bulbs" Dr. Allan R. Sandage of the Hale Observatories in California has for a number of years used the brightest elliptical galaxy in each cluster of galaxies. It has been an extension of this work by Drs. Jerome Kristian and William Westfall, with Dr. Sandage, that suggests enough slowing of the universe's expansion to imply eventual collapse.

The quasars had seemed hopeless as standard candles because they appeared highly variable or irregular in brightness. It has only been in recent observations that those with certain spectral features seem to be uniformly bright and enabled a group at the Johns Hopkins University

Continued on Page 13, Column 1

STUDIES DEAL A BLOW TO UNIVERSE THEORY

Continued From Page A1

to deduce that they imply what the group feels is a closed, finite universe.

In both tests, the observed brightness of each object has been compared with its observed motion away from the earth, caused by expansion of the universe. This motion is manifest in a shift of spectral lines in light from the object toward the red end of the spectrum.

is at the opposite, or short-wave end. The spectral lines are lengthened, or "red-shifted," by the same effect that lowers the push of a receding horn.

In a uniformly expanding universe this "red shift" increases systematically at greater distances. When the extent of the red shift is plotted graphically against observed luminosity for a large number of galaxies, they tend to lie along a straight line. This implies uniform expansion at increasing distances into space, and therefore into the past.

The most distant galaxies and seemingly even more distant quasars lie so far away that their light has taken billions of years to reach the earth. They are therefore being seen when the universe was relatively young. Estimates of its present age range from 10 to 20 billion

years from their dimmed luminosity, the red shifts should show whether the expansion then was sufficiently more rapid than today to indicate a substantial slowing.

If the extent to which a soaring rocket is slowing can be determined, it is possible to predict whether it will fall back to earth or sail off into space forever. The same test could be applied to the expansion of the universe.

The standard candle used by the Johns Hopkins group concerned the brightness of quasar emissions at certain ultraviolet wave lengths, such as those from hydrogen known as Lyman alpha, relative to the background light of the quasars. Earlier observations by others, such as Jack A. Baldwin of the Lick Observatory in California, had suggested that this

test could be made. Most quasars are so far away that otherwise invisible ultraviolet wave lengths have been shifted to the visible part of the spectrum. To see the slowing trend, however, it was necessary to apply the same test to a closer quasar whose ultraviolet emissions could not be seen except from above the atmosphere.

This was done with a rocket shot from the White Sands Proving Ground in New Mexico last April, carrying the largest optical telescope ever sent aloft in that manner. For almost six minutes it scanned the brightest, and presumably nearest, quasar, known as 3C 273.

When its recession velocity was compared with that of five extremely distant quasars, determined by the spectral meth-

od, the result was a value of 1.0, or q zero. If it exceeds 0.5 the universe is closed. The admittedly tentative indication from the quasars was 1.0.

The Hale Observatories group has not yet published its findings but they have been widely circulated. They are based on observations of 139 galaxies, some previously reported, but 30 or 40 of them new. They implied slowing was 1.6, with an error margin of 0.4.

Report in a British Publication

The significance, as the Hale observers point out, depends heavily on whether galaxies change their intrinsic brightness with age. Some believe that as their stars burn out they get dimmer. Some say the brilliant galaxies being used have grown brighter by swallowing neighbor galaxies.

15 issue of the British journal Nature.

Those who have become convinced expansion of the universe will never end base their point of view on evidence that has not been reported. The strongest evidence in their favor concerns the apparent absence of enough material within the universe, in terms of tons per cubic light year, to generate the gravity needed to hold it together.

Efforts to observe even a substantial fraction of such material have been unconvincing. Furthermore, the large amount of heavy hydrogen, or deuterium, seemingly formed in the explosive birth of the universe is taken to imply insufficient density even at that early age.

The subject is one with emotional over-

SOMATOSTATIN

RECOMBINANT DNA RESEARCH 39

Substance Usually Made in Brain Grown in Bacteria

By HAROLD M. SCHMECK Jr.

Special to The New York Times

WASHINGTON, Nov. 2—Scientists in California have successfully grown in bacteria a substance that is normally produced in animal and human brains and is believed to have important potential for treating diabetes and other serious disorders.

In testimony before a Senate subcommittee today, Dr. Philip Handler, president of the National Academy of Sciences, called the achievement "a scientific triumph of the first order."

The substance, called somatostatin, has important functions in controlling the

body's production of insulin and human growth hormone. In nature it is not produced in bacteria at all.

Yet, by the techniques of recombinant DNA research, the scientists in California inserted into bacteria the genetic instructions for making somatostatin together with all the necessary control information to make the bacterial cells produce the foreign substance.

Subject of Controversy

Recombinant DNA research, also known as gene splicing, is a field of study that has generated much controversy in recent years because it offers the possibility of conferring on one type of organism traits

and potentialities native to far different forms of life.

Both Dr. Handler and Dr. Paul Berg, of Stanford University, cited the new, still-unpublished work on somatostatin as evidence that the gene splicing research does have great potential.

They were among nine witnesses who testified today at a hearing of the Senate Commerce Committee's Subcommittee on Science, Technology and Space under their chairmanship of Senator Adlai E. Stevenson 3d, Democrat of Illinois.

The hearings are on legislation to regulate recombinant DNA research, a legislative effort that has been stalled in both

Senate and House for several months.

Dr. Handler said that the achievement with somatostatin was important because it was a clear demonstration that all the genetic information needed to make a protein that is normally made in a mammalian cell, in fact in the human brain, could be transferred to a bacterial cell and would function there as it did in its normal environment.

Delay After Discovery

Dr. Berg, who described the feat as "astonishing," said that about two gallons of bacterial culture produced five milligrams of pure somatostatin. He noted that the original discovery of somatostatin several years ago required a year's analysis of the material in nearly half a million sheep brains to produce a comparable five milligrams of somatostatin.

Last month Dr. Roger Guillemin of the Salk Institute, in La Jolla, Calif., and Dr. Andrew V. Schally of the Veterans Administration Hospital and Tulane University, New Orleans, shared a Nobel Prize for research including the discovery of somatostatin.

The production of somatostatin in bacterial culture was achieved by a collaborative effort of scientists at the University of California, San Francisco, City of Hope Medical Center in Durante and the Salk Institute. One of the principal leaders in the work was Dr. Herbert Boyer, whose team earlier had incorporated the gene for making insulin into bacteria.

In an important respect the achievement in transplanting the somatostatin gene was an advance over the earlier insulin work. Although the insulin gene

was reproduced in the bacteria, it did not actually make the bacteria produce insulin. In the somatostatin research the scientists did achieve production of the substance by the bacteria.

Scientists at the University of California declined to discuss the details of the work because it had not yet been accepted for publication by a scientific journal. They confirmed, though, that the statements by Dr. Handler and Dr. Berg were correct.

The genes for producing the human brain substance were spliced into cells of bacteria called *Escherichia coli* of a strain so modified that it apparently will not grow outside the laboratory. The choice of this type of E. Coli bacteria is a safety precaution required in a recombinant DNA research.

Sex and the single sign

A PISCES with a Venus in Taurus and a Scorpion superego, this guy is combining his love for astrology with an understanding of Freudian theory.

Astroanalysis.

Jeff Willis, a 21-year-old senior here, says Pisceans belong to one of the two esoteric signs (the other being Scorpio) which give one an ability to "feel and read emotions, see motives and understand principles of the supernatural."

"What I'm presently trying to do is...combine the principles of astrology with the principles of psychology and Freud's theory," says Willis. "Sure I'm an amateur and there's holes in the theory, but for the most part it's all clicking."

"Astrology is one of the most reliable sources for marriage and seeing how well you'll be able to live with somebody," he says, putting the emphasis on romance. And psychoanalysis is respected by most psychologists for its ability to predict adult sexual behavior, he says.

"While I can't get into it too deeply right now because it's a potentially exhaustive subject and I'm a full-time student, I might write a book about it after I graduate. Right now, I fool with it when I'm in the mood to blow off studies or socialize," he admits.

WILLIS BECAME interested in astrology last winter when a friend gave him an ordinary horoscope. Later the friend taught him to read an ephemeris—a book serving as a guide to the location of the planets on a given day, usually used to look up birthdates.

"You must have a feel for astrology," he says, "not just anyone can pick it up. You have to be looking for something." "Astrology's blunt—it tells your good as well as your bad characteristics. Some people are too insecure to handle it."

Willis has spent a good deal of time studying astrological marriage charts, comparing the signs to learn how the personalities coincide and conflict. As for psychoanalysis, Willis says he has always admired Sigmund Freud as a man ahead of his time. "His theories aren't accepted by many because most people are simply too shallow to understand," he says.

Willis, a Pisces, says this is one of the most creative signs where thoughts can rise unhindered from the id, a source of raw instinct. "Thinking and writing are my two favorite hobbies," he says.

WILLIS IS the author of two novels, one written when he was 16 and never published, and another written a year ago currently being considered by two publishers. 'Destin Heat' is a story about two 19-year-olds' encounter with love, emotion and sexual sensitivity during a Florida summer.

Willis envisions another book on Astroanalysis, but warns that it is strictly in the genesis stage. He does, however,



By PAUL GAINES

like to talk on the subject informally and has 'counseled' more than 20 others.

According to Astroanalysis, the Freudian id corresponds to a person's sign. "The id controls the energy of personality, it doesn't reason, it's driven by the pleasure principle with components of destructive impulses," he explains.

"It's a reservoir of unrestrained instinct. The person's sign (Leo, Libra, etc.) reflects his inner self and carries the basic characteristics of his id," according to Willis.

The Freudian ego, a mediator between the instincts of the id and the outside world, corresponds to the astrological influence of a person's planets, moon and ascendent. The ascendent designates the direction of the sun on the date of birth, he says.

THE MOON rules the emotions and is the strongest influence next to the sun sign, while the planets influence the person's attitudes and reasoning capacity. "The ego is on the outskirts of the id, the sun sign regulates the ego like a foreman—it takes id energy and channels it into behavior," Willis contends.

But it was the link between the Freudian superego and astrology that gave Willis the key to his new theory. In psychoanalysis, the superego is the mental apparatus which develops as a result of outside social influences—parents, friends and society.

Willis has astroanalyzed his parents and reflects on their influence. "The frightening thing about my mother and father was their absolute personality conflict. My father was a Scorpio and my mother a Capricorn. Capricorns tend to be dominating people but Scorpios simply cannot be dominated," he says.

"I was the first child and my father had the strongest influence," he says, recalling that Freudian theory emphasizes the influence of parental images. "Today, I'm drawn to Scorpios, I welcome them, they represent security to me."

"WE'RE NOW in the age of Aquarias, so everyone has some Aquarian tendencies in their superego," he continues. "People tend to be more open-minded and friendly," he says.

"When opposite sexes meet," he says, "the ego-ideal is activated and certain preconscious requirements strive to be fulfilled. These requirements relate directly to the signs of the couple involved. If they are well-matched, the id is motivated to be an emotional reaction," he explains.

In general, fire signs go well with air signs; water signs mix well with earth signs, he says. "If the signs match, nine out of ten times the relationship will be happy, but the position of the planets must be considered, too," he says.

"But it's more than the mating of two egos," he continues. "There has to be some link with the pleasure principle for the deepest kind of love to exist. The id, ego and superego must combine," he explains.

When the air signs fall in love, it is usually going to be a superego love. The relationship will be based on social motivations—on responses already learned. The relationship between a Gemini and an Aquarias might tend to be one of simple companionship, for example.

ON THE OTHER hand, a Pisces and a Scorpio will talk with their eyes, know what each other is thinking and ultimately become a part of each other, he says. "The passions of their ids will combine."

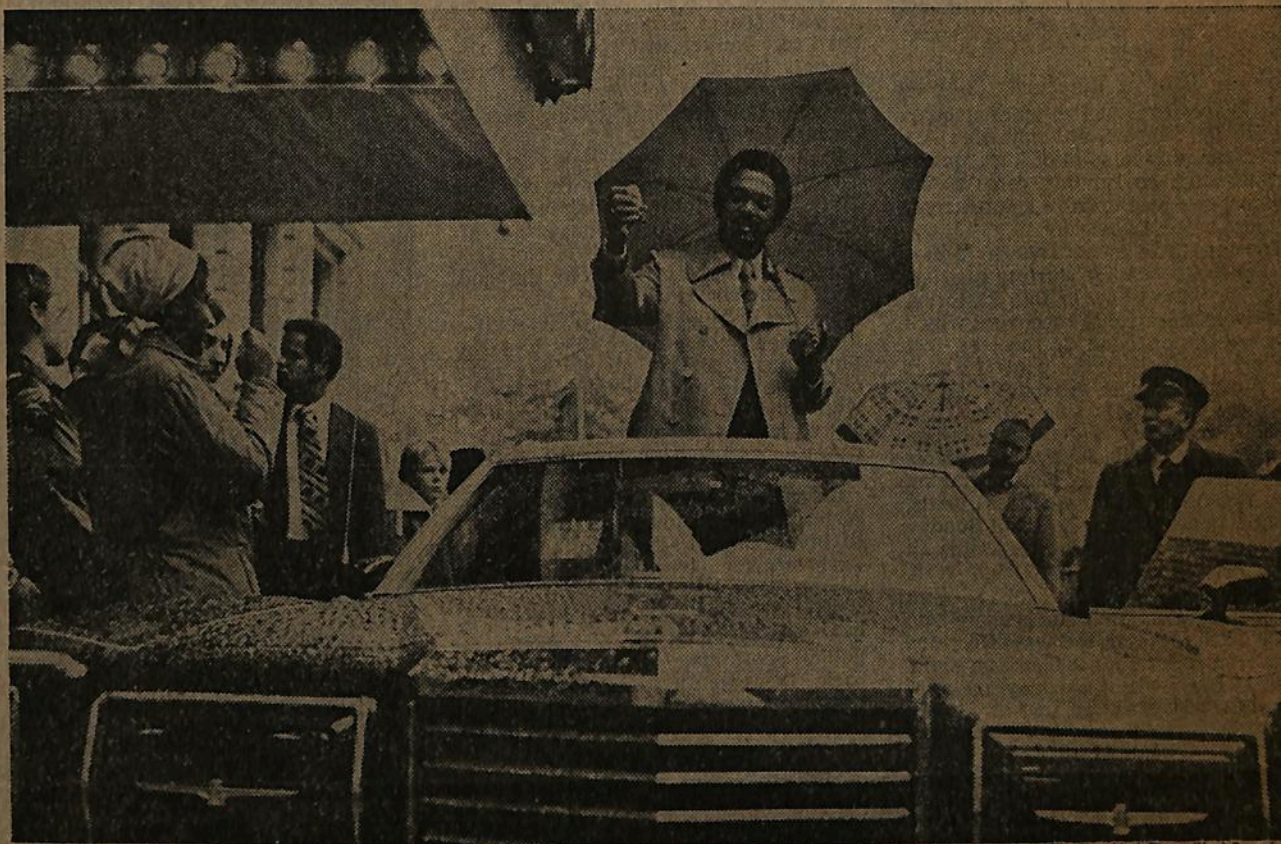
The id is the best motivator for dating, says Willis, because if you just meet someone at a bar or a party you know little about them and depend on emanations from the inner self.

