A. Vibert Douglas

Travels

International Student Service '48.
Summer Seminars in Europe 1948-50

2303.9
Box 2
File 13

ASTRONOMY, PHYSICS, AND PHILOSOPHY

By

A. VIBERT DOUGLAS

ISS Can Seminars
in Europe
I - II - III -

Reprinted from
The Journal of the Royal Astronomical Society of Canada
March, 1945

Sir Walter Moberly. The Crisis in the University

p 269 - .. Know the Bible as a record of progressive revelation to minds at varying degrees of crudity or discernment culminating in a climax up to which everything before it leads and from which everything after it springs.

Old symbols have lost their meaning "gone dead on the minds of most people today. New symbols have to be found" .. "genuinely truthful and undistorted description of experience!" "The only value remaining to us in the collapse of values is sincerity". p 269.

The wind bloweth where it listeth. The masters in science and scholarship need elbow room. p. 154.

Notes:

Social Significance of Science

1. Science reveals the setting of human life in the cosmos.

2. Man's search for truth is a great international record.

3. Swords into ploughshares: or the tragedy of the reverse (Joel.

4. The scientist as a humanist: his obligations as a 20th century citizen.

Sci. a humanity

Search for truth - not to be impeded

I.S.S. Summer Seminar
Lectures.

1949 1 & 2.
1950

Lecture I

3rd Can. Seminar, I.S.S., Pontigny

The Cosmic Setting

as a member of the Can. Com. of I.S.S. ⟵ Geneva, Leysin, Combloux, Relief Seminars.

1. Introdn: 3 Can. Seminars Schloss Plön, Breda + P.
Privilege to think through some of the great problems facing mankind, together.

2. The drama of mankind on this earth should be studied against the bkgd. of the cosmic setting.
most of you are students of man and his history + his thinking.
Let us consider this earth on wh. he finds himself — the earth in space + in time

3. Primitive man + the great thinkers of the centuries before 1543 placed the earth at the centre of the Universe
moon, sun + planets + the great sphere studded with stars moved around the earth.
Constellns + 7 moving bodies — music of spheres.

Mans earliest philosophy involves this cosmic picture
man

4. Copernicus + subsequent cosmologists have erected a cosmology which displaces the earth to a very subsidiary position — . . .
~~Mans~~ philosophy must be re-framed against this bkgd.

Solar System. galaxy, other galaxies.

The space scale
These are the immensities of space.

5. The time scale.
arguments for finite time 10^{10} yrs.
Many 1000 millions went by before the earth was condensed + cooled enough for the first traces of primitive plant life — later animal life of more + more complex type + ½ mill to 1 million years ago man — Only in the last 10 thousand years has man emerged into a record keeping + record transmitting.
Druids here + in the Brit. Isles 4000 years ago.
This historic abbey not 1000 years. cf. age of earth > $1000 \cdot 10^6$

Gen Smuts : statesman & philosopher. Holism & Evolution

The great values retain their unfading glory and derive new meaning from a cosmic setting.

Vastness of time ahead for earth as an abode for man.

Nature has cataclysms but most of her operations are slow gradual processes.

Keep the Time factor in your thoughts

& plan to make your influence in the world towards making the future history of man kind on the Earth a worthy chapter of cosmic history.

If you have "a sizzling enthusiasm" (O Sitwell) for life, for what is good, true, beautiful, then all the experiences of life & the realm of thought & emotion will be enriched by awareness of the cosmic background.

1950 July 10.

3rd Seminar – Pontigny
Lecture II.

Yest. I said that the great importance + intrinsic value of man was an easy, obvious + logical deduction from the pre-copernican cosmology – the geocentric universe.

After Copernicus + increasingly as the vastness of the universe of stellar galaxies was established, philosophers had to find other reasons to support believe in this essential importance of man.

There were some even in pre Cop. era who based their belief on mans intellectual and spiritual attributes – Psalmist – Shakes. But for the average man it was a great shock + as you know Copernicus' book was placed on the Index for over 2½ centuries. But in spite of misguided efforts to suppress new ideas, the truth won out in the long run.

To-day the pernicious philosophy of collective man is endangering this belief in individual human dignity – a phil. of coll. man which in the name of humanity rides roughshod over man.

Prime Mover
Take an example of Aris. –
Ev. of Creation
W.
Goethe – [illegible] of Ideas

1950 Bonrigne 3rd Seminar II

2nd Seminar
Kasteel Bouvigne
Breda 1949

I-1

The Social Significance of Science – I.

Throughout the centuries science has been one of the major influences moulding the course of civilization. It has increased the ~~physical~~ power of man over his physical environment. It has liberated the mind & spirit of man from ignorance, superstition and fear. It has influenced his philosophy and indeed every aspect of his life and thought.

In this (first) address I want to take something of an historic and general approach.

In my [second] last address I shall deal more explicitly with the significance, the urgent significance, of science in society today with all its pressing immediate problems – We must not, we dare not neglect the potential role of science in the world of today & tomorrow.

I 2

1. Briefly: Cosmic setting of our human society. 10^{27} : 10^{28}

2. What is science?

~~I am told that~~ In mediaeval times there were two main divisions of human thought Divinity and the Humanities — and the latter included natural philosophy or physical science just as truly as the other branches of investigation more usually associated with the word humanities today. The greatest men of Science are in the best of the humane tradition, scholars seeking for the truth & seeking to understand something of its significance in the whole range of human experience

Read. Sir Richard Gregory. p. 203, 204.

(1)

Unity of all Knowledge. ~~The growth of Sci~~

3. all Knowledge is the result of an inner urge to ask questions — a natural inborn Curiosity.

"The desire to seek" Frances Bacons description of the man of science — "patience to doubt, fondness to meditate, slowness to assert, readiness to reconsider, carefulness to dispose and set in order .... a man that hates every kind of imposture"

The Scientist is essentially & superlatively a truth seeker — one for whom truth matters and his touchstone of truth is nature. That is the essence of the experimental method the Scientific Method

4. Build your speculations & theories — but deduce from them crucial tests & discard

or modify your theory honestly as a result of observation and experimental fact

~~Pasteur~~:

Kepler: Bow down before facts and let them speak to you. There is the essential reverence for the truth as revealed or discovered in nature, humility before the vast marvellous spectacle of the ~~physical~~ Universe. [~~which the Oxford Dictionary defines as the whole creation and the Creator.~~]

5. The growth of science is due both to the natural curiosity and to the pressure of practical necessity.

Take astronomy — the oldest of the sciences why the oldest? Curiosity about the most unreachable, the most distant – the moon, sun, planets, stars and clusters of stars and the primary practical needs of early man for units of time + a system of chronology and for finding direction over ocean or desert

∴ study of rel posns + rel. motions of cel. bodies.

6. Progress in science has been dependent upon creative imagination of the highest quality. In this the scientist is akin to the poet + the artist

Brewster: The first gift required by the researcher is the gift also of the poet + artist — a vivid imagination.

That gives him his start — then critical analysis must follow

Blake Imagination goes forth in uncurbed glory

(Aristarchus of Samos
Copernicus 1543. geocentric to heliocentric
Galileo - falling bodies. pendulum
Kepler - defying the ~~[illegible]~~ generalizing
Newton Principia 1687. ⊙ argument.

Lagrange
Laplace
Fourier
Wm R. Hamilton
Clerk Maxwell

J.J.T.
Rutherford - Bohr 1910.

Einstein 1915 - de Sitter
~~de Sitter~~ Lemaître
~~Lemaître~~
Eddington 1924-44

||^{el} in physics
Q. Thy
Wave Mech.

(3)

6a Rôle of Intuition in Sci. [Intl. Record] H Weyl, G. Lemaître, Eddington, Max Born.

7. → Misunderstanding of scientific theory by philosophers - more dogmatic than the scientist wd. be - draws sweeping deductions not justified
caution of sci. bec. he knows the
The Heresy of Finality - nothing static
Synthesis - Approaches - - Prime Mover. Ep. of
theory is a TOOL not a CREED
concretion
Worker of
Ideas

Newton himself no materialist
materialism of 18th 19th centuries

Today a mechanistic universe is not based on the sci. of Today - determinacy has dropped out of sci
Princ. of indeterminacy (2) - but not Causality
Born -

Thos. Huxley: Red note Bk. p. 129.

J.H. Jeans: Physics & Phil. (Bl. note Bk. p. 58.

omitted L.P. Jacks goes further: the universe revealed by science shows pattern, structure, balance, harmony ... from a great spiral galaxy of ~~100,000,000,000~~ stars to a snow crystal, or an oxygen atom ...

"In such a universe the human creator of beauty, even the humblest, may feel himself in harmony, a wanted guest, a welcome collaborator and completely at home as a fellow worker with the Living God."

There is no doubt about this dual satisfaction which the scientist derives from his work – a pleasure both intellectual and aesthetic.

Eddington ... ard. p. 239. devastating beauty of

Kepler – fragrance of ambrosia

—

Beauty

Keats Beauty is Truth.

The history of sci. down the centuries is a great international record of truth-seeking

One lesson of science for every worker in the realm of knowledge is its unswerving devotion to Truth its integrity of motive & method – its high faith in honesty.

3rd. Can. Seminar ISS
Pontigny 1950 July 12.

Lecture III

Introdn. Gen. Chisholms stark grim statement of the tragic results of another war, 10% survive. biological > destructive power than atomic

atomic energy to kill 20 10^6 people - beyond that atmosphere deadly for 100 years —

Can mankind outgrow the war mentality?

Some people have said war is an economic problem or a population problem

Read AC Geddes

(1)

What are the lessons from these grim facts & from the experiences of the last ~~36~~ years.

1. Science has placed tremendous forces for good or for evil in mens hands.
2. The decision to use them in one way or another is not usually made by the scientists Gov. Chisholm placed on <u>us</u> the citizens the resp.

Social aspects of Science TODAY.

This age is often called the age of sci. & with some justification
Sci. has probed many of the secrets of nature and placed vast stores of energy and knowledge in the hands of mankind.
Used wisely this knowledge & this power can benefit the whole of mankind by the honest facing of the problems of food, fuel and shelter (health) for a rapidly increasing population
Used wrongly as in bacterial and atomic warfare, they can bring inconceivable suffering & calamity upon the human race.

1952 Omit

→ Science in this last war. courage & heroism & self sacrifice not enough.

Rabelais: Sci. without conscience is damnation.

DuBridge: M.I.T. p. 226-230 238.

1950

→ Constructive uses of sci. Today! Andrew Marrington

1. Atomic energy - power! 20 yrs! At En. control - sov. rights - Inspection
   hist. - (2) medical research.
   H bomb (3)
   (4) pure sci. neutron diffraction of organic crystal structure
2. V-2 Rockets. upper atmosphere meteorology, cosmic rays ionization. temps, spectra
3. Radar ships safety, navigation
   airplanes
   meteors -
   Short wave radiation from Sun & galaxy

OVER

4. Drugs. legitimate use & misuse.
Sanctity of personality

pennicillan
anaesthetics.
new Def. of Health

[5. WHO ~~Gregory p. 208.~~ Chisholm, T.B.]

6. FAO & natural resources of timber & soil conservation.
It is not the fault of the scientists if our resources are squandered, soil eroded & impoverished, fertilizing materials wasted, We know better. Compost.
Sci. has disease resistant seeds
wheat eg. for northern latitudes.

