История научных публикаций

Предшественники и конкуренты

- Copernicus “*De revolutionibus orbium coelestium*”
- Bacon “*Novum organum*”
- Kepler “*Dioptice*”
- Galileo “*Sidereus nuncius*”
- Descartes “*Discours de la mŭthode*”
- Newton “*Principia*”

Работы ученых древности

- Только рукописи

ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI

COMPRESE IN TRE LETTERE SCRITTE

ALL'ILLVSTRISSIMO SIGNOR

MARCO VELSERI LINCEO

DVVMVIRO D'AVGVSTA

CONSIGLIERO DI SVA MAESTA CESAREA

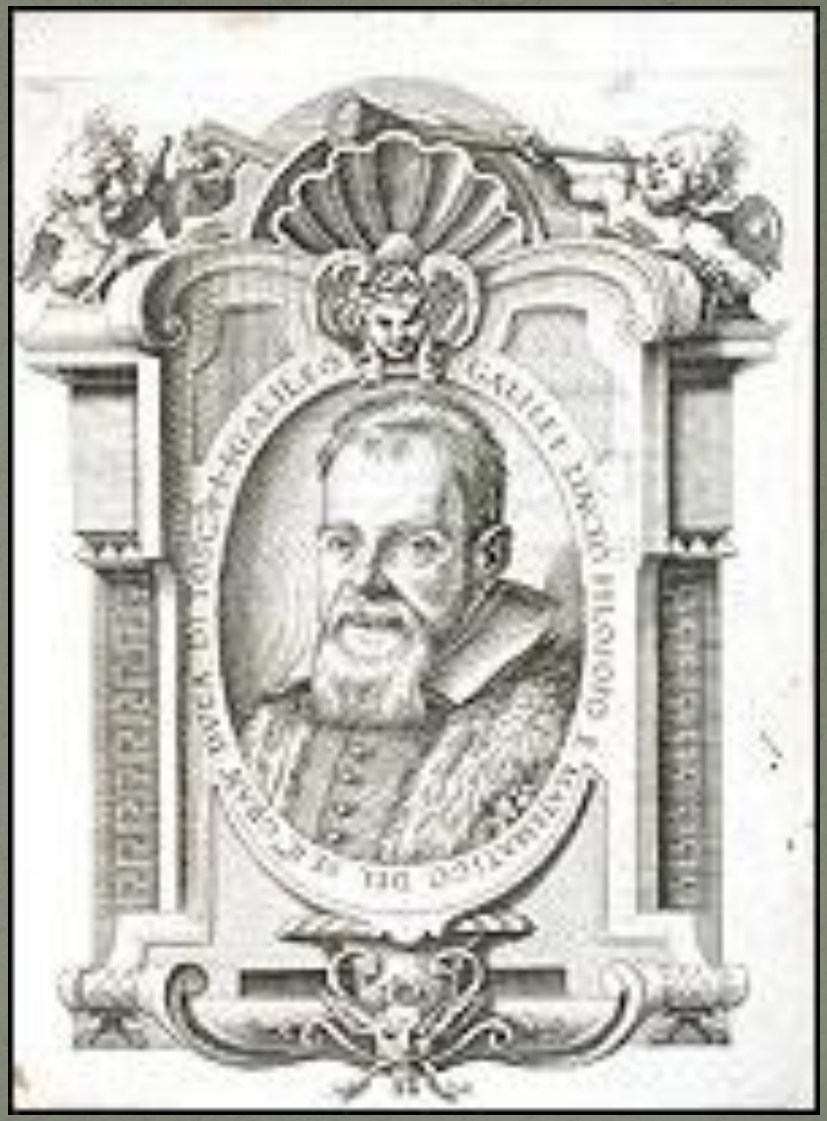
DAL SIGNOR

GALILEO GALILEI LINCEO

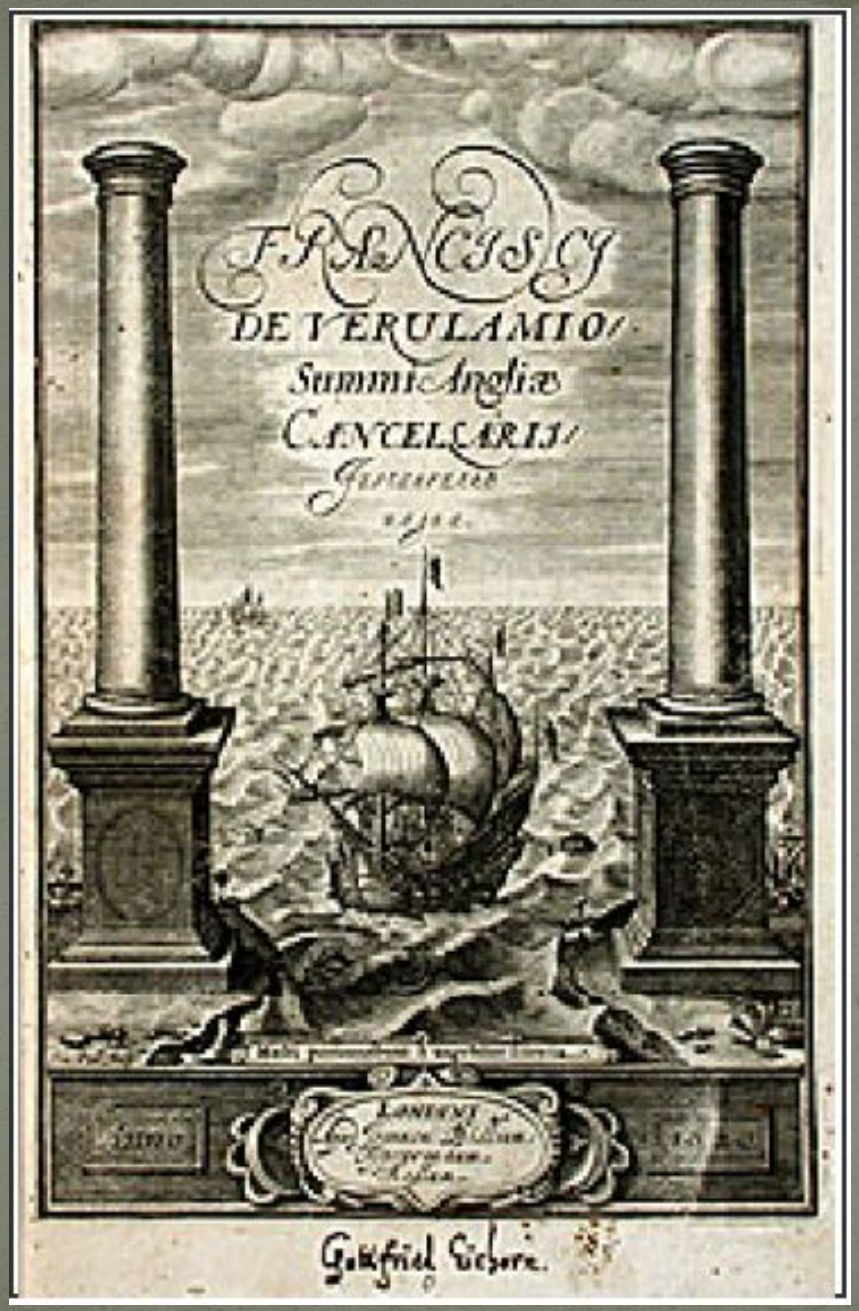
Nobil Fiorentino, Filosofo Matematico Primario del Serenissi.
D. COSIMO II. GRAN DVCA DI TOSCANA.

Si aggiungono nell'fine le Lettere, e Disquisitioni del istesso Apelle.