In many cases, the id can cause the superego to rationalize, and the fate of the relationship boils down to the ego-ideal, he says. Freudian theory says that we go around with hidden ego-ideals, unconscious images of our perfect mate based on childhood impressions of a parent or some other prominent figure.

"If a couple gets together and the electricity starts flowing—it has to be the passion of the id. If one discovers, however, that the other's been to bed with

Photo by Bill Feig and John DeRienzo

(Continued on Page 16)



The New York Times/Neal Bond

At the Plaza Hotel, Reggie Jackson stands in—and holds the keys to—the car he was awarded by Sport Magazine after they named him the most valuable player of the World Series.

Red Smith

Hemingway Wouldn't Have Dared

Reggie Jackson posed leaning against the new Thunderbird outside the Fifth Avenue entrance to the Plaza. Beside him was his sister, Tina Jones, with her small daughter Alex. Tina is getting the car from Reggie, who drives a Rolls-Royce as befits the richest player in baseball. This is the second time Sport Magazine has awarded an auto to Jackson as the most valuable player in the World Series. In 1973 when he led the Oakland A's to victory over the New York Mets, he gave the car to charity but after his three consecutive home runs destroyed the Los Angeles Dodgers Tuesday night and gave the Yankees their first championship in 15 years, Tina told him, "My name is Charity." So yesterday they posed on the wet pavement while flashbulbs popped and crowds watched from the sidewalks and hotel guests packed the steps beneath the marquee. Over the traffic noises came a chant: Reg-gie Reg-gie! Reg-gie! It seemed an echo from the right-field stands of Yankee Stadium until the source was located—crowded windows on the ninth floor of the building that houses the Paris Cinema. Obviously, no corner of New York is off limits to Reggie Jackson's idolators this week.

Sports
of
The Times

"Ernest Hemingway, one of the greatest writers in the world, couldn't write a better ending for me," Reggie was to say in his formal acceptance speech. The fact is that Hemingway, a realist, wouldn't have stooped to the mawkish melodrama Reggie injected into the climax of a summer-long soap opera.

Luxury of Being Thrilled

The plot was absurd: millionaire newcomer who talks too much becomes storm center of stormiest clubhouse in

and couldn't play in it. His father has the ring from Oakland's 1973 series, his mother the one from 1974.

"I think I'll have this year's made into a trophy," he said. "This world Series has great meaning to me. This isn't just a baseball story to me."

He spoke quietly, holding nothing back.

"A thrill?" he said. "My mom is thrilled, and my dad and the people around me. I don't have the luxury of being thrilled. My first World Series, my first home run, my first M.V.P. award, those were thrills. I've become a man in the last two years."

"I'd like to be accepted as a great person, more than a ballplayer. I'd like my accomplishments to be treated humanistically, what they mean to people, to mankind, to black people. Being under water all summer and coming through. For someone whose chances are dull and look very dim, I'd like them to be able to read the story of this year. What happened to Reggie Jackson before that is not important. This year has strengthened my character and changed my personality."

Good Things for Jackie R.

Could he endure another year like this?

"Probably. I'd hope I wouldn't have to. My life as a human being is gonna be better for it and that's what counts. As a ballplayer, I don't know."

In late innings when Billy Martin replaced him with Paul Blair to strengthen the defense, did that hurt his pride?

"Selfishly, yes, but you always have to take yourself out of context. If the manager feels he has his nine best men on the field, that's his job."

There was a moment's hesitation. Then: "I don't want to sound brash or cocky but I'm above being put down

How the Other Half Dies: The Real Reasons for World Hunger

by Susan George

"A most intelligent, urgent and thought-provoking book on a truly vital subject."—John Kenneth Galbraith

"At last! *The book for anyone remotely interested in over 500 million people who live in 'absolute' poverty . . . Susan George explodes the myths which enable us to blame poverty on the poor.*"

—*Times Educational Supplement*

" . . . I liked [*How The Other Half Dies*] just a mite better than [*Food First*] because [it] is more compact and better organized."

—Alden Whitman, *LA Times Book Review*

"This book . . . shows how *consciously* . . . rich men and powerful organizations [plan] to use food shortages for political purposes in the next decade or two. It also gives some ideas of how terrifying the food situation already is, and how the poor are blamed for their own suffering . . . Read it . . . !"—*The New Statesman*

"World Hunger . . . is a consequence not of scarcity or of the growth of population, but of political and economic choices. . . *How The Other Half Dies* will be widely discussed. . . [it] has the considerable merit of drawing on non-American sources, including recent studies of the world food economy sponsored by the French Government."—Emma Rothschild, *NY Times Book Review*

" . . . Passionately written and astutely researched . . . scathing in some passages . . . marshalling facts in a well-organized polemic which, had it been penned by a Galbraith, might receive national attention."—*Publishers Weekly*

Contents: Rich man, poor man: who's the thief? / The population myth / Local elites—and how to join them / Technology: now who pays to do what and to whom? / The Green Revolution / Planned scarcity / There's no business like agribusiness / Food aid? . . . Or weapon? / *Et tu*, UN? / IBRD, or, is the Bank really a developer? / What can 'they' do? / What can I do? / Appendix: agricultural inputs / A few useful addresses / References / Index

The author is a fellow of the Transnational Institute, Institute for Policy Studies, and as such helped to write the TNI report on the World Food Conference held in Rome in 1974, World Hunger: Causes and Remedies.

May 1977 76-52614 328 pp. SBN 0-916672-07-7 \$12.50 cloth
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PROPOSALS FOR UPPER RANKS OF LIVING THINGS*

Hamilton P. Traub**

The discovery of the nucleus in plants (Brown, 1831), the promulgation of the cell theory for plants (Schleiden, 1838), and its extension to animals by Schwann (1839) together with the advent of modern virology with the work of Twort in 1915 and d'Hérelle in 1917, who demonstrated the particulate nature of viruses, and contributions of later workers, have laid the basis for the recognition of the primary lineagic groups of organisms - cellular and non-cellular. These groups are thus placed in the primary rank as superkingdoms - *Cellularae* and *Acellularae*.

When it was realized a decade ago that the procaryotic and eucaryotic cellular organization represented another profound structural and developmental discontinuity in biology - this time under Superkingdom *Cellularae* (Traub, 1963, 1964) - it was evident that this was *common ground* upon which all biologists might agree, and that the time had arrived for proposals to standardize the upper ranks for the linordination of organisms. Since then attempts have been made to establish the upper ranks, Superkingdom, Kingdom, Subkingdom, Infrakingdom, etc. (Traub, 1963, 1964, 1971, 1973), all in use, and thus to avoid the making of superfluous new names for the upper ranks.

Moore (1974) has recently proposed *three* groups in the primary rank - Dominion 1. *Virus*, Dominion 2. *Prokaryota* and Dominion 3. *Eukaryota*. However, allowing these *three* entities in the primary rank fails to take into consideration the fundamental differences between *cellular* (pro-, and eucaryotes) and *non-cellular* (virus) organization, and overlooks the fact that the choice is limited to one contrasting pair. Living things are either *cellular* or *non-cellular* on the primary level, Superkingdom 1. *Cellularae* vs. Superkingdom 2. *Acellularae*. The contrasting pair, procaryotes vs. eucaryotes belongs in the secondary rank of cellular organisms, Kingdom 1. *Procaryotae* vs. Kingdom 2. *Eucaryotae* (Traub, 1963, 1964, 1971, 1973). Thus, the upper ranks, Superkingdom, Kingdom, Subkingdom, Infrakingdom, etc., are sufficient for the needs as shown in Table 1, which places a roof over living things on the basis of fundamental differences in an evolutionary sequence.

TABLE 1. Four upper ranks used in grouping living things. Based on Traub (1963, 1964, 1971, 1973).

1a. Cellular organisms	Superkingdom 1. CELLULARAE
2a. Procaryotic organisms	Kingdom 1. PROCARYOTAE
3a. Autotrophic procaryotes: Blue	
-green Algae, and other procaryotic autotrophs	Subkingdom 1. AUTOBACAE
3b. Heterotrophic procaryotes (bacteria)	Subkingdom 2. HETEROBACAE
2b. Eucaryotic organisms	Kingdom 2. EUCARYOTAE
4a. Autotrophic eucaryotes; green plants plants, and added	
neoheterotrophs, <i>Cuscuta</i> , etc.	Subkingdom 2. PLANTAE
4b. Mesoheterotrophic eucaryotes (Fungi)	Subkingdom 2. HETEROPLANTAE (fungi)
4c. Archiheterotrophic eucaryotes, animals	Subkingdom 3. ANIMALIA

* Financial support towards publication is gratefully acknowledged. (Ed.)

** Editor, The American Plant Life Society, Box 150, La Jolla, Calif. 92037.

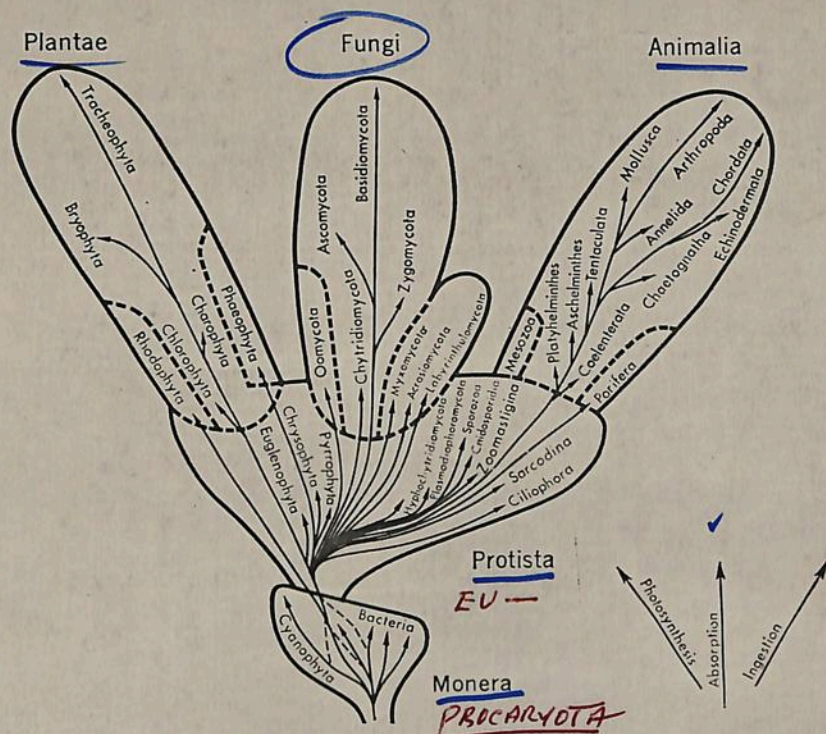


Fig. 3. Whittaker's five-kingdom evolutionary scheme; reproduced with kind permission from *Science* 163: 150-160, 1969 (fig. 3 R. H. Whittaker). Copyright 1969 by the American Association for the Advancement of Science.

strong affinities with Phaeophyta (Plantae) and Oomycota (Fungi) and no obvious affinities with Ciliophora or Sporozoa.

Secondly, higher kingdoms in both schemes are polyphyletic (on present ideas) to a degree that is profoundly disturbing to the ideal of a natural classification. Drawing the protistan line at the unicell/multicell boundary forces Whittaker to include Rhodophyta and Phaeophyta in Plantae with the green plants; Oomycota, Myxomycota, Acrasiomycota and Labyrinthulomycota with the "true" Fungi; and Mesozoa and Porifera with the Metazoa in Animalia. As Whittaker himself says, his three kingdoms of higher organisms appear less as kingdoms than as alliances of separate multicellular groups.

The main question for our discussion is, then, does a scheme like that of Copeland or Whittaker represent the best broad classification we can make at present, despite its acknowledged limitations, or are there sensible (better) alternatives?

Margulis (1973) has recently suggested a modification of Whittaker's system (Fig. 4). This removes phyla from Plantae, Fungi and Animalia into the upper reaches of the Protista, leaving the three kingdoms of higher organisms arguably monophyletic. It does, of course, increase the heterogeneity of the Protista and objections to that kingdom on those grounds. It is, in effect, a partial return to Copeland's scheme with the main exception of

RESSIE JACKSON [- 3 HOME RUNS 1977 WORLD SERIES]



NOBEL PRIZES 1977

PHYSICS { Philip W. Anderson - Princeton } subatomic particles
{ John Hansbrouck Van Vleck } Harvard } magnetism

CHEMISTRY { Ilya Prigogine - ^bMOSCOW → BRUSSELS → U. TEXAS } THERMODYNAMICS

MICROBIOLOGY { Roger Guillemin - SALK INST. LA JOLLA, CAL. } RECOMBINANT DNA (E. coli)
{ Andrew V. Schally - TULANE U. } SOMATOSTATIN (PROTEIN)

Normandy Found IN SHEEP BRAIN & HUMAN
CONTROLS INSULIN & GROWTH HORMONES

GENETIC INFO SUCCESSFULLY TRANSFERRED TO E. coli

∴ E. coli → SOMATOSTATIN.

CURRENT MICROBIOLOGY

CARL W. WOESE - UNIV. ILLINOIS } METHANOGENS

BACTERIA-LIKE ORGANISMS ?

$CO_2 \xrightarrow{\text{ANEROBIC}} CH_4 \uparrow$



1969

BL

New York

First true protein is synthesized

Chemists at Rockefeller University in New York City and at Merck, Sharp & Dohme Laboratories in Rahway, N.J., have independently accomplished the first laboratory synthesis of an enzyme, ribonuclease.

With its molecular weight of 13,700, ribonuclease is the first "true" protein ever synthesized. All the proteins previously made—including insulin—weigh less than 10,000, and technically are only polypeptides.