7. Minerals: Worlds resources are not unlimited.
Role of scientists in geophys. prospecting
in finding new alloys
in finding substitutes
ie Nylon.
tons (?)

Social Implications of Sci
8. Conant / Nature 1948 June

9. AVD Astr. in W. at W.

e. Lilienthal
d Bush
(a) Bernal.
(b) Born
C — Discuss Scientists restrictions
& divided loyalty.
not unique to Scientist

Finale p. 7 of AVD typed article on Soc. Sig of Sci.

Extract from Letter to G.V.D. 1948 April 15
from A C Geddes.

War arises out of the collision of opposing fanaticisms. [Zionism in its extreme form]

I have never subscribed to the idea that wars are economic in their real origins. There is always some obsession in the background, just as there is at the present moment in the Kremlin where I am sure they are sincerely convinced, in spite of overwhelming evidence to the contrary, that the British Empire is seeking an opportunity to do Russia harm or to do them in.

The cause of war is mass insanity, as a result of which some objective becomes so overwhelmingly important in the imagination of a community that all other 'interests' and all others' 'interests' are as nothing in the balance.

Of one thing I am quite certain – no economic interest anywhere in the world today has even the most remote wish for war or for even international tension.

The best hope for peace that I can see is that the English speaking world should be strong, tolerant, and consistently friendly in spite of 'insults', pin pricks and other provocations. The strong can be tolerant. The weak can only appease and that is fatal in dealing with fanatics. (Sgd) Geddes.

Prof. of anatomy, soldier, cabinet minister
ambassador, late chairman Rio Tinto Co,
London.

U

Outlines for ISS
Summer Seminar

1948 Schloss Plön

I

Historical approach:

an international record

* This age is often referred to as the age of science and with some justification

Science has probed many of the secrets of nature and placed vast stores of energy and knowledge in the hands of mankind.

Used wisely this knowledge can benefit the whole of mankind, facing squarely the great problems mentioned by Mr McKenzie of food, heat & shelter for a steadily increasing population.

Used wrongly as in bacterial and atomic warfare, it can bring inconceivable suffering & calamity upon the human race.

ISSSS Schloss Plön.

Lecture 1. 1948 July 3.

Introdn. *

We are gathered here at this Seminar bec. we believe that the greatest need of the world today is PEACE.

We believe that educated thinking men & women can exercise a powerful influence towards bringing about a state of mind in which peace can be established and maintained.

In this universe nothing is static.

anw. Every act leaves the world with a deeper or a fainter impress of God.

Interpretations may be different, but it means this: your influence in all aspects of daily life

One way to work for peace is to realize yourself & help others to realize the tremendous debt which people of every nation owe to the great thinkers of other nations.

If I take astron. & physics to illustrate this international record it is not bec. I think they are exceptional – rather that they are typical

I Historic approach – an intl. record.
The oldest science: astron & physics
Early astron & physics arose from man's practical needs and his innate curiosity.

(a) Early astron. Time. Dirn:
see Immensities of T & S, introdn.

Lunar month N. 29.530614 dys
K 29.530594 "
True. 29.530596 "

1. Naburiannu & Kidinnu
2. Gks – Hipparchus, Ptolemy
3. Copernicus
4. Tycho Brahe
5. Kepler
6. Galileo
7. Newton
8. Struve
9. Le Verrier & the gt math.
10. De Sitter & JH Oort.
11. JS Plaskett.
12. Shapley.

15 nationalities here represented

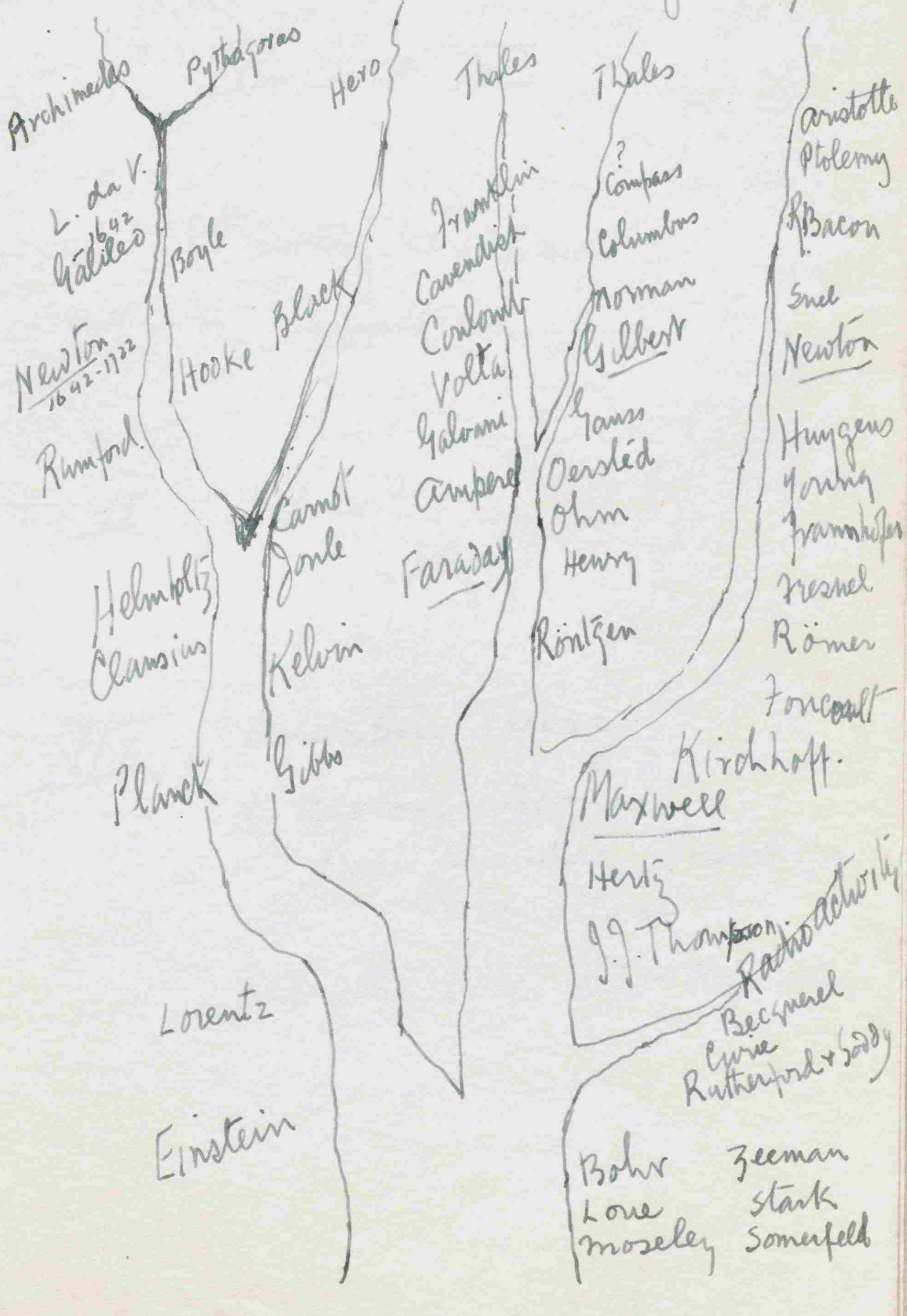
Spectroscopy: Newton, Fraunhofer & Kirchhoff, Secchi, WS Adams, Eddington, Russell & Hertzsprung, Edlen, Saha, Vegard

Cosmology: Laplace, Einstein, Weyl, de Sitter, Eddington, Lemaître.

(b) Physics – River & tributaries.

Ref. {J.H.J. Mees for Chem., Biology

Mechanics Sound. Heat Elect. Mag. Light



II and III

20th Century developments
in Physical Sci

II Relativity
+ Cosmology.

III Quantum Theory
+ Atomic Theories.
Bohr, Heisenberg, Schrödinger
Born, Dirac &c

Eddingtons bridge betw Rel. + Atomic
Theories

Lecture 2 Introdn

1

Attributes of man of science - Francis Bacon.

"the desire to seek, patience to doubt, fondness to meditate, slowness to assert, readiness to reconsider, carefulness to set in order .... a man that hates every kind of imposture."

These should be the attributes of every seeker after truth in every field of study.

man's curiosity

winged imagination.

critical judgment

and surrounding all integrity

both in method & motive.

+ make us think

II Kepler
Newton
Hamilton - generalized coordinates + momenta.
Observed difficulties M + M, Hg, mass of el.
Einstein.
Relativity Time + space.
Tests - 4
Read AN Whitehead on Roy Soc meeting in Sci + Mod. World. p. 15.

Atomic Theory

Planck etc See J H. Jeans notes. ②
+ AS Edd. on $qp - pq = \frac{ih}{2\pi}$

Rutherford
Bohr See H D Smythe ①

Schloss Plön
Lecture 2 1948 July 5.

✓ Introdn: Brown man of Sci.

✓ i. The body of a man - say 60 or 70 Kilograms or 10 or 11 stone or 150 pounds - is a quantity of matter...
10^{27} atoms = 1 man 10^{28} men = 1 star.

✓ ii The cosmic setting. earth - sun - galaxy - interstellar matter other galaxies.

as we look outward in space, we are looking backward in time.
100 000 l. y. our gal. 800 000 l. y. M31 500 10^6 to most distant photographed.

Vastness of time + space.

Field M. Smuts' the great values retain their unfading glory and derive new meaning from a cosmic setting.

✓ Voltaire:
✓ Hardy - Spirit of Pity this terrestrial tragedy,
" Ironic or comedy? That should wake us up + make us think

What have the physical scientists found out about the minutest things and the vastest things?

Consider the success of Newtonian mechanics - + the applicn of the law of gravitation - It enabled men to predict the posns of sun moon + planets, of comets, of tides + the precession of the equinox, to explain the oblateness of the earth, the motions of double stars &c. Triumph upon triumph until middle of 19th century.

i No motion relative to ether measurable. 15. vel of light constant
ii mass of electron incr. with high vel. 3 10^{10}
iii Perih. of mercury

Challenge. Einstein. Eqns x.y.z.t. spacetime.
identities - laws arising from observed relations of energy, momentum + stress.
grav. law of wh. Newtonian is a special simple case.

De S. 3 tests. merc., bending of light eclipse 1919. dense matter; red shift

Read Whitehead. p. 15.

Weyl. + Eddington. + Lemaître.

Expanding Universe. J. J. T TOOL

Ended here

3 Types of Law. Edd. N.P.W. 244.

Laws of atomicity. Next Topic.

Lecture 3.

i. Kepler. Bow down before facts

J. J. 'Tool not creed.' facts in widest sense.

ii. 3 types of law. Edd NPW p. 244

1. identical laws.
2. statistical "
3. transcendental — atomicity.

for 17 years after NPW. Edd. sought the basis of these laws.

iii. Electromagnetic radiations

Planck. E = h ν.

Bohr.

Heisen etc see notes. I II

iv. Eddington Epistemological approach.

I

J H Jeans – The growth of Phys. Sci.

p. 330 et seq

→ Planck. Q. Thy. 1900 vibrators $E = h\nu$
Einstein 1905 radiation as a flight $= mc^2$
of bullets or "light arrows.
Lorentz saw conflict with undulatory theory

→ Bohr. 1913 – atomic "states"

→ Heisenberg 1925: discarded unobservables
→ Born & Jordan. within atom and concentrated on spectrum lines

following H's lead evolved – matrix mechanics – i.e. atomic scale workings of nature followed Newtonian forms but simple algebraic quantities of Newton had to be replaced by matrices.
If generalized coords. + momenta of Hamilton's equations are suitably replaced by matrices, the laws so obtained appear to govern all atomic physics. (p 332)

→ De Broglie 1924 The moving electron as a train of waves

II

→ Davisson & Germer 1927 electron diffraction similar to X ray patterns from a crystal.