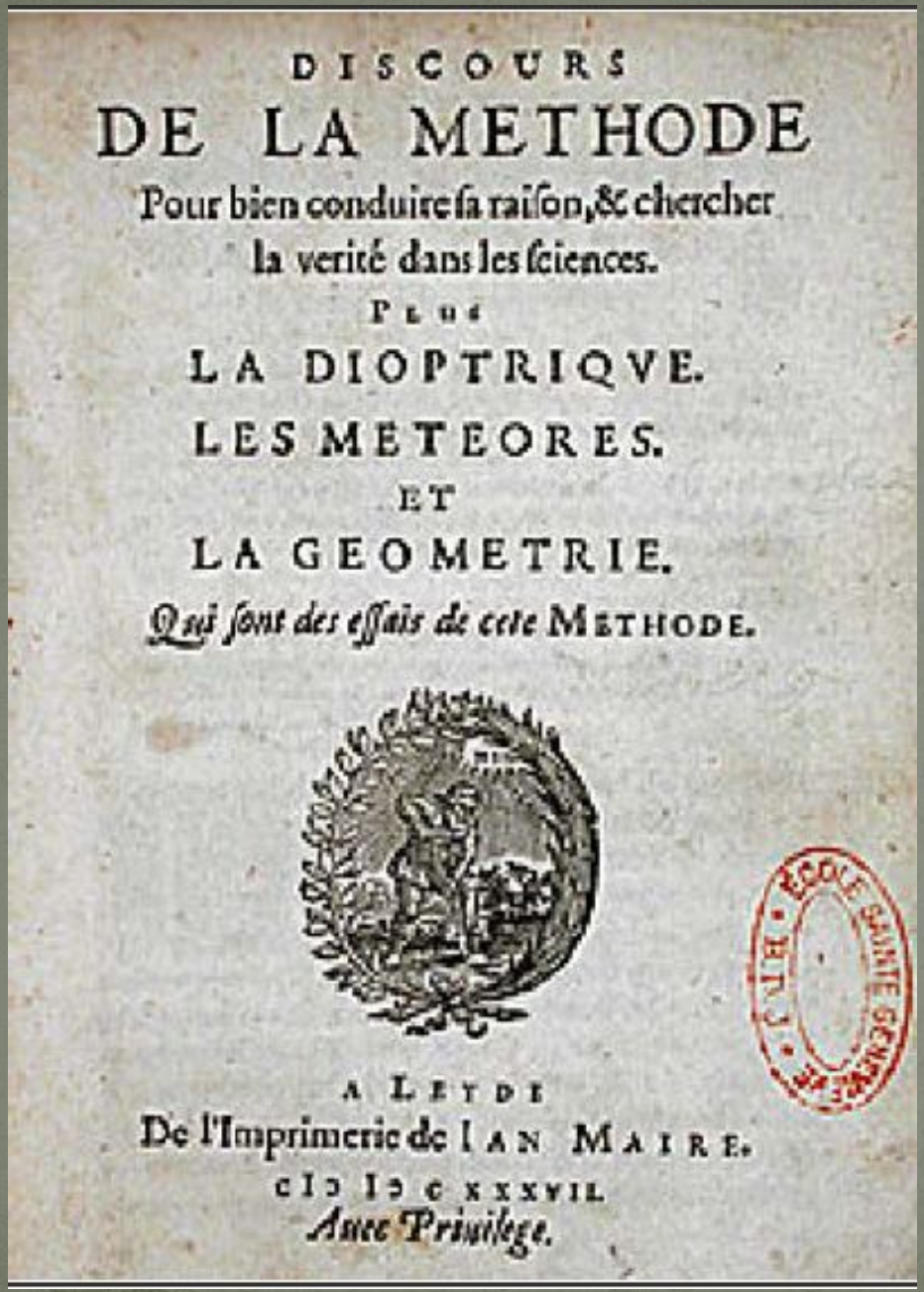
IN ROMA, Appresso Giacomo Mascardi. MDCXIII.
CON LICENZA DE' SVPERIORI.



,"We live immersed in the bottom of a sea of elemental air..."