Because of this achievement, a new path has been opened for studies of how enzymes function as catalysts in the living cell. For it will now be possible to modify experimentally the composition and structure of a complete enzyme, and therefore determine how it affects catalytic properties.

Using entirely different techniques, the two teams—Robert Merrifield and Bernd Gutte of Rockefeller, and Robert Denkwalter and Ralph Hirschmann of Merck, Sharp & Dohme—arrived almost simultaneously at the same results.

For Merrifield the synthesis is the culmination of almost 10 years' work, which began with the development of a revolutionary process—the solid-phase method—for assembling long chains of amino acids into protein molecules [SR, 25 Nov '68, 31]. Solid-phase synthesis uses an insoluble solid support, which acts as an anchor for the growing protein chain. The first amino acid is bound to a small polystyrene bead and each successive amino acid is added in a stepwise fashion. The entire procedure is automated.

Merrifield applied his solid-phase method—and assembled the twisting chain of 124 amino acids of ribonuclease by starting at one end of the chain and going straight through to the terminal point.

The Merck team, however, made their ribonuclease in solution by assembling many separately synthesized fragments of the enzyme. About five

years ago, Denkwalter and Hirschmann developed their own, highly efficient synthesis procedure—the N-Carboxyanhydride process (NCA). The NCA process permits the rapid synthesis of small polypeptide chains by drastically reducing the total number of protecting groups that are usually required in the synthesis of proteins.

Protecting groups are chemical modifiers that guard exposed parts of the growing protein molecule against unwanted reactions. In the synthesis of ribonuclease, the total number of these groups was restricted to 16, as opposed to the 55 required by classical procedures.

In both methods, the correct folding of the amino acid chain into a three-dimensional, pretzel-like structure occurred spontaneously after the chain was completed. This confirms the belief that information for the architectural design of ribonuclease is built-in; that is, the sequence of amino acids in the chain contains all the plans for chainfolding.

Until now there were serious doubts that Merrifield's novel scheme could

be applied to synthesizing molecules as large as the enzymes. It was believed that impurities might build too rapidly in his method. But Merrifield's success will make believers out of skeptics.

As recently as 10 years ago it was doubted that the synthesis of an enzyme by any laboratory method would ever be possible. However, protein chemists stubbornly picked away at the problems and during the past five years a dozen-or-so polypeptide hormones—including insulin—were artificially produced.

The next enzyme that might be synthesized is staphylococcal nuclease, which is very similar in function and appearance to ribonuclease. At the National Institute of Arthritis and Metabolic Diseases, David Ontjes, using the Merrifield scheme, has already synthesized one of the two chains making up nuclease, but he refuses to predict when a total synthesis will be accomplished.

Ribonuclease catalyzes the breakdown of ribonucleic acid (RNA), whereas nuclease catalyzes the breakdown of nucleic acid (DNA).

LATE NEWS

The MIT campus was thrown into an uproar last month over a falsely announced "research strike." The trouble began with these provocative words—"scientists should stop their work and discuss their problems"—in a meeting invitation to MIT faculty and scientists from the newly formed Union of Concerned Scientists. The meeting will be held March 4. A group of students took it upon themselves to announce that a "research strike" was being planned against MIT. The purpose of the meeting is to build up pressure on Washington to do less military research and more socially-oriented research.

Meanwhile, politically oriented dissent is boiling up in the American Physical Society again. At its meeting here next week, members will try to block Chicago as the site of next year's meeting and press for APS involvement in non-science issues affecting physicists.

Sen. Ted Kennedy will chair a new research subcommittee of the Senate Labor & Public Welfare Committee, with jurisdiction over NSF's budget.

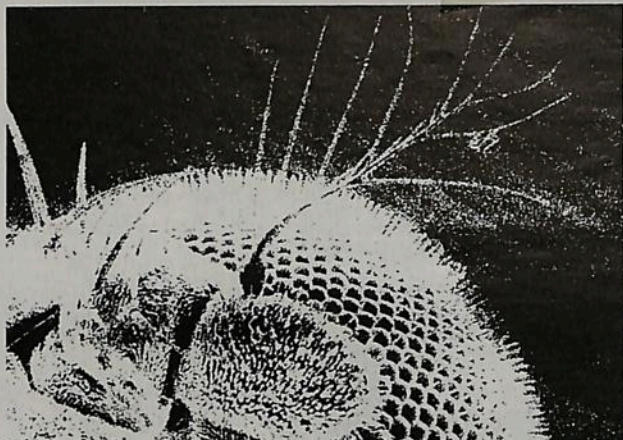
The New Yorker Nov. 21, 1977

59



"To recombinant DNA!"

• •



W. H. FREEMAN AND COMPANY
660 Market Street, San Francisco, CA 94104

An Introduction to Genetic Analysis

David T. Suzuki and Anthony J. F. Griffiths,
University of British Columbia

This concise, clearly written text for a one-semester or two-quarter introductory genetics course follows a broadly historical sequence, reflecting the authors' conviction that "a student begins much as biologists did at the turn of the century: asking general questions about the laws governing the inheritance of traits. Only when basic ground rules are established can we go on to pose questions about the next level of organization." By combining this emphasis on themes and organizing principles with a solid quantitative treatment, the book gives students a sound conceptual grasp of the full scope of classical and modern genetics.

All of the materials in *An Introduction to Genetic Analysis* have been thoroughly class-tested—this is a text written with the student in mind. The language throughout is conversational and undogmatic. Processes more easily understood visually—meiosis, mitosis, DNA replication, and RNA translation—are portrayed in flip-book animation sequences, allowing the student to see a "motion picture" of the processes. Each chapter includes a wide variety of exercises, ranging from the easy to the challenging, and none requires more mathematical background than high-school algebra.

"Well illustrated. Explains topics clearly and intelligibly. Gives students good feeling for methods in classical genetics and how geneticists think. A good balance between classical and molecular with a slight emphasis on the classical. Excellent problems."

—C. William Birky, Ohio State University

1976, 468 pages, 383 illustrations plus 209 pages of flip book animation, 0574-5, \$15.95 *An Answer Book is available.*

NEW

Available in Summer 1978:

Recombinant DNA

Readings from SCIENTIFIC AMERICAN

With Introductions by

David Freifelder, Brandeis University

This anthology is comprised of 13 articles selected and organized into sections by noted DNA researcher David Freifelder.

CONTENTS:

Basic Molecular Biology

Introduction

Nucleic Acids—Crick

How Cells Make Molecules—Allfrey/Mirsky

The Genetic Code: III—Crick

Ribosomes—Nomura

The Chemical Structure of Proteins—Stein/Moore

The Biological Basis of Genetic Manipulation

Introduction

The Recognition of DNA in Bacteria—Luria

The Molecule of Infectious Drug Resistance—Clowes

How Viruses Insert Their DNA into the DNA of the Host

Cell—Campbell

The Isolation of Genes—Brown

The Synthesis of DNA—Kornberg

RNA-Directed DNA Synthesis—Temin

The Manipulation of Genes—Cohen

The Controversy

Introduction

The Recombinant-DNA Debate—Grobstein

Epilogue

■ All articles are also available as separate offprints.

NEW Readings in Sociobiology

Edited by

T. H. Clutton-Brock, University of Cambridge, and
P. Harvey, University of Sussex, United Kingdom

The nineteen papers included in *Readings in Sociobiology*, some of them now difficult to obtain, present the most important theoretical contributions to the development of sociobiology and some of the more recent work which illustrates or elaborates those theories.

The four main sections deal with the levels of operation of natural selection, the concept of animals as mechanisms for gene replication, the evolutionary mechanisms favoring cooperative and disruptive behavior, and some attempted explanations of species differences in social behavior. Each section is preceded by an introduction that provides essential background for student readers. As a result, *Readings in Sociobiology* is not only an important source book for workers in the field who wish to return to the original papers; it is also a valuable supplement and inexpensive text for second and third year undergraduates in anthropology, animal behavior/ethology, ecology, population biology, and evolutionary studies.

Spring 1978, 0191-X, cloth \$18.00, 0190-1, paper \$9.00

CONTENTS:

Group Benefit or Individual Advantage?

Intergroup Selection in the Evolution of Social Systems.

Wynne-Edwards

Group Selection. Maynard Smith

The Evolution of Altruistic Behavior. Hamilton

Reproductive Strategies

On r - and K -Selection. Pianka

Parental Investment and Sexual Selection. Trivers

Parental Investment—A Prospective Analysis. Maynard Smith

On the Evolution of Mating Systems in Birds and Mammals.

Orians

Co-operation and Disruption

Geometry for the Selfish Herd. Hamilton

Kin Selection in Lions and in Evolution. Bertram

The Evolution of Alarm Calls. Maynard Smith

The Evolution of Reciprocal Altruism. Trivers

Reciprocal Altruism in Olive Baboons. Packer

Parent-Offspring Conflict. Trivers

Evolution and the Theory of Games. Maynard Smith

Assessment Strategy and the Evolution of Fighting Behavior.
Parker

Evolutionary Rules and Primate Societies

Clutton-Brock and Harvey

Comparative Social Behavior

The Ants. Wilson

The Significance of the Pair-bond and Sexual Selection

in Birds. Lack

Primate Ecology and Social Organization.

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Vernon Reynolds, University of Oxford

The Biology of Human Action demonstrates that the aggressive competitive nature of contemporary industrial society is not a biological fact of life, but, in reality, counter to the *physiological* needs of human beings. Society and physiology should harmonize. The evidence of stress-related diseases in today's society is evidence that they do not. This book points the way toward a new, cooperative, natural human society. This is thought-provoking reading for courses in social biology, anthropology, sociology, and psychology.

1976, 269 pages, 46 illustrations, 0494-3, paper \$6.95



British Museum, London

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The Principles and Practices of Statistics in Biological Research

Robert R. Sokal and F. James Rohlf,
State University of New York at Stony Brook

"I intend to adopt *Biometry* because of 1) the keys to the selection of statistical tests, 2) the tabulated algorithms [boxes], and 3) the emphasis on experimental design and application of statistics. . . . I am so impressed that *Biometry* is the superior text that I'm designing the course around it."

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—ASLIB Book List (U.K.)

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These tables comprise most of the material that the biologist, geologist, or social scientist needs to have when working with statistics. The tables offer greater convenience, breadth, and diversity than the tables usually included in textbooks of statistics or biometry. Each table is accompanied by an explanation of its nature and instructions for its use. An introductory section on interpolation precedes the main body of the tables.

1969, 253 pages, 5 illustrations, 0673-3, cloth \$12.00,
0664-4, paper \$6.00

Numerical Taxonomy

The Principles and Practice of Numerical Classification

Peter H. A. Sneath, The University of Leicester, and
Robert R. Sokal, State University of New York at Stony Brook

"This volume is an almost indispensable reference. It is remarkably detailed; the authors seemingly have considered every nuance of their subject and probably they have cited every significant paper ever published in the field. . . . The book thus constitutes a complete history of an authentic scientific movement—one that challenged the precepts of a major biological cherished beliefs."—W. R. Lockhart,
American Society of Microbiology News

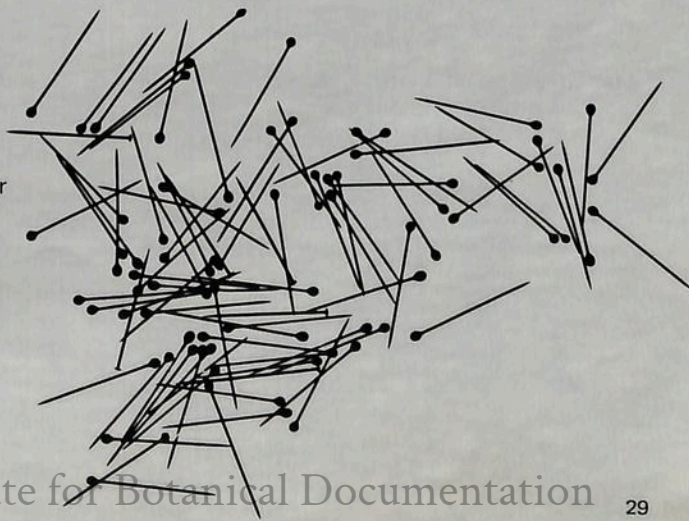
1973, 573 pages, 81 illustrations, 9 tables, 0697-0, \$27.00
(No complimentary copies; will be sent on approval only.)

Proceedings of the Eighth International Conference on Numerical Taxonomy

Edited by George F. Estabrook, University of Michigan

This volume contains the papers presented and ensuing discussions at the Eighth International Conference on Numerical Taxonomy, held at the Fundacao Calouste Gulbeukian, Oeiras, Portugal, in 1975. It offers a survey of research in quantitative systematics by the most active contributors to the field. The book is a valuable reference for students and professionals in the field of quantitative systematics and an essential acquisition for research libraries.

1976, 429 pages, 40 illustrations, 0555-9, \$16.00
(No complimentary copies; will be sent on approval only.)



A fascinating history of the development of our understanding of DNA structure

NEW

The DNA Molecule

Structure and Properties

Readings from Original Papers and a Historical Narrative

David Freifelder, Brandeis University

Noted DNA researcher David Freifelder has created a text that provides students with an insight into how scientific ideas evolve. This text is a unique combination of original papers that are effectively integrated with the author's narrative. The papers on DNA structure were organized into specific areas of research. Each section is prefaced by a narrative that provides factual information about DNA structure, relates the reaction of the scientific community, and discusses how the papers added to the understanding of DNA structure.

The DNA Molecule is a valuable supplement to courses on molecular biology, molecular genetics, and nucleic acids. The biochemistry student, the geneticist, or a student of molecular biology will understand this book without difficulty. For the beginner or those unfamiliar with molecular biology several appendixes were added that describe biological phenomena discussed in the text. Stimulating questions and a bibliography are included at the end of each section.

1977, 499 pages, 274 illustrations, 0287-8, cloth \$20.00, 0286-X, paper \$12.00

CONTENTS:

DNA: The Genetic Material

The History of the Identification of DNA as the Genetic Substance.

The Double Helix

The Elucidation of the Three-Dimensional Structure of DNA

The DNA of an Individual Phage or Bacterium as a Single Molecule

Methods of Isolating DNA

The Large Size of DNA Molecules

Measurement of the Molecular Weight of DNA.

Separation of the DNA Strands

DNA Denaturation

Factors Determining the Stability of DNA

Hydrophobic Forces in the DNA Molecule

Substructure of the Double Helix

Variants of the Basic DNA Model: Fine Points of Structure.