→ G P Thomson 1928 – electrons through a thin metal film – ditto result

∴ matter appeared to consist of waves rather than ptcls

→ Schrödinger (at Berlin) 1926 applied these ideas to the motion of an electron inside an atom substituting a train of waves for each Bohr atom.

→ * Heisenberg then came in "principle of uncertainty" or indeterminacy

→ Born 1926 showed the math. waves of de B. + S. can be interpreted as "graphs exhibiting the probabilities of electrons being at the various points of space – no waves at a pt. means zero probability – The waves do not exist in ord. 3-dimens. space but in a purely imaginary multi-dimens. space. ∴ they are mere math. constructs – nevertheless their propagation acc. to definite known equations gives a perfect account of happenings inside atom or at least of the radiation that comes out –

→ Dirac 1930. Quantum mechanics unified the foregoing matrix mech. + wave mech.

P.T.O.

Dirac, cont'd.

his basic conception is that fundamental processes of nature cannot be depicted as happening in space + time ... beyond anything we can observe. there is a substratum of events that do not permit of such representation

Eddington N.P.W.

Schrödinger's model of a particle is a wave-group.

p. 207. $qp - pq = \frac{ih}{2\pi}$

q + p are coordinates and momenta
($\sqrt{-1}$ is a signal to look out for waves + oscillations)

q + p are not simple numerical measures or qp-pq wd = 0

for Schrödinger
p is an operator i.e. his momentum is not a quantity.

for Born + Jordan
p is a matrix not one quantity nor several but an infinite no. of quantities arranged in systematic array

for Dirac
p is a symbol without any numerical interpretation

Lecture IV

i. To day I am combining material from three lectures which I had planned to give you into one because of time table requirements: ~~to day~~

i, In the Hebrew Scriptures
Swords to plowshares.

p3

Read DuBridge.

Sci must be free.

ii. Atomic energy. Prof Whitmore
peace uses:
astron uses. novae, stellar energy sources.

V-2 rockets.

Radar. navigation safety
meteor research.
radio from Sun + milky Way.

WHJ

Lecture IV

Schloss Plön
1948 July 8.

i) The physical scientist depends on the guidance of intuition when everything else fails him.
faith reason. AVD: APP pp. 1 2. Edd
intuition. + Whitehead.
" p: 2.

Dingle: The missing factor in sci.

Self-criticism + synthesis.
Contrast of phil + sci. (certainty + incompleteness; completeness (with uncertainty); a process)

Johnson: Science & the meanings of truth. p3

Schrödinger: What is life.

Weyl: see AVD: assoc. p 238
Edd: "

Rabelais: Science without conscience is damnation.

The responsibility is on us to ~~live and even if necessary to die~~ insist on the right use of all knowledge for the good not for the destruction of mankind.

Growth and Implications of Science

I History of Science an international record.

Physics
Astronomy
Chem.
Geol.
Biology -

Expand to I A. Relativity Q mech. &c.

Free interchange of ideas - { exceptions trade secrets not in fundamental research. exc. for eras of conundrums Kept Boyle -

Bacon - char. of man of sci.

II. Cooperation in wartime research.

Atomic energy. - Bethe & [illegible].
Basic researches 1890 — 39.
*Smyth X rays — nuclear fission

Radar. J J T on electrons 1917.
Curiosity

Projectiles
Aeronautical problems - pressure suits
Sea sickness McGill -
Food & nutrition - Q. Linseed oil into edible fat.
Penicillin -

Secrecy - an emergency necessity a peacetime tragedy

*Smyth. loc. cit. conclusion

Rabelais - Sci. sine conscientia damnation.

IV. Philos. Implications of Modern Sci

Interlocking of all knowledge
part of avd paper

Schroedinger What is life?

Dingle Missing factor in Sci.

Ethics not which we choose
but how we make our choices.
motive

Eddington. Synthesis of physical theory + Knowledge in atomic + cosmic nature

E A Milne - Time.

Martin 2 reviews (D)

Whittaker - Space & Spirit.

Edd. + Weyl. (avd summary

avd. Sci - method - (Hibbert J.)

Indeterminism + C G Darwin In W. at War. Ignorance is now respectable.

July
2 Fri.

10. Meeting of Can. Students – Security Officer
11. Talk on Plön facilities.

3 Sat. 10 ~~Mackenzie~~ Macin Gay Opening address.

11 Mackenzie.

2. AvD. 45 min. 1st.

3 Seminar – Topics for student papers.

M. Tu. W. Fri. Seminars
9 Ger.

5 Mon	9		
	10	D. 2nd	pm Opening ceremonies + evening
	11	~~Phil~~	2 – 3³⁰ Seminar
6 Tues,	9		
	10	D 3rd	2 – 3³⁰ Seminar. 15 min break.
	11	Mack.	
7 Wed.	9, 10, 11	~~Seminars~~	free
8 Th.	10	D 4th	2 – 3³⁰ Seminars
	11	~~Mack~~ Mackenzie.	
9. Fri.	10	~~[illegible]~~ Mackenzie.	Seminar.
	11	Phil	

Optional
Beginners' German
9am 5 days.

Evenings – Discussion
2 per week.

Natural Philosophy of Cause and Chance by Max Born
Oxford University Press, pp. 215, 1949 $4.00

The publication of the Waynflete Lectures of 1948, with various additions and a largely technical appendix, is an event wholeheartedly to be welcomed. Max Born is a master thinker, craftsman and teacher in the domain of mathematical physics. He is stimulating also when he writes on its significance to philosophy, though he disclaims special qualifications in the latter field by saying, "My philosophical convictions...are not much more than common sense improved by sporadic reading." (p.3)

Causality and determinism in the old physics are discussed and illustrated in five chapters, leading to the conclusion that "with ordinary thermodynamics the descriptive method of physics has come to its natural end." Atomistics and statistics provide the fresh start. The great names recur time and again: Boltzmann, Gibbs, Planck, Einstein.

Born defines causality as "the postulate that one physical situation depends on another" (p.102) and shows that in modern physics causality is not eliminated but only a "traditional interpretation of it consisting in its identification with determinism". He sums up his arguments thus, "Chance has become the primary notion, mechanics an expression of its quantitative laws, and the overwhelming evidence of causality with all its attributes in the realm of ordinary experience is satisfactorily explained by the statistical laws of large numbers." (p.121)

In the final chapter entitled Metaphysical Conclusions, the author contrasts his own (and most physicists') views with those of Einstein, "the greatest living physicist", and concludes that "even an exact science like physics is based on fundamental beliefs". (p.123). He states his belief that science has two complementary aspects in its "practical collective endeavour for the improvement of human conditions" and as a "pursuit of mental desires, the hunger for knowledge and understanding, a sister of art, philosophy and religion". (p.128)
In this view he is unblinkered by the Marxism that narrows the vision of a

* Martin Johnson - Science & the Meanings of Truth

scientist like Bernal to the former aspect only.

Born's concluding words in the appendix are:

"There are two objectionable types of believers: those who believe the incredible and those who believe that 'belief' must be discarded and replaced by 'the scientific method'. Between these two extremes on the right and the left there is enough scope for believing the reasonable and reasoning on sound beliefs. Faith, imagination, and intuition are decisive factors in the progress of science as in any other human activity."

G.W.D.

1950 May 10.

The Social Significance of Science

I

Throughout the centuries science has been one of the major influences moulding the course of civilization. That it has increased man's control over his environment is so obvious as to need little elaboration. From cave dwelling to modern skyscraper, from primitive cart or dugout to airplane, from roots, berries and the skins of animals to synthetic foods and fabrics, from the resonant boom of percussion on a hollowed log to radio and television, the changes in man's environment and range of activities have been due to the application of simple or of less simple scientific principles.

The growth of knowledge which has resulted in establishing these principles is an inspiring record of seeking, searching, observing, finding, testing, modifying, confirming discarding and then trying again and yet again. The challenge of the unknown has called forth many of the noblest characteristics of the human mind and spirit. It has required intuitive insight, winged imagination, indefatigable patience and creative ingenuity both theoretical and practical. It has demanded unflinching self criticism, deep faith in the worthwhileness of truth seeking, and integrity both of motive and of method. "High faith in honesty" is the hallmark of the scholar.

These great qualities have not been the sole possession of the scientists, but in no other scholars nor in artists, nor in any other group of men, have these characteristic been more pronounced. Indeed the scientist through the centuries has set an unparalleled example of singleness of purpose in truth seeking.

Science has moulded man's physical surroundings; it has also influenced his mental and spiritual environment. Trevelyan has described "the easily terrified imagination of primitive man". Writing of the Britons of the Roman occupation he says, "every spring, wood, river and hill was haunted by named or nameless spirits, to be worshipped, propitiated, and at fall of night avoided. Such very ancient gods and the fear of them were strong with the strength and terrible with the terror of the untamed, all-enveloping wilderness." Two influences have worked against this primitive dread of unseen and unknown evil - one is faith in an omnipotent God of love and light, the other is science.

It is only against the background of man's unreasoned dread of evil influences and of malevolence in the mysterious forces of nature that the full miracle of the power of religious faith to dispel fear can be appreciated. Passages of calm assurance such as are contained in Psalm 23 or 46 or 91, written over 21 centuries ago, are an amazing revelation of the reality of this power. But it is science that has made the light shine to banish the darkness of ignorance and superstition and all the unreasoned fears to which they give rise. Science has thus been a great liberating influence with its appeal to the intellect, to common sense, based on a rational interpretation of more and ever more of the phenomena of the world in which man finds himself - a world of vastness inconceivable, of complexity, of beauty, of endless change but of ordered change, a cosmos not a chaos, a universe of which he is himself a part. Chemistry has displaced alchemy, astronomy has discredited the superstitions of astrology, meteorology can forecast storms so that warning signals can be flashed over continent and ocean, the biological and medical sciences can fight and to some extent prevent disease with increasing effectiveness and understanding, psychological science can throw considerable light upon the problems of personality and into the deep recesses of the mind. And through recognition of its own limitations, science directs attention to the vast realm of spiritual experience - the realm of religion.

The point may therefore be made with justice that, far from being deadly enemies or even rivals, true religion and science have been co-workers in the long struggle against fear that is born of ignorance and superstition.

The tragedy of many centuries has been that too often religious leaders have themselves succumbed to fear in the face of the new truths which science was bringing to light; and that too often there have been philosophers or disciples of the great men of science who have misinterpreted new scientific ideas, drawn unjustifiable, sweeping conclusions about the all-sufficiency of science to the apparent discrediting of things spiritual. Thus both religion and science, in their respective wars upon fear, have been less successful than they should have been.