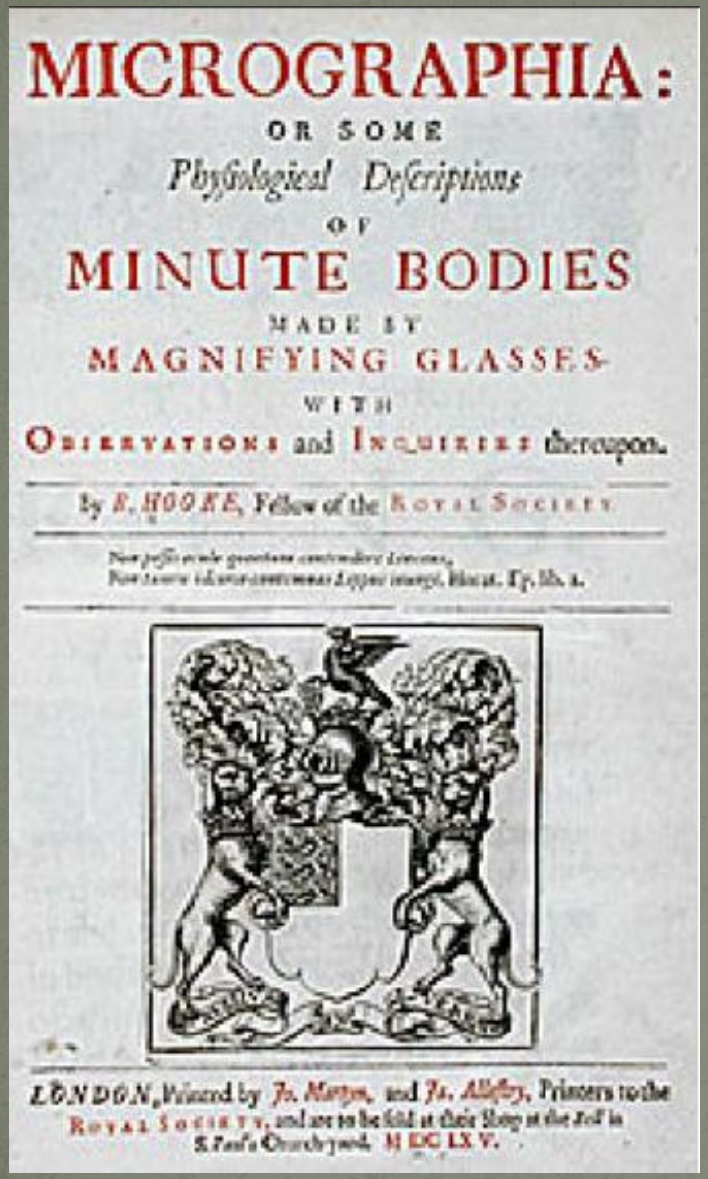
Francis Bacon projected his *Instauratio magna* to be a lengthy work, but completed only two parts: Advancement of Learning, first published in 1605, and *Novum organum* (right), published in 1620. In *Novum organum* (The new instrument), Bacon argued that science should be based on induction, and that through careful observation and collection of data one can infer general principles about the natural world. The author's name on the title page (Francisci de Verulamio) refers to the peerage --Baron Verulam--granted to Bacon in 1618. The allegorical frontispiece portrays the ship of science sailing through the Pillars of Hercules and into a new world.



DISCOURS
DE LA METHODE
Pour bien conduire sa raison, & chercher
la verité dans les sciences.
Plus
LA DIOPTRIQVE.
LES METEORES.
ET
LA GEOMETRIE.
Qui sont des essais de cette METHODE.

A LEYDE
De l'Imprimerie de IAN MAIRE.
CIↃ IↃ C XXXVII.
Avec Privilege.

In *Discours de la méthode*, a collection of essays published in 1637, Descartes laid out his approach for using reason to guide scientific inquiry. This landmark work also contained essays on optics, meteorology and analytical geometry in which Descartes applied his method. Descartes wrote *Discours* in French, rather than Latin, to make it accessible to readers outside of scholarly circles.



MICROGRAPHIA:

OR SOME

Physiological Descriptions

OF

MINUTE BODIES

MADE BY

MAGNIFYING GLASSES

WITH

OBSERVATIONS and INQUIRIES thereupon.

By R. HOOKE, Fellow of the ROYAL SOCIETY

LONDON, Printed by Jo. Martyn, and Ja. Allestry, Printers to the ROYAL SOCIETY, and are to be sold at their Shop at the Bell in S. Paul's Church-yard. MDCLXV.