Naturally Occurring Single-Stranded DNA

The Phage ϕ X174 Experiments

Circular and Supercoiled DNA Molecules

The Discovery of Circular DNA

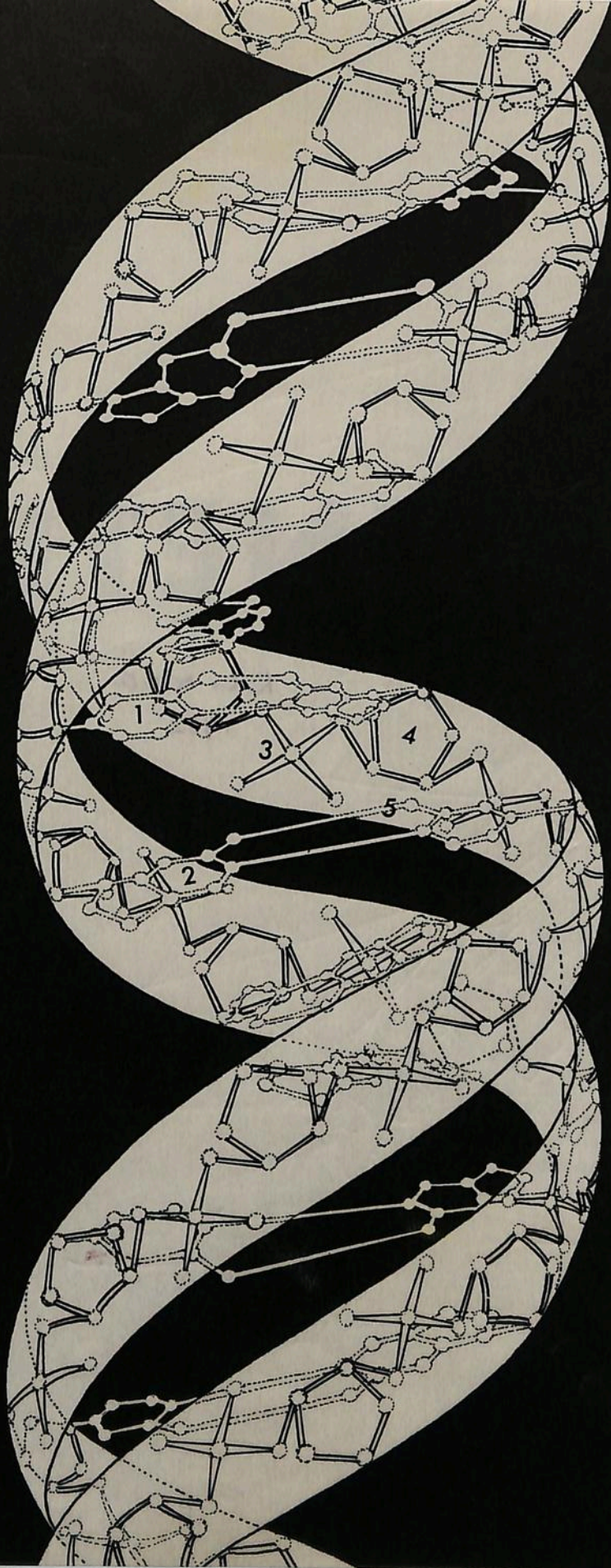
Epilogue

What Do We Know?



H. Delius and A. Worcel from *Journal of Molecular Biology*

The deoxyribonucleic acid double helix. The two ribbons represent two parallel polynucleotide chains coiled in right-handed helices about a common axis. The chains are held together by specific hydrogen bonds between opposite purines and pyrimidines. The distance between adjacent nucleotide pairs is 3.4 Å. The molecule may contain as many as 25,000 of these nucleotide pairs. Within the nucleus the DNA is intimately associated with a basic protein which presumably occupies the narrow groove between the nucleotide chains. Under this arrangement the phosphoric acid residues of DNA are neutralized by the basic amino acids of the histone. It has been suggested that template ribonucleoprotein chains can be synthesized within the wide groove of the DNA helix. 1, purine; 2, pyrimidine; 3, phosphoric acid residue; 4, deoxyribose; and 5, a hydrogen bond linking a purine and a pyrimidine.



Scientists Seek to Influence Legislation on Gene Research

By HAROLD M. SCHMECK Jr.

Special to The New York Times

WASHINGTON, July 4—Scientists and their organizations are making a strong effort to influence pending legislation under which the Federal Government would, for the first time, regulate an important field of basic biological research.

That field, recombinant DNA research or gene splicing, has aroused controversy and regulatory moves within the scientific community itself. There have been predictions of grave dangers as well as revolutionary benefits for mankind. A national debate has broadened to include fears for the genetic future of humans and the proposition, heretical to most scientists, that some questions of biology may be so freighted with danger that answers should not even be sought.

Nonetheless, some scientists fear the proposed legislation will set a precedent that ultimately may bring a large share of biological research under government regulation, and many more believe the proposed penalties might limit research of great potential value. Others prefer Federal regulation of this one field to exist at all in nature. Animal genes, for

In recombinant DNA research, genes of one species are spliced to the genetic material of a far different form of life a possible patchwork of local restrictions, to produce combinations that may not example, have been transplanted into bacteria. DNA (deoxyribonucleic acid) forms the genes and chromosomes of all living things—man and animals, insects, plants and microbes.

Years of Hot Debate

A hot debate over the propriety and safety of recombinant DNA research has been in progress for several years. When the gene splicing techniques were first shown to be possible, the scientists involved called a world moratorium on certain types of experiments because the potential dangers were so severe and knowledge was too limited to insure safety. That moratorium has been replaced by a set of strict guidelines published by the National Institutes of Health.

Bills presently before each house of

Congress would make the guidelines, or their equivalent, binding throughout the United States and would provide serious penalties for violations.

A bill sponsored by Senator Edward M. Kennedy, Democrat of Massachusetts, is expected to reach a Senate vote late this month. A bill sponsored by Representative Paul G. Rogers, Democrat of Florida, will probably come before the House later in the summer.

An effort on behalf of the Rogers bill, with modifications, is being mounted by the American Society for Microbiology. Officers of this scientific group say their effort is supported by the governing body of the largest biological research organization in the country, the Federation of American Societies for Experimental Biology, and by the governing bodies or chief officers of several other influential groups, including the American Institute of Biological Sciences, the National Society for Medical Research and the Association of American Medical Colleges.

Bills Differ on Monitoring

The Senate bill does not appear to have comparable backing from biologists' groups, but Senator Kennedy is a leader in health affairs in Congress, and bills that he sponsors in this field generally have a good chance of passage.

One major difference between the two bills is that the Senate version calls for a permanent national commission, with its chairman appointed by the President, to regulate and monitor all recombinant DNA research conducted in the United States. Proponents say this is necessary because of the importance of the subject and the need to give the regulatory agency enough power to regulate industry as well as academic research institutions.

The groups favoring the Rogers bill, which would give the regulatory task to a special advisory committee under the Secretary of Health, Education and Welfare, argue that a commission would entail an unnecessary bureaucracy and, in effect, would constitute expensive overkill.

The Kennedy bill has been approved by the Senate Human Resources Commit-

tee, but Senator Gaylord Nelson, Democrat of Wisconsin, is understood to be drafting a dissenting minority report. The House bill is still in the Commerce Committee.

Both bills would pre-empt state or local laws limiting recombinant DNA research, although localities could apply for exemptions if they were prepared to show that tighter regulations were needed.

Many scientists have campaigned for such Federal pre-emption on the ground that a patchwork of state and local prohibitions could stifle all research in this field.

Officers of the American Society for Microbiology and other scientists have criticized both bills' provisions for fines of as much as several thousand dollars a day for experimentation that flouts the guidelines. The scientists claim that this will make the research virtually uninsurable for universities, forcing them to halt their studies, and that industry will take its recombinant DNA research activities abroad.

The debate over recombinant DNA work has spread beyond the scientific community to include philosophers, theologians, industrialists, labor spokesmen and activists of many kinds.

Speculation on Risks and Benefits

The potential benefits predicted by some include important new food crops, new medicines and possible cures for some presently incurable diseases. Potential risks cited by others include plagues of altered viruses or germs attacking humans, animals and plants, as well as human genetic engineering for malevolent purposes.

All of these potential benefits and risks are subjects of speculation at present.

Writing on the current recombinant DNA debate in the July issue of Scientific American, Dr. Clifford Grobstein of the University of California at San Diego says the huge breadth of predictions, ranging almost from global disaster to the solving of global problems, simply demonstrates the great uncertainties that still exist concerning the potential of this type of research.

At a recent meeting of specialists in these studies, 137 scientists signed a statement urging Congress to avoid unnecessarily restrictive legislation that could deny to society the benefits of this kind of research. It was at a 1973 conference of this same annual series, called the Gordon Conferences, that scientists called for a moratorium on some recombinant DNA experiments.

Opponents of the research, including Dr. George Wald of Harvard, a Nobel Prize winner, have recently urged establishment of another and even more sweeping moratorium. Some critics have charged that continuation of the research would lead to Nazi-like efforts to warp the genetic endowment of the human race.

In sharp contrast to this charge, the National Board of Americans for Democratic Action, at a quarterly meeting here last week, passed a resolution warning that Government attempts to control free inquiry, including scientific research, have in the past presaged totalitarian oppression.

equipment, and to Dr. G. E. R. Deacon and the captain and officers of R.R.S. *Discovery II* for their part in making the observations.

¹Young, F. B., Gerrard, H., and Jevons, W., *Phil. Mag.*, 40, 149 (1920).

²Longuet-Higgins, M. S., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, 5, 285 (1949).

³Von Arx, W. S., Woods Hole Papers in Phys. Oceanog. Meteor., 11 (3) (1950).

⁴Ekman, V. W., *Arkiv. Mat. Astron. Fysik. (Stockholm)*, 2 (11) (1905).

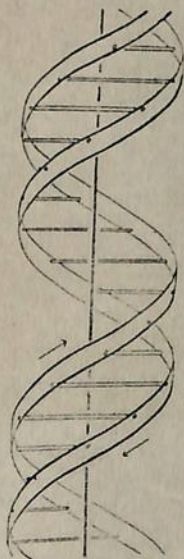
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey¹. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate-sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis.

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate di-ester groups joining β -D-deoxyribofuranose residues with 3',5' linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's² model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There

is a residue on each chain every 3.4 Å, in the z-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 Å. The distance of a phosphorus atom from the fibre axis is 10 Å. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical z-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally^{3,4} that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data^{5,6} on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. P. Wilkins, Dr. R. E. Franklin and their co-workers at

1962 NOBEL PRIZE WILKINS

WATSON CRICK

Michael Smith

F. SANGER

et al

1977

The First Complete Nucleotide Sequencing of an Organism's DNA

Sequence determination of the 5,386 nucleotides of the bacterial virus ϕ X174, which infects E. coli, has led to some unexpected discoveries about gene structure

"Even the smallest functional DNA varieties seen, those occurring in certain small phages, must contain something like 5,000 nucleotides in a row. We may, therefore, leave the task of reading the complete nucleotide sequence of a DNA to the 21st century, which will, however, have other worries."—*Progress in Nucleic Acid Research and Molecular Biology*, 1968

" ϕ X174 sequenced" —*Nature*, 1977

The lapse of only nine years between an informed and entirely reasonable estimate made in 1968 of the difficulties presented by the structure of the total DNA of an organism and the publication in 1977 (1) of the total sequence of the DNA of a bacterial virus—the bacteriophage ϕ X-174—which contains a circular chain of 5,386 nucleotides (Fig. 1), implies



Figure 1. The circular DNA molecule shown is the double-stranded form of ϕ X174; the strand on the left has looped back on itself. In this

electron micrograph, 1 millimeter of the DNA strand contains 38 nucleotides. (Electron micrograph courtesy of G. Nigel Godson.)

Dr. Smith is a Research Associate of the Medical Research Council of Canada and Professor at the University of British Columbia. In 1975-76 he spent an extended study leave, supported by the Medical Research Council of Canada, in the laboratory of Dr. F. Sanger, working on part of the sequence of ϕ X174 DNA. The research interests of his group include the development of simple methods for synthesis of oligodeoxyribonucleotides; the use of synthetic oligodeoxyribonucleotides in gene isolation, in DNA and RNA sequence determination, and in specific mutagenesis; the sequence of parvovirus and yeast DNA; the isolation of new restriction enzymes; and the developmental biochemistry of the salmonid testis. The author is indebted to Dr. Sanger for the hospitality and excitement of his laboratory and to Dr. G. N. Godson for discussions about the contents of this article. Address: Department of Biochemistry, Faculty of Medicine, Univ. of British Columbia, Vancouver, BC, Canada V6T 1W5.

entirely unpredicted technical advances. These advances represent beautiful examples of scientific detective work and ingenuity rather than the development of new and sophisticated machines. It is for this reason that this field of molecular biology—DNA-sequence determination—at present is one of the most intellectually and experimentally exciting areas of scientific endeavor.

In this article, I will discuss the basic principles of the new methods for DNA-sequence determination, the sequence of ϕ X174 DNA, the demonstration of overlapping genes in ϕ X174, and some of the implications of the ϕ X174 DNA sequence.

Methods for sequence determination

Readers of *American Scientist* will be familiar with the importance of bacterial "restriction" enzymes, which cleave DNA at specific short sequences, in the construction of recombinant DNA (B. D. Davis, September 1977). These enzymes are equally important to DNA-sequence determination, because they can be used to cut a large DNA molecule into precise and more manageable fragments. These fragments can be easily separated by electrophoresis in acrylamide or agarose gels, where their mobilities are inversely proportional to the logarithm of their

Jan. 1980

-2-

Recombinant DNA - A New Bill

Sen. Adlai E. Stevenson (D-Ill.) has announced he will introduce legislation to require everyone conducting recombinant DNA work of any kind (including research, production, or transportation) outside the NIH Guidelines to submit a description of those activities to the Secretary of HEW. This information will include the source of DNA, the host-vector system, level of physical containment, volume of growth media, and an outline of the experiment, plus any other information the Secretary requests. Proprietary data will be kept secret unless the Secretary determines that the work is so risky that disclosure is necessary to protect the public and/or the environment.