Religion and science must fight fear side by side with mutual respect and trust, like the Great Twin Brethren who turned the tide of battle against the evil Tarquins, for there are black Tarquinic evils in the world today which neither religion alone nor science alone can overcome. But if religion and science complement one another and stand together, they can overcome the darkness of individual fear and ~~the ominous~~ prevent a whirlwind of mass hysteria which would drive the world towards the calamity of another war. ~~so wide-spread in the world today.~~

II

The fears which grip many people in many countries today, are largely the result of two things. Some sociologists have transferred the emphasis of basic importance from the individual and his essential value, to society or mankind in the mass. Thus the state ceases to be servant to the people. As soon as the individual finds himself servant to the state, a cog only in a vast inhuman machine, his freedom is diminished and he is a prey to fear of the future, since his own destiny is less and less in his own hands and his dignity as an individual is largely denied. Professor A. Boyce Gibson has called this "a new philosophy of life - the philosophy of collective man.... [it] regards the human person as a means only; in the name of humanity, it rides roughshod over men." No wonder there is fear in men's minds.

A second ground for fear today is the spectacular acceleration in scientific advance, and the harnessing of atomic, chemical, bacterial forces to the destructive purposes of war. The technical achievements in engines of war, bombs and bombers, guided ram jet missiles, proximity fuses and new under water craft, all aim~~ed~~ at the destruction of ones fellow men and their works, are indeed enough to explain much of the ~~panic fear~~ alarm, restlessness, and cynicism that are widespread.

From every side one hears the blame for the world's present day evils directed against the scientists: they are to blame for the spread of materialism and the lowering of ethical standards; they only are responsible for the devilish inventions of modern warfare; they will not be content until they have blown up the world.... so run the comments.

Being untrue, all such statements and the frame of mind from which they arise are potentially ~~very~~ dangerous. Let us not forget nor allow the public to forget that we owe the victory of 1945, our freedom, and quite possibly our lives to the scientists. All the courage, the heroism, the self-sacrifice of army, navy and air force could not alone have saved us from defeat. Good and evil exist side by side in the world, and everything, including the fruits of science, can be used constructively or destructively.

But it is not the free choice of the scientists to expend their finest efforts on the destructive applications of science. When they do so, it is because of the pressure of the society to which they belong, a pressure which harnesses every potential resource throughout the state in a vast effort of self preservation or of national aggression. If it be for the latter purpose, the scientist has the choice of cooperating or of being branded a traitor and suffering the consequences; if it be the self preservation of a state threatened by a ruthless aggressor, the scientist can play the part of a conscientious objector if he wishes, but he is more likely to accept the tragic necessity of turning his energies to the problems of survival which include both defense and attack.

The great advances made by scientists under the stress of war necessity can happily be turned to constructive ends in a peace time program. This is true of atomic energy, of aeronautics, of radar, of rockets, of ~~many~~ medical and surgical discoveries. The future welfare of mankind is immeasurably more hopeful than it was before these discoveries were made. But the realization of this welfare depends largely upon the wisdom of our spokesmen at the United Nations and upon an informed dynamic public opinion throughout our countries. In this social order scientists have a significant part to play - and they must play it not only as scientists but as scientists who are active citizens.

The ~~[illegible]~~ immediate and the long range effects of exaggerated secrecy born of fear are obvious and very disturbing to the scientist. Science stagnates in an atmosphere of secrecy; it flourishes in freedom, not only national but international freedom. Restrictions upon the free interchange of ideas, denial of the right of all peoples to the new knowledge arising from man's great international heritage of the accumulated knowledge of past centuries, are dangerous - they breed distrust, suspicion and fear. These form a vicious spiral of increased distrust still less freedom, yet more suspicion, and eventual war is the dire consequence. Scientists everywhere should be working for freedom and for strict intellectual honesty.

These together with the international cooperation born of fair play and kindliness are the only bases on which peace can be maintained - the sort of peace which makes disarmament practicable. An armed truce is not peace.

III

Many able men have expressed their views in no uncertain terms on the social significance of science. A few quotations follow. The names of these authors carry weight.

L.A. Du Bridge, Director of the Radiation Laboratory, M.I.T. - "Science must be free ...free exchange of ideas and free discussion...freedom from controls and restrictions... freedom from direction and so-called planning from above...In November 1945 and henceforth, secrecy on basic scientific matters is not only unnecessary but it is dangerous. It is unnecessary because the facts of nature cannot be hid...It is dangerous because it interferes with our own scientific progress, gives a false sense of security, and endangers international good will and understanding."

The Editor of <u>Nature</u> reported on a lecture delivered at Yale by President J.B. Conant of Harvard - "Man's power over Nature is obtained only by studying and using the facts, and the facts will not consent to adapt themselves to fit a man-made theory...We should consider the problem of the relationship between the intellectual and the spiritual sides of man's life, between the science of acquiring knowledge and the art of using it....Man's material advance has outstripped his spiritual progress...could anything do more to help recapture moral control than the universal recognition that physical science belongs in essence to the humanities."

Lord Boyd Orr, whose food surplus proposal was turned down by the U.S.A. in 1946 in the UN, a refusal which, according to a recent editorial writer, may have more disastrous consequences than many Security Council vetoes - "There is no hope of peace until mankind frees itself from superstitions and inherited beliefs, looks at the facts as they are, and seeks to adjust the structure of society so that the great powers that science has given us might be directed towards beneficial instead of destructive ends...This new age with modern science might be a great age, freeing man from physical poverty and his mind from ignorance and false beliefs...creating a new faith in mankind itself."

Vannevar Bush, president of the Carnegie Institution and first chairman of Research and Development Board of U.S.A. Department of Defense - "I believe first that the technological future is far less dreadful and frightening than many of us have been led to believe, and that the hopeful aspects of modern applied science outweigh by a heavy margin its threat to our civilization. I believe, second, that the democratic process is itself an asset with which, if we find the enthusiasm and the skill to use it and the faith to make it strong, we can build a world in which all men can live in prosperity and peace...[another war] need not come if we realistically enough and with enough determination resolve that it shall not...if we learn to make our democracy work...[if] we believe in human dignity and human freedom...can submerge selfishness and petty motive, make our way of life function with true effectiveness for the good of all."

David E. Lilienthal, chairman of the U.S. Atomic Energy Commission, 1946-49 - "The purpose and atmosphere of science and technology must be moral. Science is not simply a body of knowledge, it is a thing of the spirit. It is the spirit of adventure, the urge to know what lies beyond...a way of thinking...a faith in the power of knowledge, a deep conviction that the truth can make men free...that man's hopes lie in expanding the area in which reason, not arbitrary force, directs his destiny and determines his relations to his fellow men the world over...Greater knowledge about the world...greater love and understanding among men...greater faith in humankind and in the purposes of the Creator of the Universe. Knowledge, love, faith - with these three the Atomic Age, the age in which we live, can become an age of mercy, of joy and of hope, one of the blessed periods of all history."

Lord ~~Auckland~~ Geddes, professor of anatomy, soldier, cabinet minister, ambassador, business man ~~chairman of the Rio Tinto Co., London~~ - "I have never submitted to the idea that wars are economic in their real origins. There is always some obsession in the background...The cause of war is mass insanity as a result of which some objective becomes so overwhelmingly important in the imagination of a community that all other interests and all others' interests are as nothing in the balance."

Sir Richard Gregory, F.R.S. - "The spirit of human brotherhood will never be established by a single religion, but with this ideal as the driving force of them all. It is the essential factor of all international equations...Both science and religion can cooperate in this humanistic service, each in its own field and in its own way, yet united in their endeavours to attain high ideals by works as well as by faith. These are the influences which have affected the course of civilization and the progress of the human race..."

The problems facing mankind are ~~very~~ complex, the dealings of man with man, the attitude of nation to nation. No solutions making for international good will and world peace will be achieved by men of narrow mind, myopic sight and dwarfed soul. Faith in mankind, far vision in time and space, the winged imagination that leaps the barrier of here and now, knowledge of the best in the past, comprehension of the needs of the present and the possibilities of the future - these are the qualities of mind and spirit needed in every walk of life and needed superlatively in the leaders of the nations. The man of science must play a larger part in mass education, he must endeavour to bring into all the affairs of his community and nation his standards of freedom and integrity, and the ideals, aims, and methods of the scientific approach to facts and problems.

The misuse of science drives home with bitter and tragic intensity the truth of the words of Rabalais, "Science without conscience is damnation". Science is not unique in this context. The moral and intellectual level of a whole people is on trial. If men of science be not stifled by cramping restrictions, if they keep close touch with ethical principles and lose not sight of moral values, if they hold fast to their incomparable standards of integrity in truth seeking, then when the history of the next 500 years comes to be written, amongst the most important chapters will be found those on the social significance of science. It should and can be a noble record.

To QQ Jan 23
+ To GVA copy Jan 23

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J. D. Bernal. The social responsibility of science is to get down to the urgent practical job of securing the conditions for a good life for all the people of the world – this is the first time in human history that men have had the knowledge and with it the power to tackle this job. That is why the crisis of our time is something new and different from any of the crises of the past.

Freedom of necessity. p. 85.

THE FREEDOM OF NECESSITY. J.D. Bernal, F.R.S.
(Routledge and Kegan Paul, 18s. net)

...freedom is a necessity for scientists in their work more than it is for most other professions, even perhaps than for the artist. ...

The only people who can possibly run a plan for science are scientists, because they are the only people who know what it is all about. ...

Philipp Lenard
German Physics
1937

"Jewish physics can best and most justly be characterized by recalling the activity of one who is probably its most prominent representative, the pure-blooded Jew Albert Einstein. His relativity theory was to transform and dominate all physics; but when faced with reality, it no longer has a leg to stand on. Nor was it intended to be true. In contrast to the equally intractable and solicitous desire for truth of the Aryan scientist, the Jew lacks to a striking degree any comprehension of truth-that is, of anything more than an apparent agreement with a reality that occurs independently of human thought."

Philipp Lenard
Munich lecture
1937

"The entire development of natural science is a communal effort of Aryan scientists, among whom the Germans are numerically foremost. The period of Heinrich Hertz coincides with the gradual development of a Jewish natural science, which took advantage of the obscure situation in the physics of the ether and branched off from the course of development of Aryan physics. By systematically filling academic positions with Jews and by assuming an increasingly dictatorial attitude, this Jewish natural science tried to deprive Aryan physics of its foundations, to dogmatize, and to oppress all thinking about nature. Ultimately it replaced these foundations by a deceptive imaginary structure known as the relativity theory, above which it simultaneously inscribed the typically Jewish taboo - that is, 'not to be touched.' This development was temporarily and causally coincident with the victory of Jewry in other fields druing the postwar period."

the exercise of all our talents and with the belief and hope that by so doing we are helping to make men sublime, morally and spiritually, as well as godly in the sense of religious faith. So may the Earth become part of the heavens of the universe in spirit, as it is already in truth.

IV.

The effect of science on philosophy has been greater than is generally realized. ~~[illegible]~~ Copernicus and Galileo ~~forced the~~ brought about the overthrow of geocentricism and, as a logical ~~necessity~~ result the abandonment of anthropomorphic philosophy. Science has forced logicians to scrutinize and develop their methods. The meaning of the word Truth has had to be revised in the light of the new methods developed by modern mathematical physicists. Relativity theory and quantum theory have forced philosophy to take cognizance of new ideas, whose implications ~~and of new statistical methods of~~ are fundamental. One of these ~~and~~ is the interrelatedness (not the identity) of space and time. Philosophical arguments based on an hypothetical determinacy have become

A SCIENTIST LOOKS AHEAD

The impressive career of the scientist-philosopher Vannevar Bush, author of "Modern Arms and Free Men" (New York: Simon and Schuster), includes positions of the first rank - vice president and dean of engineering at the Massachusetts Institute of Technology; president of the Carnegie Institution of Washington; chairman of the National Advisory Committee on Aeronautics, and as head of the National Defense Research Committee and its successor agency, the Office of Scientific Research and Development. Finally Dr. Bush was appointed as the first chairman of the Research and Development Board, the agency of the Department of Defense charged with the supervision of all military research and development, and the integration of that work into the planning of the armed services.