In 1665, the British scientist Robert Hooke published *Micrographia:* or, *Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses*. The book was richly illustrated with engravings of dozens of objects that had come under his scrutiny, including a flea, a wasp, and a tick, as well as a number of plants. Each drawing was accompanied by text describing Hooke's observations. In one of these passages, Hooke coined the term "cell" to describe the microscopic structures he saw in a piece of cork. In 1679, Hooke became editor of *Philosophical Collections*, a short-lived replacement for the *Transactions*.

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By *R. HOOKE*, Fellow of the ROYAL SOCIETY.

Non possis oculo quantum contendere Linceus,
Non tamen idcirco contemnas Lippus inungi. Horat. Ep. lib. 1.

LONDON, Printed by *Jo. Martyn*, and *Ja. Allestry*, Printers to the ROYAL SOCIETY, and are to be sold at their Shop at the *Bell* in S. *Paul's* Church-yard. M DC LX V.

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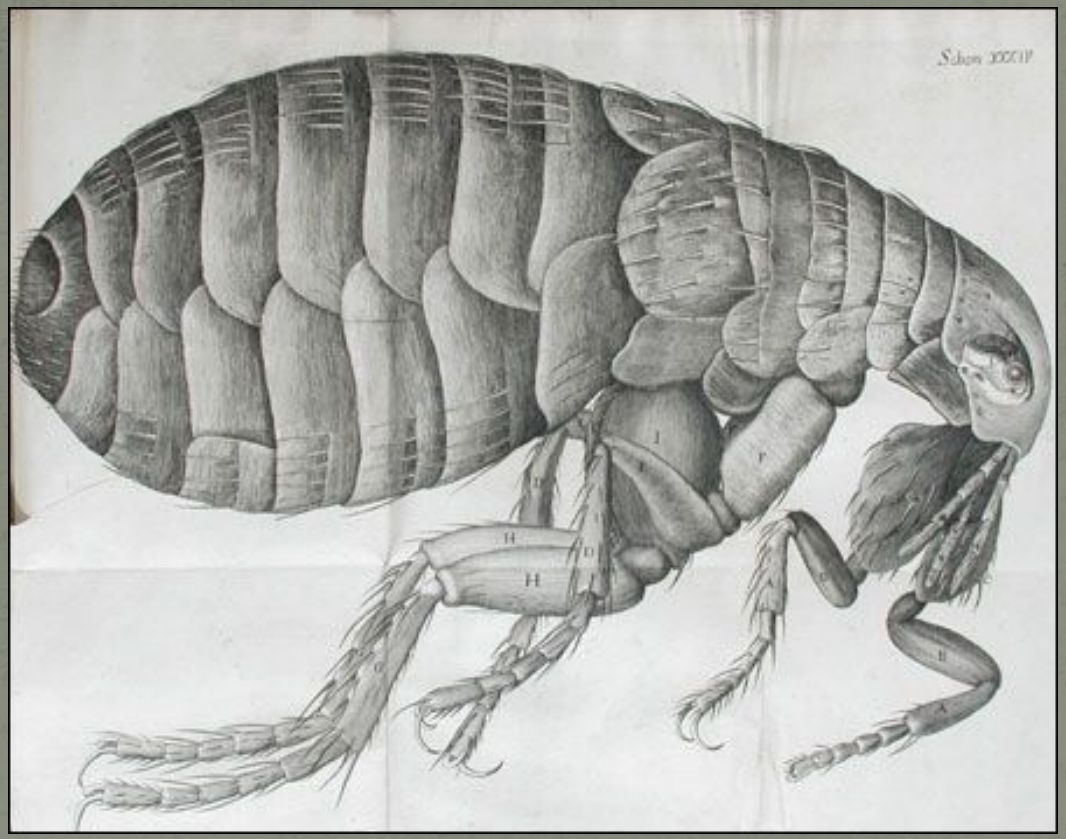
In

As in the engraving of a flea (left), the illustrations folded out of the book to allow for large, highly detailed drawings. The text accompanying this image reads, "The strength and beauty of this small creature, had it no other relation at all to man, would deserve a description."