The draft bill, entitled the "Recombinant DNA Research Notification Act," carries a penalty of \$5,000 a day for failure to inform HEW of the research, but no penalties for falsification of information, failure to obtain HEW approval (now a voluntary step), or conducting hazardous activities. Presumably disclosure of the danger with the attendant publicity would force discontinuation of dangerous work; otherwise the offender would have to be prosecuted under another law.

In a letter to HEW Secretary Patricia Harris, Stevenson expressed concern that the relaxation of the NIH Guidelines had been premature. A proposed rulemaking in the 30 November *Federal Register* reduces the containment requirements for *E. coli* K-12 host-vector systems to P1, the lowest level. Stevenson asked why NIH had not waited until certain risk assessment studies had been completed.

The regulation also provides for voluntary registration with HEW of recombinant DNA activities by institutions not subject to the Guidelines. Such voluntary compliance, wrote Stevenson, is "seriously flawed." Although the senator recognizes that most firms are complying voluntarily with the Guidelines, he believes a law with teeth to force registration is needed. However, he does not want to promote legislation that would impede development of recombinant DNA products with commercial potential, Steve Merrill, a staff member of Stevenson's Subcommittee on Science, Technology, and Space, explained. Stevenson also questioned whether NIH had had sufficient experience to judge whether local institutional review committees actually were maintaining safe laboratory practices.

An oversight hearing is scheduled for 30 January before the Stevenson subcommittee. At that time the senator will press NIH officials for answers to his questions if he has not received a reply from Harris. He also expects to initiate discussion on the patentability of recombinant DNA techniques and products, the competitive position of the United States in this field, and

the effects of regulation, even voluntary compliance, on this promising new industry.

Jurisdiction for DNA legislation does not lie with the Stevenson subcommittee, but rather with Sen. Edward M. Kennedy's Health Subcommittee. The Kennedy staff has not expressed much interest in Stevenson's bill, and on the House side Rep. Henry Waxman's Subcommittee on Health is only mildly interested.

Forum readers wishing to comment on the proposed bill may address letters to Sen. Stevenson, Committee on Commerce, Science, and Transportation, 5202 DSOB, Washington, DC 20510.

"GENETIC ENGINEERING"

THE PHILOSOPHY OF
BIOLOGY

Michael Ruse

Associate Professor of Philosophy
in the University of Guelph, Ontario



HUTCHINSON UNIVERSITY LIBRARY
LONDON

1973

presence. Proteins are polypeptide chains or combinations of such chains, and these in turn are long, string-like molecules made up of literally hundreds of links—each link being an amino acid. Since proteins play so ubiquitous a role in the cell and since they have so many parts, it might seem to be a task beyond human ability to bring even a semblance of understanding to the molecular level of the cell, and hence, to the problems of heredity. However, formidable though the task may be, there are some guides for reason. The chief one at this point is that although there are so many different proteins, each performing such different tasks, the types of amino acid building block are restricted to twenty. It would seem therefore that any difference in protein is a function of a difference in amino acid order. Using this fact as a key, one can now start to unlock some of the molecular secrets of the cell, and one can build up a very detailed molecular theory of genetics.

First, one must locate within the cell the templates which can serve both for the manufacture of fresh supplies of protein and for reproducing themselves, thus passing on to new cells the information required for protein synthesis. It turns out that these templates are not themselves proteins, but are instead nucleic acids. There are two kinds of nucleic acid, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), and since it is usually the former which is the ultimate carrier of genetic information, let us take a close look at it.

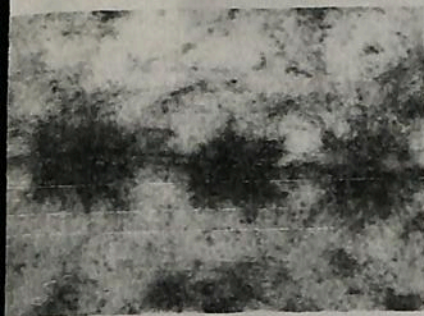
In large organisms DNA is to be found in the chromosomes; but some small organisms dispense with chromosomes and the nucleic acid is to be found on its own within the organism's shell. It is another of the long macromolecules which are so prevalent in the cell, being a polymer of deoxyribose sugars joined by phosphate links. To each sugar is attached, as side chain, a nitrogen-containing base which must be one of four kinds, either adenine or guanine (purines) or thymine or cytosine (pyrimidines). (The bases, together with the sugars and phosphates, are called 'nucleotides'.) The DNA molecule is normally paired, and the two molecules are twisted around each other to form a helix. One finds that adenine on one molecule pairs with thymine on the other, and guanine pairs with cytosine, and it is believed that it is in the order of these four bases along the DNA molecule that is carried the information required to make new proteins.

Now, as we have seen, DNA must do two jobs. The first task is that of replication, so that its information can be passed on to new cells. In order for this to happen the two strands of DNA in a helix start to come apart, and then, with the aid of enzymes, complementary nucleotides line up against the nucleotides of the unzipped single strands of DNA. Thus the precise order of the nucleotides is passed

on to a new DNA strand, although obviously the new strand is the complement of the old strand and it must therefore duplicate itself before one gets a DNA strand identical to the first strand. The second task of DNA is to make proteins—it does not do this directly but via an intermediary, RNA. RNA is like DNA in that it is a long strand of nucleotides, but where DNA has thymine, RNA has uracil. There seem to be three types of RNA, all with different functions within the cell: messenger RNA (mRNA), ribosome RNA (rRNA), and soluble or transfer RNA (sRNA or tRNA). All three types are copied off DNA in much the same way as DNA replicates itself, except that a different enzyme is involved, and obviously uracil (not thymine) pairs with adenine. The rRNA molecules, together with some proteins, go to form the ribosomes, which in turn serve as the sites of protein synthesis within the cell. The mRNA travels from the nucleus to the ribosomes, carrying with it the information needed for the synthesis of different proteins. Finally, the sRNA picks up free amino acids within the cell, bringing them over to the ribosomes, where they can be lined up in appropriate order against the mRNA, joined and cast off as completed polypeptide chains. Thus one gets the all-important synthesis of proteins.

Clearly, this is but a sketch of DNA replication and of protein synthesis. Necessarily many important steps have been omitted. One omission which must be remedied arises from the fact that proteins consist of twenty amino acids, but that RNA (like DNA) carries but four different nucleotides. This means that there cannot be a 1-1 correspondence between the nucleotides of mRNA and the amino acids of proteins. It is suggested that three nucleotides code for an amino acid, and since there are 4^3 possible different triplets of ordered nucleotides, it is also suggested that many of the triplets are degenerate (i.e. code for the same amino acid) and that other triplets make no sense at all (i.e. do not code for any acids). Recently, molecular biologists have made great advances in finding exactly which triplets code for which amino acids.

So far in the discussion we have assumed that everything always goes according to plan—however, even in the molecular world things can go wrong, and so let us now see how normal protein synthesis might be disrupted. The most obvious place at which trouble could start is on the DNA molecule—if something happens here then not only is it liable to be reflected right through to the proteins of the present cell, but also it is likely to be passed on to new cells as well. Three types of alterations to the DNA information chain seem possible—nucleotides might be added to the chain, they might be eliminated, and the original nucleotides might be altered. It would appear that all three of these types of changes occur; however,



(a) 0.25 μ m



(b) 0.1 μ m

5-25

Junctions between cells. (a) Desmosomes cement cells to adjoining cells. Here three desmosomes connect the cell membranes of two adjacent skin cells of a salamander larva. (b) Tight junction (arrow) seals the spaces between cells. A desmosome is visi-

Table 5-2 Comparison of Prokaryotic, Animal, and Plant Cells

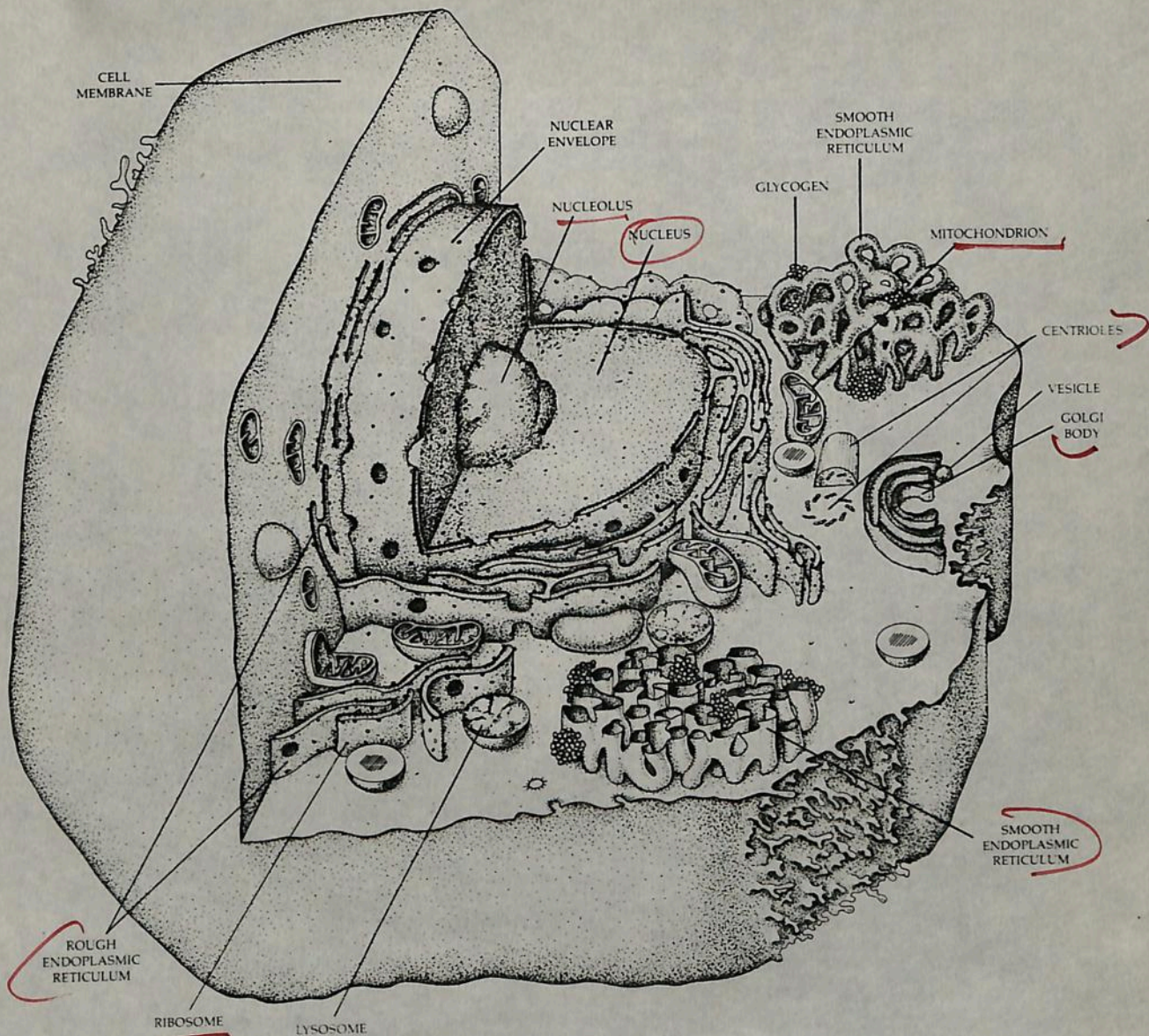
	PROKARYOTE	ANIMAL	PLANT	FUNGUS
Cell membrane	Present	Present	Present	
Cell wall	Present (noncellulose polysaccharide plus protein)	Absent	Present (cellulose)	
Nucleus	No nuclear envelope	Surrounded by nuclear envelope	Surrounded by nuclear envelope	
Chromosomes	Single, containing only DNA	Multiple, containing DNA and protein	Multiple, containing DNA and protein	
Endoplasmic reticulum	Absent	Usually present	Usually present	
Mitochondria	Absent	Present	Present	
Plastids	Absent	Absent	Present in many cell types; chloroplasts in photosynthetic cells	
Ribosomes	Present (smaller)	Present	Present	
Golgi bodies	Absent	Present	Present	
Lysosomes	Absent	Often present	Usually absent	
Vacuoles	Absent	Small or absent	Usually large single vacuole in mature cell	
9 + 2 cilia or flagella	Absent	Often present	Absent (in higher plants)	
Centrioles	Absent	Present	Absent (in higher plants)	

Cell-Cell Junctions

Three functional types of junctions between animal cells can now be distinguished by the electron microscope: (1) junctions that hold together adjacent cells in a tissue; these are called *desmosomes*; (2) junctions between cells that keep materials from leaking through tissues; these are called *tight junctions*; and (3) junctions through which cells can exchange nutrient molecules and molecular communications; these are called *gap junctions*.

Desmosomes have often been compared to spot welds between cells. They consist of plaques of dense fibrous material between cells with clusters of filaments from the cytoplasm of the neighboring cells looping in and out of them. They attach cells to one another and give tissues mechanical strength. They are found in especially large numbers in tissues subjected to severe mechanical stress, such as the skin.