Dr. Bush says, "I believe, first, that the technological future is far less dreadful and frightening than many of us have been led to believe, and that the hopeful aspects of modern applied science outweigh by a heavy margin its threat to our civilization. I believe, second, that the democratic process is itself an asset with which, if we find the enthusiasm and the skill to use it and the faith to make it strong, we can build a world in which all men can live in prosperity and peace."

As one might expect from the title of his book, the author keeps returning to this thought. He is convinced that a society of free men in a "world that science has altered" can create a "strength far beyond what can be created and maintained by any regimented dictatorship."

The closing chapters of the book deal with the "age-long contest between those who would build and those who would dominate."

He reviews the "miraculous" instruments of World War II, including radar, the eye which helped save Britain during the Nazis' all-out bombing campaign; sonar, the under-water ear which served to break the Nazis' U-boat campaign; missiles, such as the V-1 which "might well have stopped the invasion" of Normandy; also rocket-firing bazookas which can stop tanks; recoilless guns which can be carried by two men and which have the power of 75-mm. howitzers.

He has a great respect for the submarine which is now able to stay submerged for long periods "with only a small end of a pipe sticking out like a swimmer breathing through a straw," able to outrun pursuers and overtake fast convoys, and carrying long-range homing torpedoes which could be fired beyond the hearing of sonar.

The atom bomb, he admits, would no doubt be dropped in a new world war, but he says that it is not the absolute weapon it has been thought to be and "the cost of manufacturing and delivering it might well exhaust a nation."

"There need be no more great wars," he says, "yet there may be...... If democracy loses its touch, then no great war will be needed to overwhelm it. If it keeps and enhances its strength, then no great war need come again. Yet there is a chance...and free men must be ready." The author concludes his observations with this sage generalization, "As science goes forward, it distributes its uses both to those who destroy and to those who preserve."

Summary. Influence of Sci

1. Throughout our daily life by its practical applications

2. Freeing mankind from fear ~~&~~ superstition born of ignorance

3. Influencing philosophy, through cosmology, physical theory & biological theory.

4. Opening a vision of aesthetic value & removing logical arguments in opposition to a spiritual interpretation

5. Giving a great international record over 23 centuries of Truth seeking.

and actually I place this emphasis on Truth as most important.

over

It is one of the tragedies of our time that in at least one country science is being thwarted, warped, twisted for propaganda ends. We know what has happened to some geneticists who have refused to distort truth for political ends. Any interference with the free spirit of inquiry, the honest search for truth in our own societies must be fought relentlessly.

To tamper with truth will destroy scientific and other progress & worse than that it will destroy the moral fibre of man. Ask any psychiatrist what is the cause of the great increase in mental illness and he will reply, it is largely due to mans refusal to face the truth about himself & about his environment.

What are the social implications of Science? I place first this emphasis on Truth.

and in every country through the centuries there have been men filled with the divine afflatus of the Truth Seeker,

[illegible]

Shelly There is one road to peace and that is Truth.

Augustine Courage my mind & press on mightily. Press on where truth begins to dawn.

The great practical problems - food, clothing, warmth, and power.

M.H.O - penicillin, surgery. nutrition.

Radar

V2

Conant in Nature -

Sir R. Gregory.

Sci. cannot be forced into a political mould & made a tool of some ideology.

Chance - J.H. Jeans.

Bruno. things have not come about by chance but through the determining mind

A.N. Whitehead. The order of nature is no accident.. sci & religion

Schroedinger What is life.

Gods and Men

Sir Richard Gregory

The spirit of human brotherhood will never be established through the agency of a single religion, but with this ideal as the driving force of them all. It is the essential factor of all international equations and will determine whether the human race will make its kingdom on Earth worthy of exaltation to the spiritual kingdom of Heaven. Both science and religion can co-operate in this humanistic service, each in its own field and in its own way, yet united in their endeavours to attain high ideals by works as well as by faith. These are the influences which have affected the course of civilization and the progress of the human race whatever relative values are attached to them.

Humanism, in the sense in which it is now best understood, is the integration of all human influences which promote the development of the human race, whether it includes the teaching of a particular religion or not. Whatever principles or practices raise man out of his animal ancestry and add to his status among living creatures can rightly be termed humanistic. Their spirit is manifested in works of science as well as in art and literature, and the measure of their value is that of improving human welfare on the highest standards that the mind can conceive. When these standards are supremely represented by attributes attached to a deity or deities, they are the elements of a religion of humanity, and devotion to them is the expression of an endeavour to cultivate goodness in thought and action.

Whatever views are held as to the meaning and purpose of man's existence, he finds himself on a globe from which he has to obtain material needs of life, and also with a mind which can appreciate such abstract qualities as beauty and love, justice and truth, whether seen on the Earth or projected on the heavens. Ethical or philosophic humanism takes account of all these factors of cultural development, secular or secred. It understands very clearly that the Earth is but a temporary home not only for the short space of individual life but also for the whole human race, As tenants or trustees our duty is to make the best use of the resources of our heritage by the exercise of all our talents and with the belief and hope that by so doing we are helping to make men sublime, morally and spiritually, as well as godly in the sense of religious faith. So may the Earth become part of the heavens of the universe in spirit, as it is already in truth.

P. 203

....science - the domain of reason - is systematic and formulated knowledge in all fields of human understanding - natural, moral, social and political.

(1) Natural science, or natural philosophy, is only one division of science as thus defined, yet, by general usage, the single word now signifies organized natural knowledge. The history of civilization from this point of view is a history of intellectual development in which science has been the chief factor in changing habits of thought from superficial observation and speculative and anthropomorphic theories of causation to clear concepts, rational conclusions, and progressive principles in the advancement of man and society.

....the general view in literary and other intellectual circles is that men of science are insensitive to beauty and incapable of deep emotion.

An increasing number of people now realize that the conception of a great scientific theory may be as significant an achievement, as high an activity, as the creation of a great work of pure literature.

Sir Richard Gregory

2 senses ? If the biochemist can

Is your acceptance of the possibility of creating life by chemistry in accordance with the christian faith? egg in an incubator.

Does a philosophy with cosmic background not mean a philosophy where humanity takes relief from the *fact* that universal life continues independent of human conditions, where a human philosophy should be based on human beings as ends and purposes in themselves.

If a fact then it is not escapism but honesty and sensible to take it into account - draw what lessons you can from it, what encouragement or what warning you can. but do *not* close your eyes to it. All Knowledge is One no water tight compartments. ∴ do not confine your thoughts or restrict them solely to *one* sphere - anew The worship of God is an adventure of the spirit, the study of nature, human or natural is an adventure of the mind —— perhaps both are adventures of both mind + spirit.

History is on our Side.
Jos. Needham.

p. 183. total no. of scientific men of first class reputation exiled from G. & Austria up to end of 1938 was 1880 and from Italy 225 from Spain 103, from Czechoslovakia 160.

Lord Rutherfords "Academic Assistance Council" placed about half in Br. & half in USA.

25% of Germany's Nobel prizewinners :-
Physics Schrödinger. Einstein. Franck, Hertz, Born, Hess. Chem Höber, Physiology Meyerhof and through Gt. B. to USA Chem Fajans, Freundlich Physics Stern etc.

In Gt. B. are also M Polanyi Chem; etc etc. and the Warburg Inst. of the Hist. of Thought & that transferred from Hamburg to London a valuable contribution to scholarship.

ASTRONOMY, PHYSICS, AND PHILOSOPHY

By A. Vibert Douglas

(The Address of the Retiring President of the Royal Astronomical Society of Canada)

I

IN the search for knowledge, whether it be knowledge of the physical world close around us or of the vast universe external to the earth or whether it be knowledge in the realm of philosophy and human conduct, the starting point is faith and the first step is frequently taken by the guidance of intuition. Then reason carries on, working inductively upon the facts of observation and experiment and deductively from the resulting generalizations, hypotheses and theories to point out crucial tests and observations. In the light of the results of these crucial tests, the generalizations must then be reconsidered. Thus the scientific method gets underway and whither it leads the honest seeker after truth must follow. "Trust in reason," wrote Dean Inge voicing in this age the thinking of Clement of Alexandria in the sixth century, "in reason which rests ultimately upon faith in the Divine Logos, the self revealing soul of the Universe." "In the age of reason," says Sir Arthur Eddington, "faith yet remains supreme; for reason is one of the articles of faith."

This basic and fundamental position of faith in the realm of ethics and the moral law is said to be the main thought behind Dostoevski's great novel, *Crime and Punishment*. In a recent article by E. M. Dodd on this subject, it is stated that recognition of Moral

Law "is not an act of Reason in the sense of intellection . . . Reason cannot exalt Altruism into an obligation nor establish the idea of the sanctity of human life; these perceptions are the reward of Faith, and it is in virtue of them alone that Reason is relevant to human life at all." Whether or not we are convinced that this is true of all men, we may probably agree with the late Poet Laureate when he writes "Verily by Beauty it is that we come at Wisdom yet not by Reason at Beauty."

In the realm of science we find the basic rôle of faith enunciated thus by A. N. Whitehead: "Faith in reason is trust that the ultimate natures of things lie together in harmony which defies mere arbitrariness." It is this faith in the order of Nature that has sustained men of science in their search for truth in spite of all difficulties, false clues, shattered theories and apparent failures; it has led them to defy discouragement and to erect through the centuries the stately edifice of science which we know today, an edifice that is growing before our eyes and will continue to grow as long as thinking man inhabits the earth.

Man's reliance upon an intuitive leading is no less certain here than in the realm of philosophy. Three of the greatest mathematicians of our time have borne testimony to this fact. Describing his attempt to derive from "world-geometry" not only gravitational phenomena, as in the pioneer work of Einstein, but also the full range of electromagnetic phenomena, Weyl says that in order "to bring about the transition from affine to metrical geometry we must once more draw from the fountain of intuition." Similarly, Lemaître, referring to one particular line of reasoning at the outset to his theory of an expanding universe, writes that "this method provides a very intuitional way of considering the equations of the universe." Eddington has written as follows: "In science we sometimes have convictions as to the right solution of a problem which we cherish but cannot justify; we are influenced by some innate sense of the fitness of things."

We should not forget however that though intuition may suggest a starting point it must never be thought of as providing a resting place. It is reason that must take this wisp of intuitive thought and examine it, test it, stretch it, weave it, harness it. Thus in their fundamental approach to the furtherance of knowledge we see that philosophy, physics and astronomy have much in common. It is equally true that there have been strong mutual influences exerted by each on the others as knowledge grew in these fields.

II

Within the interlocking fields of mathematics, physics and astronomy, the influences have been continuous and sometimes spectacular. Both physics and astronomy depend upon mathematics as a tool. The investigations into conic sections by Appolonius of Perga and other early geometers were ready to hand when Kepler, many centuries later, sought out his empirical laws of planetary motion. When Newton subsequently established their theoretical validity in terms of the inverse square law of gravitation, and when he investigated the trajectories of projectiles, it was this geometry that he found to be applicable. When he encountered certain fundamental problems in mechanics and stellar dynamics and discovered his mathematical tools to be inadequate, Newton invented fluxions. Other problems remained unsolved until Sir William Rowan Hamilton invented quaternions.