Tight junctions form a continuous ring around each cell in a layer of tissue, preventing leakage between cells. For example, intestinal epithelial cells are surrounded by tight junctions that keep the intestinal contents from seeping between



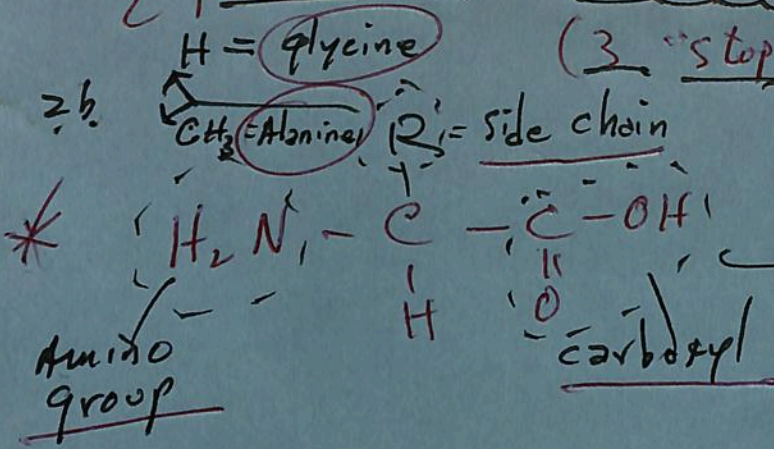
5-7

An animal cell, as interpreted from electron micrographs. Like all cells, this one is bounded by an outer cell membrane, which acts as a selectively permeable barrier to the surrounding environment. All materials that enter or leave the cell, including food, wastes, and chemical messages must pass through this barrier. Within the

subdivided by an elaborate system of membranes, the endoplasmic reticulum. In some areas, the endoplasmic reticulum is covered with ribosomes, the special structures on which amino acids are assembled into proteins. Ribosomes are also found free in the cytoplasm. Golgi bodies are packaging centers for molecules synthesized within the

surrounded by a double membrane, the nuclear envelope, which is continuous with the endoplasmic reticulum. Within the nuclear envelope is a nucleolus, the site where the ribosomes are formed, and the chromatin, which is the material of the chromosomes in an extended form. These cellular structures are all described in further de-

gene = segment of DNA $4^3 = 64$ triplets (= CODONS) of nucleotides
 DNA → 64 triplets (= CODONS) of nucleotides
 Genetic code 61 specify amino acids [20]
 (3 "stops" - terminate chain)
 ∴ 3 NUCLEOTIDES CODE 1 amino acid



Amino Acids
 ↓
 PROTEINS

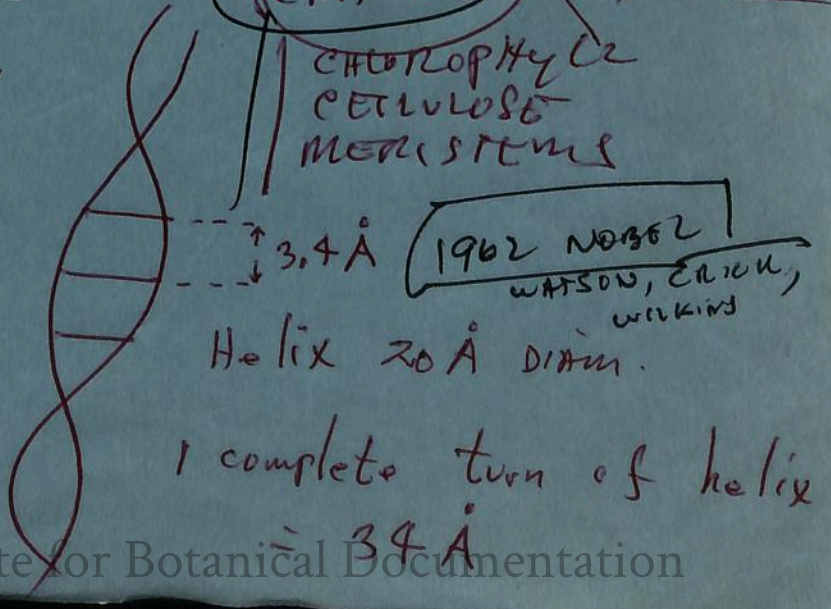
1st complete nucleotide sequence for Bacteriophage ϕ X174 (5,375)
 1977 - Sanger [England] (Phi) etc.
 CHROMOSOMES
 ↓
 DNA + PROTEIN

cell nucleus - Brown - 1831 (Eng.)
 cell theory - Schleiden / Schwann
 1838 plants 1839 Animals
 "cell" - R. Hooke - 1665

$\text{CO}(\text{NH}_2)_2$ - urea
 1828 - WOHLER
 at synthesis

CRITERIA
 CHLOROPLAST
 CELLULOSE
 MERISTEMS

"HOT, DILUTE SOUP"
 PLANT → PHOTOSYNTHESIS
 ANIMAL → INGESTION
 FUNGUS → ABSORPTION
 MONERA PROTISTA → +3



RNA in cytoplasm & nucleus.

Chemistry of chromosomes

Chromosomes isolated from bacterial & eukaryotic and analyzed.

Major substance: NUCLEOPROTEIN

PROTEIN + DEOXYRIBONUCLEIC ACID

4 repeating

1-one-chain DNA molecule composed of 5 N smaller units called NUCLEOTIDES

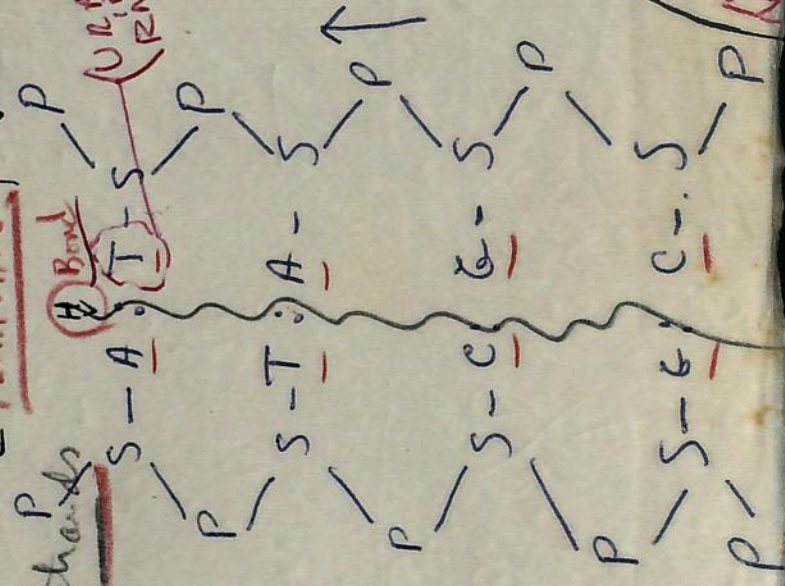
DNA The carrier of primary genetic information in all organisms

except VIRUSES

1953 - Watson & Crick is model of DNA - a double-stranded helix w. 2 polynucleotide strands bonded to purine & pyrimidine base.

James Watson & Crick is model of DNA - a double-stranded helix w. 2 polynucleotide strands bonded to purine & pyrimidine base.

Complementary strands



Direction of chain determined by sugar linkages

SEQUENCES VITAL

Replication

- 1) 5-carbon sugar
- 2) Phosphate acid
- 3) Purine or Pyrimidine ring
 - ADENINE GUANINE = Base
 - THYMINE CYTOSINE

HALL TIGERS GRAD CATS (MNE MOUSYNE)

bonded to purine & pyrimidine base.

- P = Phosphate
- S = Deoxyribose 5-C Sugar
- A = Adenine (Purine)
- G = Guanine (Purine)
- T = Thymine (Pyrimidine)
- C = Cytosine (Pyrimidine)

∴ = H bond

1 gene → 1 Polypeptide chain
Beadle, Tatum, Lederberg
 1958 NOBEL (1-32-33. Beadle)

between 5000 and 125,000. It seems unlikely that the true number of genes in man could be as few as 100 or less, or as many as several million.

35.5

The Genetic Code

The Watson-Crick model of the DNA molecule implied that genetic information is transmitted by some specific sequence of its constituent nucleotides. Since there are only four types of nucleotides—A, T, G and C—in the DNA and 20 or more kinds of amino acids in a peptide chain, it was obvious that there could not be a one-to-one correlation between nucleotide and amino acid in the coding process. If the code involved two nucleotides to specify an amino acid, the various combinations of four symbols taken two at a time would provide only 16 different combinations; again, this is not enough to account for the 20 or more different types of amino acids.

A triplet code of three nucleotides for each amino acid would permit 64 different combinations of four nucleotides taken three at a time. At first glance this would seem to provide for many more code symbols than are actually needed; however, experiments have shown that the code is "degenerate" and each amino

acid may be specified by two to as many as six different triplets.

The fundamental characteristics of the genetic code of RNA are now well established: It is a triplet code with three adjacent nucleotide bases, termed a codon, specifying each amino acid (Table 35.4). Adjacent codons do not overlap; they do not share a given base. Each single base is part of only one codon. *The genetic code appears to be universal*; that is, the codons in the DNA and RNA specify the same amino acid in all the organisms that have been studied, from viruses to man.

Early in 1961 Crick postulated that three consecutive nucleotides in a strand of messenger RNA provide the code that determines the position of a single amino acid in a polypeptide chain. Experimental evidence to support this was quickly forthcoming from experiments of Nirenberg and Matthaei regarding the incorporation of specific labeled amino acids into protein by purified enzyme systems under the direction of artificial messenger RNA's of known composition.

Nirenberg used a synthetic polyuridylic acid (UUUUU ...)—prepared by using the enzyme polynucleotide phosphorylase—as messenger and found that phenylalanine was incorporated into protein. The addition of poly U to a ribosomal protein synthesizing system led to the production of a polypeptide

Table 35.4 The Genetic Code: The Sequence of Nucleotides in the Triplet Codons of Messenger RNA Which Specify a Given Amino Acid

First Position (5' end)	Second Position	Third Position (3' end)			
		U	C	A	G
U	U	Phe	Phe	Leu	Leu
	C	Ser	Ser	Ser	Ser
	A	Tyr	Tyr	Nonsense	Nonsense
	G	Cys	Cys	Try	Try
C	U	Leu	Leu	Leu	Leu
	C	Pro	Pro	Pro	Pro
	A	His	His	Glu-NH ₂	Glu-NH ₂
	G	Arg	Arg	Arg	Arg
A	U	Ileu	Ileu	Met	Met
	C	Thr	Thr	Thr	Thr
	A	Asp-NH ₂	Asp-NH ₂	Lys	Lys
	G	Ser	Ser	Arg	Arg
G	U	Val	Val	Val	Val
	C	Ala	Ala	Ala	Ala
	A	Asp	Asp	Glu	Glu
	G	Gly	Gly	Gly	Gly

gene a segment of DNA, ENZYMES

→ determines amino acid sequence of proteins.

nucleus { (1) Nucleotide triplet codes for 1 amino acid. CODON
 (2) DNA (triplet) transcription → messenger RNA

3) mRNA → Ribosomes (cytoplasm) → tRNA Transfer

4) tRNA a link bet. DNA nucleotides and amino acid sequences

ORGANELLES of PROTEIN NUCLEUS chromosomes etc. AVERAGE mol. wt. ≈ 120

* (1) Ribosomes (organelle) formed in nucleolus 10³/cell cytoplasm. Amino acid ASSEMBLY SITES (in sequence)

(2) Golgi Bodies Glycoproteins LIPO PROTEINS transported to cell membranes

* (3) Endoplasmic Reticulum PROTEIN SYNTHESIS is "rough" with ribosomes

* (4) Mitochondria ATP PRODUCTION ENERGY CENTER

* (5) ENZYMES enzymatic proteins - ubiquitous SPECIFIC

(6) VACUOLES (plants) (amino acid chains)

CELL THEORY

HOOKE - 1665 - cork etc.
BROWN - 1831 - NUCLEUS

Leeuwenhoek
 ← 1683 →

SCHLEIDEN - 1838 - Plants
SCHWANN - 1839 - Animals
VIRCHOW - 1858 - cells from other cells

VON MÖHL - 1846
PROTODPLASMA

"MITOSIS" - FLEMMING 1882 "omnis de..."

"CHROMOSOME" - WALDEYER 1888

GOLGI - 1909
PLANT - AMMIBIA - FUNGUS

Cell wall - mic. lamella (pectins)
membrane CHO

CYTOPLASM

Nucleus

Organelles

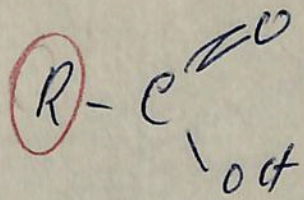
TEM
SEM

fine structure
 etc.

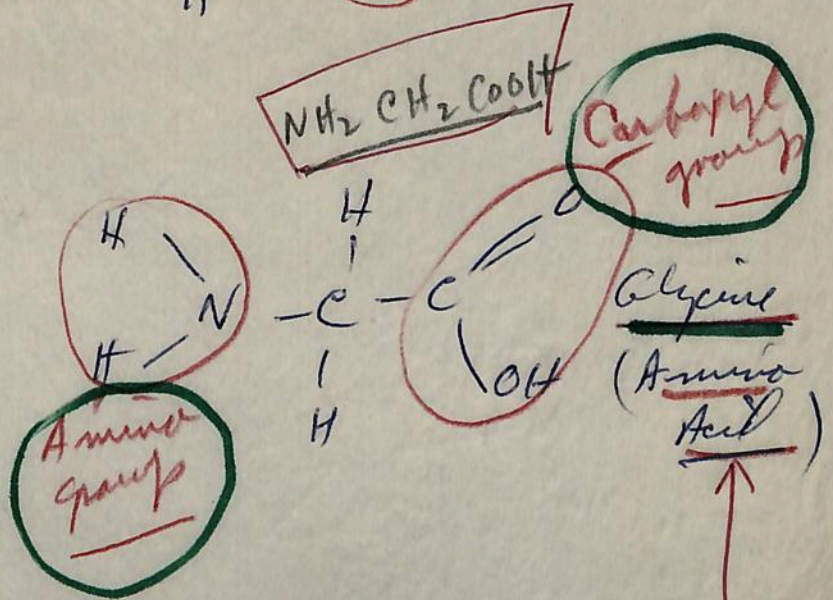
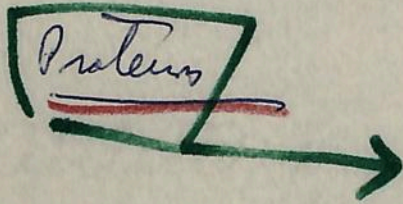
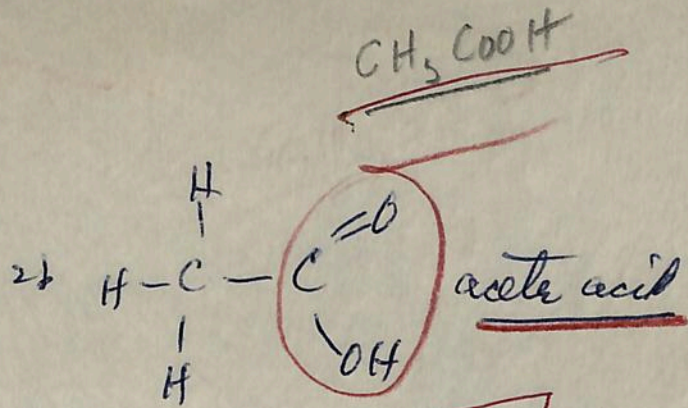
PROKARYOTES - MONERA - BACTERIA
B-G ALGAE

EUKARYOTES - PROTISTA - UNICELLULAR "plants/Animals"

Fatty Acids:



Fatty Acid



(empirical vs structural formulae)

10 Elements needed for normal plant growth:
C, H, O, P, K, N, S, Ca, Fe, Mg } Al, Cl, Na, Si also
 Molybdenum

6 Trace elements needed: B, Co, Cu, Mo, Mn, Zn

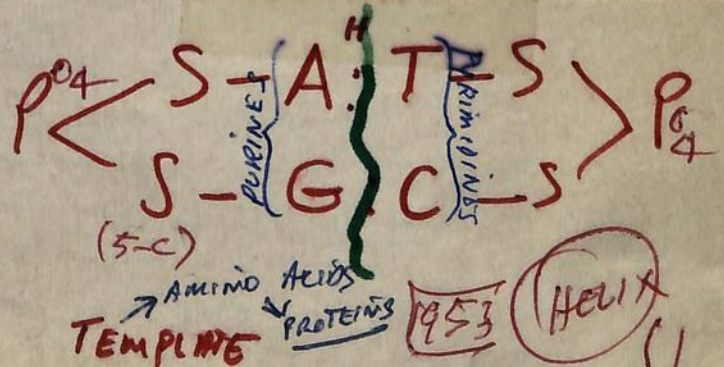
Toxic if too concentrated.