The investigations into non-Euclidean geometry by Gauss, Lobatchevsky and Riemann and the developments of tensor calculus by Ricci, Levi-Civita and Christoffel had produced mathematical tools which it was the genius of Einstein to recognize as best suited in the representation of physical phenomena. Einstein's pioneer work led to the cosmological researches of de Sitter, Weyl, Eddington, Lemaître, and subsequently of Milne, Schroedinger and Saxby.

When atomic physics and spectroscopy were faced with problems and difficulties which appeared insoluble, de Broglie initiated a new era with wave mechanics. New mathematical forms had to be invented, hence Dirac's wave-tensor calculus. Physics found new applications for determinants and theory of groups. So, too, in astronomy it was when the investigation of stellar structure was seen to involve Emden's equation that R. H. Fowler turned his attention to this problem and obtained a complete classification of all solutions of this important second-order differential equation, a permanent and beautiful contribution to pure mathematics. We need not labour this point: obviously Supply and Demand or Demand and Supply are operative principles in this realm of intellectual effort, and whether it be competitive or cooperative at the outset the result is always ultimately and cumulatively beneficial to all future investigators in these fields.

III

The close association between physics and astronomy can best be illustrated by means of a parable.—Two young investigators filled with the curiosity, imagination and faith of the scientists, came to Dame Nature and said: We wish to give our lives to scientific research, what shall we do? To one Dame Nature replied, Take thou the atom. To the other she said, Take thou the star. Perhaps you think, as they did, that their paths would never cross, the one in his laboratory delving into the profundities of things so small that no microscope will reveal them, the other in his observatory photographing a distant galaxy of many thousand million stars. You can imagine that each might become discontented with his lot, and, with that strange perversity of human nature, the one may return to Dame Nature and say: You told me to study atoms, but I should like to study stars! And the other may come back and say: You told me to study stars, but I want to study atoms! And Dame Nature will smile quietly as she replies: Yes, I told you to study the atom; return to your laboratory, bend all your energy to the task and some day you will find that the walls of your laboratory are expanding and expanding until they include—the stars. To the other she will make answer: Yes, it is true that I told you to study stars; return to your telescope, your spectrograph and your measuring instruments and lo! very soon you will discover that you are really studying atoms. This is not merely a parable, it is the actual truth.

In the light from the limb of the sun observed just before and after totality at the eclipse of 1868, an intense yellow ray was noted to which the astronomers could give no identification. The unknown atom was given the name helium because of its solar origin. Here was a challenge to the physicists and chemists, but not until 1895 did Ramsay, the chemist, find this element in the earth's atmosphere; not until some ten years later did Rutherford, the physicist, find by spectroscopy that the alpha particle, one product of radio active disintegration, is the nucleus of a helium atom; and not until the years of the first Great War was helium found in natural gas from certain wells.

Physics has been hampered in its efforts to determine the properties of matter by the existing limitations of terrestrial laboratories. How matter behaves at extremely low temperatures was not known until the development of cryogenic laboratories first at Leyden, and afterwards at Toronto and elsewhere. In high temperature investigations, the limit was until relatively recently the crater of the arc in an electric furnace—a region whose temperature just overlapped that at the radiating surface of the cooler stars. This is where astrophysics took up the investigation and observed the behaviour of matter at successively higher and higher temperature.

Today in terrestrial laboratories it is possible to obtain temperatures up to 6,400°C. with a specially controlled tungsten arc and experiments with exploding wires under high potential indicate peak temperatures of between 19,000°C. and 20,000°C. In the photospheres of stars of classes G to B the astroyphysicist has sources of continuous radiation from matter at these temperatures. The central stars of some planetary nebulae have surface temperatures which may be as high as 100,000°C. This estimate is based upon the fact that a lesser temperature would not permit of radiations which can produce in the surrounding nebulous gases high ionization such as thrice ionized oxygen. Beyond this we may not go by direct observation but astronomers have calculated the temperatures in the deep interiors of stars as exceeding 10^7 degrees. This has been done by mathematical investigation of the equilibrium conditions from photosphere to centre checking results by the observed output of energy. If the central temperature of a star be postulated too high, the liberation of energy would be so great as to blow off the surface layers by the violence of radiation pressure. On the other hand too low a central temperature would result in a general collapse of the gases forming the outer layers under gravitational forces unbalanced by sufficient gas and radiation pressure. Sir Arthur Eddington was a pioneer in this work.

A new era in spectroscopic research began when Sir William Crookes developed low pressure discharge tubes. A good vacuum today is one in which the gas pressure is reduced to about 10^{-6} mm. Hg. This is the pressure high up in the solar chromosphere as studied in the flash spectrum. The lowest pressure attainable in the laboratory is said to be about 10^{-9} mm. Hg. Even here there are still 10^{7} molecules per cc. The least dense star known to astronomy is the large infra red component of the binary system $7\,\epsilon$ Aurigae. Its density is 10^{-9} gms/cc. for though it is a massive star, its radius is three thousand times that of the sun. The solar system out to Saturn's orbit could all lie inside this star. Its substance is so tenuous that it would be transparent were it not for the partial opacity, the "Heaviside effect", due to ionization produced by the radiation from its hot bright smaller companion. In interstellar space we have matter at a temperature of about 4° Absolute, so attenuated that there is only an average of one atom in each cubic centimetre. To get a real idea of what this approach to emptiness signifies, it is necessary to remind ourselves that in a cubic centimetre of air at standard temperature and pressure there are 2.7×10^{19} molecules. The presence of interstellar lines in the spectra of distant stars reveals the behaviour in interstellar space of calcium, sodium, hydrogen, potassium, iron and ionized calcium, nitrogen, oxygen and titanium as well as the molecules CN, CH and CH^{+}. From this evidence conclusions may be drawn as to the behaviour of other atoms and molecules under analogous physical conditions.

At the other extreme, that of very high density, the physicist is limited by his inability to compress matter much beyond the natural density of the densest element, osmium 22.5 gms. per cc. The most powerful hydraulic press will not compress this by more than a small fraction. But here again the stars provide extreme conditions far exceeding those of the terrestrial laboratory. In the white dwarf stars the properties of matter at densities of 30,000 and more can be studied. In this new field for theoretical investigation R. H. Fowler showed that the statistical mechanics of degenerate gases explained the behaviour of these stars.

Yet another striking example of the interlocking of physics and astronomy is to be found in the developments of nuclear physics where experiment and theory led to the postulate of a new fundamental particle—the neutrino. Having the mass of an electron or a few multiples of this, escaping direct detection because electrically neutral, its existence is none the less a legitimate hypothesis because by no other hypothesis have the energy relations of certain known nuclear changes been balanced. The principle of conservation of energy appears to demand the existence of neutrinos. In astronomy there arose a new problem of universal significance with the realization that a supernova was a cataclysm of nature whose magnitude vastly exceeded that of an ordinary nova. To explain this catastrophic liberation of energy, Gamov has called in the assistance of the minute neutrinos. He has suggested that a very massive star may increase in central temperature to 10^9 degrees while the usual sources of stellar energy are operating, but at this point new nuclear reactions begin and neutrinos may be liberated in great numbers. These neutrinos carry off much of the gravitational energy of the star which will collapse with such suddenness that vast amounts of energy-producing gases are hurled outward. The result is the unrivalled phenomenon of a supernova.

Astrophysics is a subject bristling with unsolved problems, and with exciting hypotheses. Progress will not be due to physics alone nor to astronomy alone, but to that happy combination of both these sciences in their observational, experimental and theoretical aspects. Such a combination will achieve its highest expression in a mind of creative capacity and holistic quality capable of framing "out of three sounds . . . not a fourth sound, but a star."

IV

The influence of astronomy upon philosophy, including religious thought, is not a subject that can be briefly and categorically stated for it offers an outstanding example of the truth contained in the old maxim *Quot homines tot sententiae* or, in modern phraseology, the same stimuli may produce very different reactions in different individuals. "The ancient world," wrote Whitehead in 1925, "takes its stand upon the drama of the universe, the modern world upon the inward drama of the soul." Today many people would substitute for the soul the words society and the individual, believing that sociology, biology and psychology are now the dominating influences upon philosophy. Yet it is still very true that the inward drama of the soul and the dramas of the mind and of mankind are often profoundly influenced by the drama of the physical world where the actors are radiations, electrons, atoms and stars.

In the ancient world with its geocentric cosmology it was natural for very great importance to be attached to man. For him the sun and moon were created to give light upon the earth, for him the stars marched nightly across the sky, for him the seasons brought seed-time and harvest, for his sins the earth was visited by drought or quake or pestilence. The importance of man in the scheme of creation was sung by the Psalmist—What is man that Thou are mindful of him . . . Thou hast made him a little lower than the angels and hast crowned him with glory and honour . . . Thou hast put all things under his feet." Shakespeare had caught this spirit when he wrote his famous "What a piece of work is man! how noble in reason! how infinite in faculty! . . . in action how like an angel! in apprehension how like a god!"

When the Copernican cosmology replaced the Ptolemaic, the importance of man became no longer an obvious deduction from a survey of the physical world, and an assertion of his intrinsic importance had to be supported by arguments based solely on his intellectual or spiritual worth. This has been the case ever since. To some types of minds in whatever age the spiritual reasons always outweighed the purely physical, but there are other people to whom it comes as a great shock that man appears to be but an accidental development in very recent ages upon this little old earth, a minor planet, revolving about one quite ordinary dwarf star whose position is somewhere far out from the centre of one of the many millions of galaxies of stars. To minds of this type the Copernican cosmology represents a major upheaval of what had become traditional thought. Astronomy thereafter pictured man as a mere speck in the immensity of space, and a late-comer in time. Then geology joined forces with astronomy to measure out time by era upon era, so that the average span of a human life is to the estimated age of the earth as one minute of time to three score years and ten. Biology added to the mental upheaval by appearing to present a rigidly mechanistic view of life —the great conceptions of evolution, of natural selection, the discoveries of physiological and psychological sciences being swallowed, unmasticated and often misunderstood, by a hungry or a gullible multitude. Bishop Gore thought the effect of all these ideas upon the religious imagination, could hardly be exaggerated:- "They seemed as represented in popular literature almost to obliterate God, behind a self developing universe, and to reduce the position of man to insignificance." In our own day the great challenge is once more coming from astronomy, according to Bishop Headlam. The great popularity of various non-technical books dealing with the recent discoveries in astronomy, astrophysics and atomic physics has brought thousands of people face to face with some of these facts for the first time; and they are mentally and spiritually staggered by the immensities of time and space, and by what seems to them the grandeur or the grimness of inexorable law. It is worth noting that it is the readers rather than the authors who react in this manner. The average reader will frequently draw extreme conclusions and be swayed into adopting an essentially illogical attitude of mind very far from the position which the author himself holds and intended to convey.