GENETIC CODE

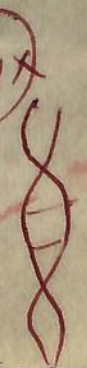
ADENINE
GUANINE
THYMINE
CYTOSINE

± 25,000 NUCLEOTIDE PAIRS

Distance bet. PAIRS (nucleotides)
3.4 Å



25,000 PAIRED BASES
 POLYNUCLEOTIDE STRANDS
 WATSON & CRICK 1953



Number of paired nucleotide bases
in 46 chromosomes (Homo) \pm 5×10^9 !

> In ϕ X174 (bacteriophage) it is 5,386 (~~5,386~~ ^{AA} ~~71~~).

(F. SANGER) (1977).
et al

16-13

The genetic code, consisting of 64 triplet combinations (codons) and their corresponding amino acids (see page 62). Since 61 triplets code 20 amino acids, there are "synonyms," as many as six for leucine, for example. Most of the synonyms, as you can see, differ only in the third nucleotide. Of the 64 codons, only 61 specify particular amino acids. The other three codons are stop signals, which cause the chain to terminate. The code is shown here as it would appear in the mRNA molecule.

		SECOND LETTER					
		C		A		G	
FIRST LETTER (5' END)	U	UUU } phe	UCU }	UAU } tyr	UGU } cys	U	
		UUC }	UCC } ser	UAC }	UGC }	C	
		UUA } leu	LCA }	UAA } stop	UGA } stop	A	
		UUG }	UCG }	UAG } stop	UGG } trp	G	
	C	CUU }	CCU }	CAU } his	CCU }	U	
		CUC } leu	CCC } pro	CAC }	CCG } arg	C	
		CUA }	CCA }	CAA } gln	CGA }	A	
		CUG }	CCG }	CAG }	CGG }	G	
	A	AUU }	ACU }	AAU } asn	AGU } ser	U	
		AUC } ile	ACC } thr	AAC }	AGC }	C	
		AUA }	ACA }	AAA } lys	AGA } arg	A	
		AUG } met	ACG }	AAG }	AGG }	G	
	G	GUU } val	GCU } ala	GAU } asp	GGU }	U	
		GUC }	GCC }	GAC }	GCC } gly	C	
		GUA }	GCA }	GAA } glu	GGA }	A	
		GUG }	GCG }	GAG }	GGG }	G	

Of the 64 possible triplet combinations, 61 of them specify particular amino acids. With 61 combinations coding for 20 amino acids, you can see that there must be more than one codon for many of the amino acids. As shown in Figure 16-13, codons specifying the same amino acid often differ only in the third nucleotide, leading to the speculation that the first two may be sufficient to hold the tRNA in most instances.

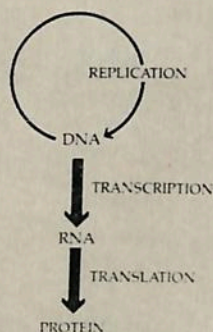
Hemoglobin Reexamined

Some of the biological implications of these findings are strikingly clear. Let us take another look at sickle cell anemia, for example, in the light of Figure 16-13. Normal hemoglobin contains glutamic acid; sickle cell hemoglobin contains valine. In mRNA, GAA or GAG specifies glutamic acid (glu), and GUU, GUC, GUA, or GUG specifies valine (val). So the difference between the two is merely the replacement of one adenine by one uracil in a molecule that, since it dictates a protein that contains more than 150 amino acids, must contain more than 450 bases. In other words, the tremendous functional difference—literally a matter of life and death—can be traced to a single "misprint" in over 450 nucleotides.

Punctuation

The genetic material, the DNA, is undifferentiated in form, being an enormously long sequence of nucleotides. Yet the information it contains is compartmentalized in the units we call genes. How is this accomplished? In a written language, punctuation takes the form of special symbols, such as spaces between words and a

A representation of the information flow from DNA to protein.



SUMMARY

Genetic information is coded in molecules of DNA, and these, in turn, determine the sequence of amino acids in molecules of protein. A gene is a segment of a DNA molecule that specifies the complete sequence of one polypeptide.

The way in which the gene directs the production of a protein, according to current theory, is as follows. Each series of three nucleotides along a DNA strand is the DNA code for a particular amino acid. The information is transcribed from the DNA to a long, single strand of RNA (ribonucleic acid). This type of RNA molecule is known as messenger RNA, or mRNA. The mRNA forms along one of the strands of DNA, following the principles of base pairing first suggested by Watson and Crick. The mRNA therefore is complementary to the DNA strand.

The mRNA strand leaves the cell's nucleus and becomes attached to a ribosome. At the point where the strand of mRNA is in contact with the ribosome, small molecules of another type of RNA, known as transfer RNA (tRNA), which serve as adapters between the mRNA and the amino acids, are bound temporarily to the mRNA strand. This bonding takes place by complementary base pairing between the mRNA codon and the tRNA anticodon. Each tRNA molecule carries the specific amino acid called for by the mRNA codon to which the tRNA attaches. Thus, following the sequence originally dictated by the DNA, the amino acid units are brought into line one by one and are formed into a polypeptide chain.

RNA ← cytoplasm

1) URACIL replaces Thymine (Pyrimidine)

2) Ribose " Deoxyribose
(OH) (H)

3) Single stranded

DEOXYRIBONUCLEIC ACID

Composition:

4 repeating units called nucleotides (Poly-)

ultimate form of genes = alleles

poly Nucleotides composed of:

± 10,000 kinds

genes in man

Bases

- 1) 5-C sugar (Deoxyribose)
- 2) Phosphate (Phosphoric Acid)
- 3) 2 Purines (Nitrogen)
 - Adenine
 - Guanine
- 4) 2 Pyrimidines (Nitrogen)
 - Cytosine
 - Thymine*

Form Pairs ± 25,000 pairs per molecule

URACIL IN RNA

Each molecule made up of 2 intertwined strands; The sequence of bases in 1 strand determines the sequence of bases in the other.

The base sequences serves as a hereditary code, such as observed in α organisms. Each strand is able to replicate its partner; strand I directs the synthesis of strand II, & v.v. Each strand maintains its physical integrity during replication.

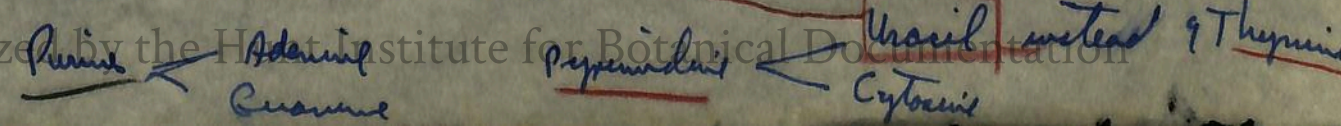
In nucleus + cytoplasm

Protein Synthesis

RNA, the 2nd major polynucleotide of living material.

- 1) 5-C sugar (Ribose)
- 2) Phosphate (same as DNA)

(BASES)



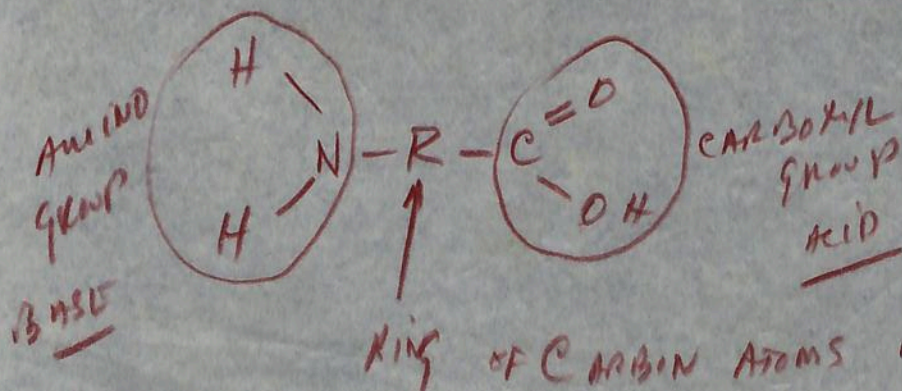
How DNA acts. Direct Translation Hypothesis

DNA a template against which proteins are built
from their amino acids, in amino acid sequence
determined by specific fitting into template

Analogy with dots & dashes translated into alphabetic
message.

But RNA (Ribonucleic Acid) must be considered,
since some plant & animal viruses have no DNA,
only RNA! (v protein)

1 Gene → 1 Enzyme



AMINO ACIDS (23)

Molecular biology

- 1) Conventional knowledge about cell
- nucleus
 - cytoplasm
 - cell wall
 - membrane
- etc. Plant
animal
fungus
- what shall a zygote develop
into — man or mouse?

Cell contains the answer: a blueprint + instructions

The instruction manual = genetic material [chromosomes in nucleus]
which is unique because: it can replicate itself.

- 1) All living things made of cells.
- 2) All cells have standard components.
- 3) Nucleus made up of genes.
- 4) Genes unique := DNA.
- 5) DNA contains coded information needed to construct the individual.

6) Composition of DNA: long chain molecule (finite)
with 4 kinds of links. A-T-G-C

The sequence of the links "spells out"

different words.

ie

A-T
C-C
C-G
T-A

7) DNA replicates itself: because it is a twin molecule,

of 2 helical strands, each composed of A-T-G-C.

is a "molecular barbed pole"

The strands are complimentary - ie the sequence

of letters in one strand determines the sequence

of letters in the twin strand. (A-T) (G-C)

when strands replicate, they first separate & each re-assembles a new strand from cell

2) How do DNA strands "know" when to replicate?

1) Each cell has a genetically controlled enzymes

For each enzyme, a gene which "instructs"
cell to make that enzyme.

Estimated 10,000 kinds of enzymes in "typical cell", means there must be same number of genes.
ie 1 gene : 1 enzyme

Analyze enzyme:

- 1) All are protein
- 2) All composed of (20) amino acids [building blocks]
- 3) Enzyme molecule contains hundreds of amino acids, linked in a chain. The sequence of the amino acids determines the kind of enzyme

How are enzymes made in a cell?

Mitochondria are centers for making enzymes.
Nucleic acid of mitochondria is RNA, which
 can make enzymes, but DNA cannot.

Still, DNA replicates itself, RNA does not.

But DNA makes the mitochondrial RNA. [How,
is unknown]

∴ RNA originates in cell nucleus and is transferred
to cytoplasm, where it makes enzymes.

DNA originates from previous DNA in cell,
 but origin of first DNA is really the question
 about the origin of LIFE. Perhaps DNA THE
FIRST LIVING THING ON EARTH. } (HOT, DILUTE SOUP)

MUTATION v DNA → NEW INFORMATION

IN THE CODE — THIS ALSO REPLICATED

DNA THE MASTER KEY TO THE CONTROL
OF THE DEVELOPMENT OF LIVING THING

— CONTROL OF EVOLUTION

THE MESSAGES OF LIFE

by
James Bonner

Biology is today on the edge of understanding how living things live. This almost-successful search for the principle, the logic, of life may someday enable us to control the step-by-step development of the human organism, to cultivate replacement organs and perhaps even to initiate life in isolated cells. A whole new world of medicine also awaits us across this threshold of understanding; among the most urgent problems which may yield to the new knowledge are the control of virus diseases and of cancer.

This new biolog--for it is a new branching of an old discipline-- is largely concerned with the molecular facts of life. One of the most complicated mysteries of nature is the way the tens of thousands of chemical compounds that compose a living creature work together to cause that creature to breath, digest and leave descendants. But this mystery is being unraveled. Every day now brings new excitement as research biologists draw close to its final solution. For they have discovered that each cell of each individual contains a blueprint, and instruction manual, which gives the cell detailed instructions on what kind of chemicals to make from the available food, on how the cell shall divide or replicate itself, on the size and shape of the systems it shall form (that is, elephant or mouse)--in short, how the cell should become a part of a particular kind of living thing.

This cellular instruction manual, which biologists call "genetic material," possesses the extraordinary power of being able to print copies of itself. These copies are then passed on to the next generation. ✓

In this way living things leave their descendants directions on how to look, how to behave, how to be. The new biology seeks to read this genetic book and to find out what kinds of instructions it transmits, how the genetic information multiplies itself, how it acts, how it enforces its decrees.

The gateway to this new understanding of the basic life pattern has been found in the study of the living cell. All creatures consist of cells and have in common cells which are very much alike. All cells are made of various standardized types of components. Living creatures may, in fact, be looked upon as a series of models made of a kind of tinkertoy, with standard interchangeable parts. For example, the largest and most spectacular part of every proper cell is a nucleus. This nucleus contains the genetic material, the chromosomes, each made up of many genes. The genes are made of a special gene substance found nowhere else-- deoxyribonucleic acid, known to biologists as DNA. The DNA of the nucleus contains, in coded form, all the information required to assemble the individual cell--and indeed, to assemble all the cells comprising an entire organ.

That DNA contains--and transmits-- genetic information, was first shown by O. T. Avery at the Rockefeller Institute more than fifteen years ago. His experiment consisted of the transplantation of genetic information from one type of bacterial cell to another. The laboratory transplantation of such genetic information requires only that a portion of the DNA of the donor cell be placed in solution, together with some of the receptor cells. The receptor cells, in a fraction of cases, incorporate the alien DNA into their own genetic complement so that it becomes a permanent part of their genetic information. In this way genes for

resistance or susceptibility to an antibiotic, or for ability or inability to cause disease--such as pneumonia, with which Avery worked--may be transferred from one strain of bacteria to another.