It is strange that men are so easily appalled by large numbers—but it is none the less certain that this is a very usual reaction. One blade of grass is intrinsically quite as wonderful as a thousand blades of grass, and ten thousand million stars are no more wonderful than is one star, yet man is overawed by mere number. We see this in Shelley, for whom "the plurality of worlds—the infinite immensity of the universe is a most awful subject of contemplation. He who rightly feels its mystery and grandeur is in no danger . . . of deifying the principle of the universe." Yet the men who actually count the stars, measure their distance, and time their revolutions are very rarely the men who deny God, the Creator of the universe. Contemplating the evidence for cause and effect—the reign of law—in the physical universe, Shelley exclaims, "Necessity! thou mother of the world!" and in his footnote he draws this conclusion "The doctrine of Necessity tends . . . utterly to destroy religion."

A few years before Shelley had written these negations in footnotes to *Queen Mab,* the very same astronomical discoveries and the great achievements of Newton were influencing the thoughts of

Immanuel Kant; but very different were his reactions. The grandeur of a planetary world, the Milky Way, the nebulae, super-systems of stars—"the infinite field of Creation—the work of God—the great Builder of the universe—We see the first members of a progressive relationship of worlds and systems—an abyss of real immensity in presence of which all the capability of human conception sinks exhausted, although it is supported by the science of number. The wisdom, the goodness, the power which have been revealed are infinite." Kant's affirmation is well known that two things moved him to reverence—the starry heavens without and the moral law within.

In Pascal we see a philosopher overwhelmed equally by the vastness of the visible world, which is itself but "an imperceptible speck in the ample bosom of nature" and by the abyss within the smallest conceivable particle of matter. Between these two extremes, he stands silent. For him there is no easy acceptance of a God revealed by Nature—a reign of Law, yes; the sublime triumphs of mathematical expression of natural law in the outer universe were in progress. Copernicus, Bruno, Kepler, Galileo, Bacon, Descartes, these were the influences so potent upon thought in the 17th Century, and on Pascal and Spinoza these influences made deep impression. But while the former turns from the outer world of nature to seek God in the spirit of man, the latter finds Him "the immanent cause of all things. . . . From the infinite nature of God, all things follow by necessity."

Given a completely random assemblage of all the energy of the stellar system, what is the probability of the present state of organization having come about by pure chance? This is the question asked and answered by Sir James Jeans whose calculation showed that the probability was so incomprehensibly small as to indicate rather impressively the logical need for a Creator, a Great Architect of the universe. Bruno arrived at a similar conclusion without climbing up a ladder of mathematical reasoning—"For things have not come about by mere accident, but through the determining mind." Whitehead likewise reaches this conclusion by no devious path—"The order of the world is no accident—the religious insight is the grasp of this truth."

There is a class of public speakers and writers who misunderstand and misuse modern scientific thought in an effort to obtain oratorical effect or to bring into sharp relief the contrast between the physical and the moral order. A stock phrase is that the physical universe is "a soulless repetitive mechanism." The picture conjured up before the mind is of stars and planets endlessly circling about their appointed orbits for ever and ever and a day—a picture of futility and changelessness; and against this mechanistic principle of nature the spirit of man is urged to fight. This conception is contrary to the true astronomical and physical picture, and much loose thinking is woven about it.

No one can ponder upon the solar system, upon the great multiple star systems, or upon the beautiful photographs of the spiral galaxies, and argue that this is a static universe. It is obviously a dynamic universe; but it is not the arena of haphazard change nor of mere repetition—it is a dynamic universe of directed change. All the change that goes on in the physical universe is towards unavailability of energy; "physically wasting but spiritually ascending," to quote the comment of Professor Whitehead who in those five words reveals himself as both physicist and philosopher. Thinking not only of cosmological changes but also of the geological and biological changes which the centuries and eras reveal, Herbert Spencer framed his evolution-formula, postulating that development in all things proceeds from a state of "indefinite unstable homogeneity" towards a "definite stable heterogeneity." It is important to note that in this famous metaphysical speculation there is no suggestion of mere repetition.

V

The dynamic phrase, The Prime Mover, is one of Aristotle's great contributions to metaphysical thought. The Greek philosophers were steeped in the astronomical knowledge of their day, and cosmological speculation flourished in their midst. Asked what was the chief object of being born into this world, Anaxagoras replied—To investigate the sun, moon and heavens. And Plato impressed upon his students that theirs was the high task of finding "what are the uniform and ordered movements by assuming which the motions of the planets can be explained." That the sun, moon, planets and stars moved, and moved in obedience to some law, was an observation of tremendous significance to the Greek philosophers. When Aristotle sought to complete his Metaphysics, he was driven inevitably and inexorably by the force of dispassionate logic to postulate the great Prime Mover. The significance of this can scarcely be overemphasized. It has influenced much philosophic thought down to the present day. It is one of the strong influences playing upon the mind of Whitehead when he undertakes the difficult task of restating a metaphysics in terms of modern language in the light of modern knowledge. With the passing of the very limited and artificial cosmology of the Greeks, the metaphysical need of God as the Prime Mover has disappeared. Motion, in the thought of the natural philosopher of the 20th Century is simply one of the many forms of energy. But an analogous metaphysical need does arise, and Whitehead is led to the conclusion that "the general character of things requires that there be such an entity. . . . God as the Principle of Concretion."

The sport of sports to the master cosmological thinkers during the past twenty years, has been to devise mathematical equations representing various geometries of space and time; equations from which would arise, or within which are embedded, so to speak, as identities the mathematical representations of the laws of nature as the astronomer and as the physicist sees them. This means that the so called laws of nature are not edicts imposed from without—the law of gravitation for example, is not what it is because the Prime Mover propels the planets around certain orbits with certain velocities. The laws of nature are what they are because the universe including the mind of man is what it is—a sentence that is inspired by Whitehead's remark that "the electron does what it does because it is what it is," which saying can be glibly made, but carries a meaning not entirely on the surface.

Now each one of these proposed cosmological equations may represent a theoretically possible universe and there may well be an infinity of such possibilities, but no one of the entries (whether of Einstein, or de Sitter, or Lemaître or other) has won the blue ribbon, because no one of their equations truly and completely represents the actual universe. Furthermore even if such an equation be formulated, this fact still remains obvious that this equation is only one of the many representing theoretically possible universes. "We conceive actuality as in essential relation to unfathomable possibility." (Whitehead)

The prime command and its result, are set forth in the Book of Genesis with stately simplicity—"And God said, Let there be light, and there *was* light"—not any kind of light, with any of the many different properties one might imagine that light could conceivably display; but the particular kind of light that plays so basic a part in our physical experience, the light whose properties are so beautifully set forth in the Maxwellian equations and quantum laws. "Every actual occasion is a limitation imposed on possibility," to quote again from the author of the phrase, the Principle of Concretion, "God is the ultimate limitation—God is not concrete, but he is the ground for concrete actuality."

Two of the baffling mysteries which challenge the mind of the philosopher are space and time. Into what category is he to put them and how define them? Newton, Leibnitz and Kant strove to clarify these terms. Newton took them for granted as things-in-themselves, —eternal, infinite, self-subsisting—a point of view that drew fire from Kant. Leibnitz classified them as ordinary concepts, to which Kant raised the objection that ordinary concepts have instances, whereas there is but one space and one time. Kant regarded space and time as the forms of perception, external and internal, respectively; in no sense things-in-themselves, yet not illusions; transcendentally ideal, but empirically real. While this critical sifting of words and ideas went on and on, the absolute Euclidean space, and "absolute, true and mathematical time" accepted explicitly by Newton, provided the frame-work within which the Newtonian celestial mechanics functioned with spectacular success for nearly two hundred years. Then the triumphant chorus of astronomical approval of absolute space and time began to falter. The motion of the perihelion of Mercury's orbit refused to conform to Newtonian calculations. Physics likewise provided food for thought—the earth's motion relative to the ether could not be detected, and the apparent mass of an electron was found to be a function of its velocity.

Einstein's Theory of Relativity swept absolute space and absolute time from the astronomical, the physical and the philosophical horizons. Three out of four crucial tests of this theory were astronomical; and it is the astronomers, naturally, who are providing the observational data that is hurling out the frontiers of explored space to almost inconceivable distances. The velocity of light being finite, the astronomer is looking backward in time as he looks outward in space. How far he is justified in interpreting what he sees in the stellar universe in terms of physical laws established in a "Here-Now" environment is a question upon which it is not wise to be dogmatic. P. W. Bridgman has warned that such a procedure applied at the limits of the astronomical time scale is a "hair raising extrapolation"! Into the thoughts of many cosmologists has come the idea that what appear to us as laws of nature are relationships between phenomena which are the result of the sum total of physical conditions as they now are, and of the selection from this sum total which is made by the mind of the natural philosopher, a selection largely dictated by the mind's own limitations. Eddington has stressed this latter part, the subjectivity of the laws, while repudiating the former part on epistemological grounds. He has said, "The constants of nature (apart from our arbitrary units) are numbers introduced by our subjective outlook, whose values can be calculated *a priori* and stand for all time."

Philosophy attempts to survey all knowledge and fit the significant principles of all departments of knowledge into a coherent whole. When Heisenberg's Principle of Uncertainty was enunciated in 1927 it very soon became grist for the philosophers' mill. Some refused to accept this indeterminism as intrinsic in the universe, attributing the uncertainty in position and momentum of a particle to man's inability to observe and measure with sufficient accuracy or to an inadequate formulation of the concepts of physics; quite failing to grasp the significance of the fact that the products of these two uncertainties is a constant. The law of causality has dropped completely out of physical science in the sense that the present system of fundamental laws can deal with probabilities but cannot predict the future of the universe. This is a fact not yet fully assimilated by philosophy. Some amateur philosophers have taken the fact of indeterminism as an argument for freedom of will in the individual—a misuse of ideas relevant to the realm of physical science which is wholly to be deprecated.

Twenty-five years ago natural philosophers and metaphysicians faced what appeared to be a deep gulf fixed between atomicity and the entire realm of macroscopic phenomena. No mathematical bridge led from quantum theory to the theory of relativity. From 1924 onward Eddington worked relentlessly to produce "a harmonization rather than a unification," of these two. The result is a theory which relates all the fundamental physical constants both atomic and cosmic. In 1936 he wrote, "Unless the structure of the nucleus has a surprise in store for us, the conclusion seems plain—there is nothing in the whole system of laws of physics that cannot be deduced unambiguously from epistemological considerations." The link is made by identifying a function of the number of independent wave-systems existing in the universe with the ratio of electrical to gravitational force between a proton and an electron. This work stands as a monument to a very great thinker. He has written (1932): "A slight reddening of the light of distant galaxies, an adventure of the mathematical imagination in spherical space, reflections on the underlying principles implied in all measurements, nature's curious choice of certain numbers such as 137 in her scheme—these and many other scraps have come together and formed a vision." And with a humorous touch he adds—"a most rare vision . . . Bottom's dream."

This work has drawn fire from Dingle, Born and others because they regard with distrust such pure Aristotelianism. Born has recently written "If they (Eddington's results) should turn out to be right I shall rejoice. But I shall not attribute this (possible) success to Eddington's philosophy, as a doctrine which could be followed by others, but to his personal genius and intuition." This, to my ears, has the sound of evasion. The Astronomer Royal has ventured the opinion that "it may well be that generations yet to come will regard Eddington's recent work as one of the most important and significant advances in science." Unfortunately few scientists and fewer philosophers have the mathematical competence to understand it fully.

Other avenues of attack have been explored in 1943-44 by Saxby, by Einstein and Bargmann, and by Schroedinger, all realizing the need of a unified theory embracing gravitation, electromagnetism and the meson field involving quantum laws. Their work develops directly from the earliest modifications of Einstein's original theory by Weyl and Eddington. It is not yet evident how successful these efforts may prove to be. Relatively few people have the training and urge to analyse such work critically. But there is good evidence that in this rarefied region the adventuring in ideas is by no means at an end.

I have dwelt at some length upon changing and developing cosmological ideas to drive home the truth of the assertion that man's interpretation of the drama of the universe has been and is a powerful influence upon philosophy in its widest sense. In the more personal and intimate philosophy which consciously or unconsciously guides the actions and attitudes of individuals in society, I believe there is need of a much greater influence from astronomy. Religion, or personal philosophy, has too often been a cause of dissention, hatred and war. Why? Is it because man is apt to be like Caliban imagining Setebos altogether such an one as himself? God, at worst a supermonster, at best a tribal deity! It is astronomy which provides the far vision in space and in time, giving us the cosmic setting so essential if we would see the world in true perspective and formulate an adequate philosophy. Like Kepler we should bow down before facts and let them speak to us. One of the facts of observation is that amid all the vastness of the stellar universe we know of one small planet upon which in the fullness of time there appears this being called man to whom truth, goodness and beauty are significant, sometimes so significant that he will count not his life dear unto himself that he may pursue these. A man's philosophy must face this fact squarely, as also the facts of the physical universe where natural law operates; a man's idea of a God must be so large that this God is Creator and Sustainer of the vast universe of stars and galaxies and also in some measure akin to the mind and spirit of man, striving, struggling, failing but striving again—both literally and metaphorically, towards the light.

Queen's University,
Kingston, Ontario.
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INTERNATIONAL ASTRONOMICAL UNION, 1948

By A. Vibert Douglas

THE seventh General Assembly of the International Astronomical Union took place from August 11-18, 1948 in the magnificent Swiss Federal Institute of Technology in Zurich. The setting was perfect. Swiss hospitality and efficiency in planning are unbounded, and Zurich has almost everything—a lake, two rivers running through the city, hills within and around the city, historic buildings, many narrow steep cobbled streets, here and there a square or triangular *platz* with a fountain or heraldic statue adorning it, a cloistered minster with traditions dating back to Charlemagne, and several smaller churches with famous clock towers; broad modern avenues, schools, colleges, research laboratories, hotels, pensions, shops, museums, and a funicular to the new residential sections high up above the lake.

Some 300 astronomers from 32 countries had gathered to renew scientific and friendly contacts, to discuss the progress in their specific fields, record achievements and difficulties, delineate new problems, and plan further cooperation.

The largest delegation was from Great Britain (about 44 astronomers), closely followed by France and the U.S.A. with 42 listed from each. There were three Canadian delegates, the Dominion Astronomer, the Director of the Dominion Astrophysical Observatory and the writer. Dr. Beals was named chairman of the Finance Committee of the I.A.U. A fourth name appearing in the list from Canada was that of a temporary resident of this country, Mlle. van Dien of Holland now on the staff of an observatory in the Dutch East Indies.

Moving about from commission to commission, from seminar to informal lunch or tea, from formal banquet to lake or mountain excursions, from a music recital at the minster to an occasional casual ramble through the old picturesque streets, one talked with many an old friend and new acquaintance. One's thoughts were continually being carried back to similar groups in other days in other surroundings. Seven of us who had met in Montreal in August 1932 preparing for the total solar eclipse met again in Zurich—Herbert Dingle, F. J. M. Stratton, J. A. Carroll, G. Abetti of Arcetri, Canon Lemaître of Louvain, S. A. Mitchell of Virginia. Seven of us, representing five nationalities, had met at Yerkes Observatory in the summer of 1925. Four of us had dined as guests of Miss Vinter Hansen at Copenhagen Observatory in early June and the previous week I had met another four at Leiden University. There were the Greenwich friends, and those from Cambridge, from Oxford, from Harvard and Mt. Wilson. There was John Jackson all the way from the Cape of Good Hope and he carried my thoughts to Greenwich in 1923 and to Boston in 1932 when we laughed together over the bicycle pump at Greenwich which had succeeded in reducing the pressure in a Shortt Clock case to a certain minimum value that was afterwards found by Loomis with elaborate apparatus and thoroughness to be the optimum pressure. Many astronomers were conscious of missing faces—ten years can thin the ranks and among the great scientists whom the I.A.U. mourned were Eddington, Jeans, A. Fowler, R. H. Fowler, E. Strömgren and Deslandres.

The I.A.U. operates through commissions, each assigned to specific tasks, and usually several of these groups were simultaneously at work.

As summaries of the proceedings and reports have appeared in *Observatory* (Vol. 68, No. 846), *Nature* (Vol. 162, No. 4127), *Sky and Telescope* (Vol. 7, No. 12), I shall restrict myself to those commissions and seminars which I attended with special interest.

The Commission on Solar Radiation was presided over by Dr. Abetti. Much discussion centred upon the variations reported, confirmed and unconfirmed, in the solar constant and in the solar field. Regarding the former, indirect and somewhat conflicting, evidence from observations on the moon, Jupiter and Saturn were reported—variations of about three per cent. may be present and more observations were urged of the total energy, the ultraviolet and in the radio range. As to the magnetic field, a recent determination gave 5 gauss; but here, too, inability to repeat readings, and the apparent occasional or perhaps periodic disappearance of the field call for fresh methods of attack on this problem. Öhman suggests detection of circular polarization of solar radio waves from one polar region at a favourable partial eclipse.

The Commission on Extragalactic Nebulae showed a geographic alignment of observational astronomers vs. theoretical investigators.

The cosmologists, McVittie in particular, urged the importance of publication of data corrected only for standard instrumental and "local" effects. Only thus could such data be used to test one theory of world structure against another. Hubble, Stebbins and Shapley presented the observational evidence. Hubble commented on the tendency for the galaxies to be in clusters, and the pressing need for stellar magnitude sequences for red and blue stars and for investigation of the effect of red shift upon apparent magnitude. Stebbins gave evidence of increased reddening with distance which might imply intergalactic matter or a higher proportion of red supergiants in the more and more remote past corresponding to our knowledge of the more and more distant galaxies. Shapley produced some evidence of the uniqueness of our galaxy from the high luminosity of our great globular clusters, and he repeated his warning that the open spiral may be a forerunner of the elliptical galaxy rather than a later development from it.

A masterly report on spectrophotometry was presented by Minnaert. In the meeting of this Commission 36, Struve summarized many recent investigations such as: CO_2 in the atmosphere of Venus of an amount equivalent to 50 metre-atmosphere; reflected sunlight from the moon and Mars resembles that from brown igneous terrestrial rock; reflections from Martian polar caps is not like that from solid CO_2, but resembles that from H_2O frost deposited on a very cold surface; green areas of Mars reflect not as from chlorophyl, but as from dry moss and lichens; Saturn's rings and five inner satellites may be composed of ice.

In Commission 29 some important contributions were: Ramberg on the spectra of the Hyades; Vyssotsky on the *G* stars and *G* band; Beals on the molecular spectra of Wolf-Rayet, *C* and *N* stars, parallel sequences of which one group shows no nitrogen but bands due to carbon and oxygen, whereas the other group has no carbon but contains bands due to helium and nitrogen, high ionization indicating temperatures of 70,000 to 100,000 degrees though these Zanstra estimates are subject to some questioning.

A symposium on the abundance of elements was a high point. Minnaert opened the three and a half hour session with a discussion of solar absorption line problems; Minnaert's table of relative abundances in the sun was compared with Menzel's values for planetary nebulae, Strömgren's values for interstellar matter and Unsold's values for T Scr. Hoyle discussed the Mass-Luminosity relations applicable to stars from 0.5 to 1.5 times the sun's mass. His conclusion that main sequence stars, in spite of the steady drain on their hydrogen by the energy-producing cycle, are still composed predominantly of hydrogen is in direct line of succession to Eddington's pioneering in this field a quarter century ago.

Then followed a stimulating paper by Klein on the origin of the isotopes of elements in their observed relative abundances. The pioneers in this investigation were Chandrasekhar and Heinrich about ten years ago. They postulated a tremendously dense and hot concentration of all the matter of the universe in the form of elemental or nuclear particles, and statistical equilibrium conditions resulted in a distribution of isotopes of the lighter elements very closely in agreement with observation, but the method broke down for the heavier elements. Klein and his associates postulate stars of nuclear matter with central temperatures of 10^{10} degrees and show that the relative abundances necessary for statistical equilibrium are in good agreement with the actual distribution.

The last contribution was a masterly review by Struve of challenging problems presented by the spectra of certain stars. He referred especially to Pearce's mighty giant binary, most massive star known, whose sharp Bq spectrum shows emission lines and also some stark effects, anomalies which make it "a very important star".

It is tempting to go on and on as the mind dwells on other meetings—Shapley on an International Observatory and Laboratory with Unesco cooperating; Stratton on exchange of astronomers and the need for travel and maintenance funds, which led the writer to draw attention to the C.C.R.U. study and research fellowships and to urge some astronomers to apply for these and spend a year at a Canadian observatory; Ambarzumian, one of seven U.S.S.R. astronomers, discussing the effects of interstellar matter in relatively small clouds having random distribution in the galactic plane; the demonstration of Lyot's polarizing filter on the sun (though this observer did not see a flare); the exciting films of solar prominences and infalling gases taken at Climax, Arizona.

My personal interest in Eddington's *Fundamental Theory*, published under that title after his death, led me to seek expressions of opinion from many of the astronomers at the congress. I found few who had taken pains to study it seriously, and only one, Canon Lamaître, who is so sure of its basic importance that he is working upon it himself. He was greatly impressed with an exerpt from a letter of Eddington's which I quoted, and which I repeat here because of its intrinsic interest (see J.R.A.S.C., Vol. 38, No. 3, 1944, p. 98) "I think the theory now deserves to be the accepted theory—my definition of an 'accepted theory' being that it is the theory that is so far right that everyone is interested in trying to discover what is wrong with it". Apropos of this, it may be of interest to refer here to a chance meeting at a lunch at Christ Church, Oxford, in July with Professor Whittaker of Liverpool University. He is a mathematician and son of Sir E. T. Whittaker who took all Eddington's manuscripts and prepared *Fundamental Theory* for the press. Both father and son believe that, though parts of the theory are unconvincing in Eddington's presentation and though his train of thought is often obscure, nevertheless time and further research will vindicate his depth of insight and establish the essential truth and fundamental importance of his last contribution to knowledge.

There is nothing static about astronomy, and to meet new demands the I.A.U. has revived the Commission on Celestial Mechanics and formed new commissions on Radio Astronomy, on History of Astronomy, and on Photometric Double Stars.

Sir Harold Spencer Jones has been succeeded in the presidency by Prof. Lindblad of Sweden; and Dr. J. H. Oort of Leiden, the capable and untiring secretary, has passed this responsibility to the broad shoulders of Dr. Strömgren of Copenhagen.

To the Council of the Royal Astronomical Society of Canada which named me a delegate to the 1948 I.A.U. Congress my thanks are herewith expressed with sincerity and appreciation. In a world where there is much political and economic distrust, it is heartening to find scientists of many nations meeting as friends, planning together for the advancement of their science, reducing to a minimum their nationalisms and petty differences, and placing integrity in research above all else.

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February 15, 1949.

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