① DNA has two characteristics which suit it uniquely to its role of information bearer. The first is a structure so arranged that it can carry information. The DNA molecule is a long chain, made up of four kinds of links, or building blocks, whose chemical names we can symbolize by the four letters, A, T, G and C. The four links may succeed one another in any of many permutations and combinations to produce many different words, all written in a four-letter alphabet, the alphabet of A, T, G and C. The DNA molecule is thus a sort of telegram, written in DNA language, which carries messages indicating how a cell shall develop and proliferate. We might call DNA a do-it-yourself book of instructions to its host cell.

② The second unique property of DNA is its ability to produce exact copies of itself. DNA can so replicate because it is a twin molecule with two long strands, each composed of the building blocks A, T, G and C. These two strands are wound around each other to form a helix, a molecular barber pole. And it is a basic law of living matter that the sequence of the letters A, T, G and C in the one strand determines the sequence of letters in the companion strand. A in the one strand must be paired with T in the second, G with C, T with A, and C with G. The two strands are, as biologists say, complementary. We believe that when the DNA replicates itself, the two strands first separate, and that each then assembles upon itself its complement, using the chemical building blocks available in the cell. When the replication has been accomplished, we have two new double strands, each indistinguishable from the original, but bearing the same coded information as the original.

The double-stranded complementary structure of DNA, first recognized by James Watson of Harvard University and Francis Crick of Cambridge University, is a concept of great significance. It suggests the basic operation by which a living organism reproduces itself. And it appears that of all the substances in the organism, only DNA possesses this power of replication. All other substances are directly or indirectly made by the DNA. The DNA might be likened to a queen bee, hatching out workers who cannot leave descendants. Only the queen bee can proliferate--only the queen can produce the infertile workers and, from time to time, a new queen bee.

The DNA is then a set of self-replicating instructions, constituting the genetic material within the nucleus of the cell. But whence do the instructions come? How are they carried out? To answer these questions, the biologist leaves the central nucleus and he prospect in the surrounding cytoplasm of the cell.

A cell contains of course a multitude of parts. In addition to its nucleus, for instance, a plant cell possesses chloroplasts. These contain not only the chlorophyll which makes plants green but also the machinery for photosynthesis, which converts carbon dioxide and the energy of light into the plant material all of us nonplants use for food. All cells also contain units of a smaller order called mitochondria--the cellular power-houses which burn the food and supply the energy for our muscular work, the operation of our nervous system and the process of chemical synthesis within the body.

All these cellular units are small, but they are large enough to be seen through a microscope, and biologists have been observing them for a generation or more. To find the direct linkage between th units in the cellular chain of command, biologists have had to descend into a still

smaller world--a world observable only after the introduction of the electron microscope in the 1940's. On this minute stage--an area where the common unit of measurement is the angstrom, or the fractional part of one hundred millionth of an inch--the most interesting objects are the cellular enzymes and the microsomes.

One of the triumphs of modern biology has been the demonstration that each of the cell's chemical reactions is speeded on its course by a specific kind of enzyme with the sole duty of hastening that particular reaction. Because the cell carries on several thousand kinds of chemical reactions, it contains several thousand kinds of enzyme molecules. We know that the enzymes a cell produces are genetically controlled--that for each enzyme there is a gene in the nucleus which orders the cell to make that particular enzyme. Since there are about 10,000 kinds of enzyme molecules in a typical cell, there must be at least an equal number of genes in the nucleus of the same cell.

A striking example of this one-for-one relationship is an enzyme found in victims of the hereditary disease called sickle cell anemia, characterized by abnormal hemoglobin of red blood cells. We now recognize the cause of this enzymatic abnormality as a hemoglobin-determining gene different from the normal.

Among the many things we know about enzymes is that each consists of an unique chemical material. All enzymes are protein, that complex material which forms so large a part of all living matter, and all are made up of the same twenty kinds of amino-acid building blocks. An enzyme molecule consists of several hundred of these building blocks linked together in a long chain. What makes a particular kind of enzyme a unique material is the sequence of the building blocks. We may say,

therefore, that an enzyme molecule is, like DNA, a message, but a message written in a twenty-letter alphabet--the alphabet of the twenty naturally occurring amino acids. ✓

The cellular enzymes perform various essential tasks in the transformation of food into cell substance. But before an enzyme molecule can perform its task, it must first be assembled by the cell from the amino-acid building blocks. One of the exciting discoveries of the new biology is how the cell makes its enzyme molecules. It is a most logical arrangement. The cell contains superenzymes, called microsomes, for making ordinary enzymes. Though the microsome is about 100 times larger than the enzyme molecule, it is still so small that we can see it only with the electron microscope. ✓

The functioning of a microsome depends upon a full set of built-in instructions. To make one particular enzyme--the hemoglobin molecule, for example--600 building blocks of twenty different kinds must be properly stapled together in the correct sequence. The building instructions are written in the microsome in coded form. The essential portion of the microsome is thus a coded directive about what kind of enzyme to make and how to make it. The building blocks of which the microsome is made are much like those of DNA, with the addition of a single chemical group essential to enzyme synthesis. The nucleic acid of the microsome, ribonucleic acid, or RNA, is more specific than the DNA of the genetic material in one respect--RNA can make enzymes; DNA cannot. But DNA can replicate itself, and RNA cannot. ✓

Microsomes, then, make enzyme molecules. But we also know that the DNA of the genetic material is the original source of the cell's information about what kinds of enzyme molecules to make. Clearly the genes

somehow determine the kind of information contained in the microsome. Microsomes, in fact, are apparently made in the nucleus and then distributed throughout the rest of the cell. Further, it appears that the formation of microsomal RNA in the nucleus takes place only in the presence of the DNA, for if the DNA is removed, the cell loses its power to make microsomal RNA.

We do not know exactly how the genetic DNA makes the microsomal RNA. Obviously the next great step is to find out. We could, for example, put some DNA in a test tube and ascertain what else has to be added to cause RNA to be made. For the present we can say that the genetic material has two functions--(a) it can replicate itself or (b) it can synthesize RNA. This RNA is packaged as microsomes which go out into the cell and make enzymes.

The amount of information contained in the RNA of a single microsome is quite small compared to that contained in all of the DNA of the nucleus. We think, in fact, that it just about equals the information contained in a single gene. If this is true, a single microsome probably contains the message of but a single gene. One gene, therefore, would contain the information necessary to make one kind of enzyme. To get this information acted upon, the gene produces its special kind of microsome within the nucleus; the microsome then sifts through the nuclear membrane and out into the cell, where it manufactures the specified enzyme. Since the genetic material of the cell consists of several thousand genes, it follows that the cell contains several thousand kinds of needed enzymes.

The success of any organism is measured by the number of descendants it leaves. The cell that leaves the most descendants wins out and populates the earth. But the division of cells to make more cells requires

the multiplication of the genetic material, the replication of the DNA. Each unit of genetic information, each gene, each chromosome, must double before cell division can take place. The two daughter cells, products of the cell division, each contain genetic information characteristic of the original parent cell--characteristic in amount and kind.

In terms of the cell, multiplication is the goal of life, and multiplication is the replication of DNA. And now we can sense the logic which requires the presence in the cell of the varied things which it contains. The genetic material of the nucleus contains information. This information is somehow transferred to microsomes. The microsomes go out into the cell and use this information to make enzymes. Some of these enzymes make building blocks for making more enzymes. Others make building blocks for making more RNA to make more microsomes. But--and most importantly--a portion of the enzymes are those which make building blocks for DNA, so that the genetic material may multiply, so that, in turn, the cell may produce more cells. A cell is a device arranged by the DNA to provide for its own welfare, to provide it with conditions suitable for its own replication. We might even say the same thing for the whole living creature.

In the logic of the living cell, then, the RNA and the enzyme molecules all originate with DNA. The DNA originates from itself, using its own body as a model. Where did the first DNA come from? The question of the origin of DNA thus is the question of the origin of life.

No one has yet synthesized life. It should, however, be possible. One would have to make some DNA and then put it in a soup containing the A, T, G and C building blocks that DNA needs to reproduce itself. The DNA to reproduce and make more DNA. Ultimately the replicating DNA would

use up one or another of the ingredients--say, A--and replication would cease. Thenceforth only the occasional DNA molecule which had acquired information on how to make A from some other precursor would be able to reproduce.

This acquisition of new information by a DNA molecule is known as mutation. Geneticists believe that mutation consists of little errors which occur from time to time in the replication of the DNA. Possibly a G is inserted where an A should be, or one letter is left out entirely, or an extra letter is put in. Once made, the error is ruthlessly re-
pllicated during the course of DNA multiplication--just as a printing press replicates all of the errors of the typesetter.

In any mutation, the altered DNA molecule will contain information slightly different from that of its parent. Often this new and randomly acquired information will serve no purpose. Occasionally, useful new information will be acquired. The properly mutated molecule will have a selective advantage over its nonmutated mates--it would be able, in our first example, to make A building blocks from some appropriate precursor and continue the production of the slightly different kind of DNA. This is natural selection at work. In time the system will run out of something else, such as the precursor of A. Only those DNA molecules will survive which have, by mutation, acquired the capacity of making the precursor of A from still another precursor.

Thus we can imagine that, as the DNA molecule reproduces and mutates in a soup containing all imaginable substances, mutation and selection will gradually enrich the soup with those DNA molecules which possess more and more sophisticated synthetic ability.

This is the kind of model most biologists today believe to be a reasonable one for the origin of life on our earth. (See How Life Began, by E. A. Evans, The Saturday Evening Post, November 26, 1960). They conceive that aeons ago the oceans were a sort of primordial soup, containing an almost infinite variety of organic compounds which persisted because there were no creatures to feed upon them. The first living creature to appear in this soup must have been a simple organism, no more than a molecule constructed by random organic chemistry, yet a molecule capable of replication and mutation, so that it could adjust to changing circumstances. It must have been a molecule of DNA. And, over the ages, this aboriginal DNA molecule gained the ability, by mutation and selection, to house itself within membranes and to produce cells. From cells arose, likewise by mutation and selection, the wonderful array of living things. ✓

A single cell is, of course, just the beginning of a complex creature such as man. Each of us, however, does develop from a single cell--the fertilized egg. The fertilized egg cell divides into two cells. Each of these divides into two, and so on. As the process continues, individual cells begin to differentiate into different types of cells--structural cells, glandular cells, secretory cells, reproductive cells, nerve cells. We know such differentiation consists basically of differentiation in enzymatic constitution--different kinds of cells containing different kinds of enzymes that, in turn, produce different structures and functions.

But this leads to a paradox. Each enzyme is apparently produced by a particular kind of microsome, derived from the DNA--quite possibly the DNA of a single gene. We know that all cells of a creature have the

same total complement of DNA and thus have all of the genes characteristic of that creature. Accordingly we should expect all cells to contain the same enzymes and therefore the same characteristics. How do cells of a single creature develop into different types?

The inescapable conclusion is that all genes do not always make their characteristic microsomes, their characteristic RNA. As an extreme example, take the cells which produce hemoglobin. In these cells all genes except those concerned with the production of microsomes for the synthesis of hemoglobin are inert; they are inoperative. Conversely, in the adult organism the gene for making hemoglobin is inoperative in all of the cells except those in the bone marrow which are concerned with the making of red blood cells.

It would appear, then, that part of the cellular system controls the activity of the genes within the nucleus, determining whether a given gene may produce its characteristic microsomes. We do not yet understand the nature of this control. Perhaps certain genes are responsible for it. Perhaps part of the information in the DNA directs the use of the rest of the information. Perhaps a portion of the DNA sends out signals informing each gene when it should be operative and when inoperative.

If biologists can learn how to turn the genes off and on, they will have taken the first step toward controlling the development of the fertilized egg into an adult organism. With such knowledge we could remedy defects as they appear in the developing child, replace worn-out organs and perhaps even initiate embryonic development in cells removed from the adult body.

Many current medical problems will yield to our increasing knowledge of cellular activity. We already know that some kinds of viruses are

essentially pieces of DNA which can enter a cell and there replicate, foraging on the host cell for nutrients as they make more viruses. This is true of the bacteriophages, the viruses which attack bacteria. Other kinds of viruses, including those of influenza and polio, are more complex and consist essentially of portions of RNA.

Though we do not yet know how these viruses multiply, we do know how to attack the problem. We must find out whether the host cell's DNA is necessary for the production of the RNA of the virus--as it is for the production of microsomal RNA--or whether the virus RNA, unlike the microsomal RNA, can multiply itself. Such knowledge might help us arrest the growth of disease viruses without harming the host cells.

As for cancer, though we can now describe the various forms of this disease and though we know there are many different agents, viruses and irritants which induce cancers, we still do not understand the basic mechanism which transforms a normal cell into a cancerous one. Possibly a cancerous cell is one in which a large number of genes are operative, genes which would remain inert in the normal course of development. Some part of the carcinogenic process may cause the cancerous cell to start producing microsomes for producing enzymes which that cell does not ordinarily produce. Perhaps, to use an exaggeration, a cancerous cell is a cell in which all the genes are operative. We do not yet know the answer;--but we expect to find it.

The new biology I have described is largely concerned with the molecular facts of life. Our progress has enabled us to make more clearly the boundary between molecular biology and the biology of even more complex matters--human behavior, for example. A fertilized egg cell develops into a creature--a human being, for instance--in response to instructions contained in the genetic material. Written down in the DNA

is a vast amount of information--instructions on how to make all the cells and tissues and arrangements needed to assemble a man. Part of the instructions contained in the DNA of a human being direct the construction of a vast network of nerve cells, the brain and its associated sense organs.

Once assembled, this neural network is capable of receiving, through the sense organs, information about the outside world. It is also capable of storing, processing, sorting and acting on the information it receives. Though DNA contains instructions on how to make a human brain, it does not put information into this brain. The brain starts off with a clean slate. Each of us gathers his own information and acts upon it in accordance with what we learn and feel. Neurobiology, the biology of the neural network, is supramolecular biology. Its study is a challenge for the biologists of the future.

But the biology of today is molecular biology--life seen as the ballet of the big molecules, the dance of the DNA. The new biology promises much for human welfare; it has already provided much understanding. Through it we have learned that each living creature is, biologically, a cellular instruction manual written in symbolic genetic language, the language of the DNA. The DNA makes the RNA; the RNA makes the enzymes; the enzymes make the building blocks for making all three. The molecular logic of the animate world rests on this tricycle of life.

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