Books and learned letters

22 *Delle Macchie Solari*

garsi, hora ristringersi; e se la Terra in se stessa si rivolgesse, quelle ancora il suo moto seguirebbono, e per esser di non molta profondità rispetto all'ampiezza, secondo la quale commanemente elle si distendono; quelle, che nel mezzo dell'Emisfero veduto apparirebbono molto larghe venendo verso l'estremità parrebbono restringersi, & in somma accidente alcuno non credo che si scorgesse, che simile non si vegga nelle macchie solari; ma perche la terra è oscura, e l'illuminazione viene dal lume esterno del Sole, se hora potesse da lontanissimo luogo esser veduta, non si vedrebbe assolutamente in lei negrezza, ò macchia alcuna cagionata dallo spargimento delle nugole, perche queste ancora riceuerebbono, & refletterebbono il lume del Sole. Della mutazion poi di figura, della irregolarità, e della dispari densità, prendane V. S. questi dua essempi.

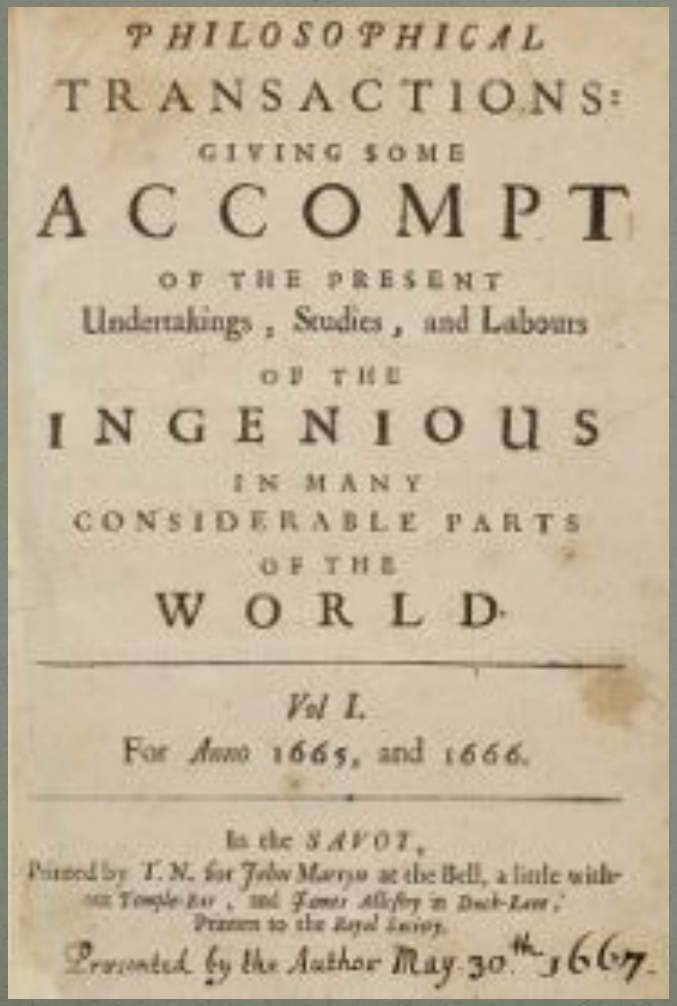
Osseruatio ni delle mutationi di densità, e figura delle macchie, e sua irregolarità.

La macchia A. che il dì 5. d'Aprile passato nel tramontar del Sole si vedeua tenuissima, e poco oscura, il giorno seguente si vidde pur nel tramontar del Sole, come la macchia B. cresciuta in scurità, e mutata di figura, & il giorno settimo fù simile alla figura C. e la positura loro fù sempre lontana dalla circonferenza del Sole.

Il giorno 26. dell'istesso mese, nel tramontar del Sole cominciò ad apparir nella parte suprema della sua circonferenza vna macchia simile alla D. la quale il giorno 28. era come la E. il 29. come

Published in 1613, Galileo Galilei's *Istoria e dimostrazioni intorno alle macchie solari e loro accidenti (Account and demonstrations concerning sunspots and their origins)*, contained letters by Galileo on sunspots. By including illustrations of his observations on the same page as the text, he was able to refer to a particular spot (e.g. "La macchia A.") and the date on which he observed it.

В 1665 г. выходит первый номер первого научного журнала *Philosophical Transactions*

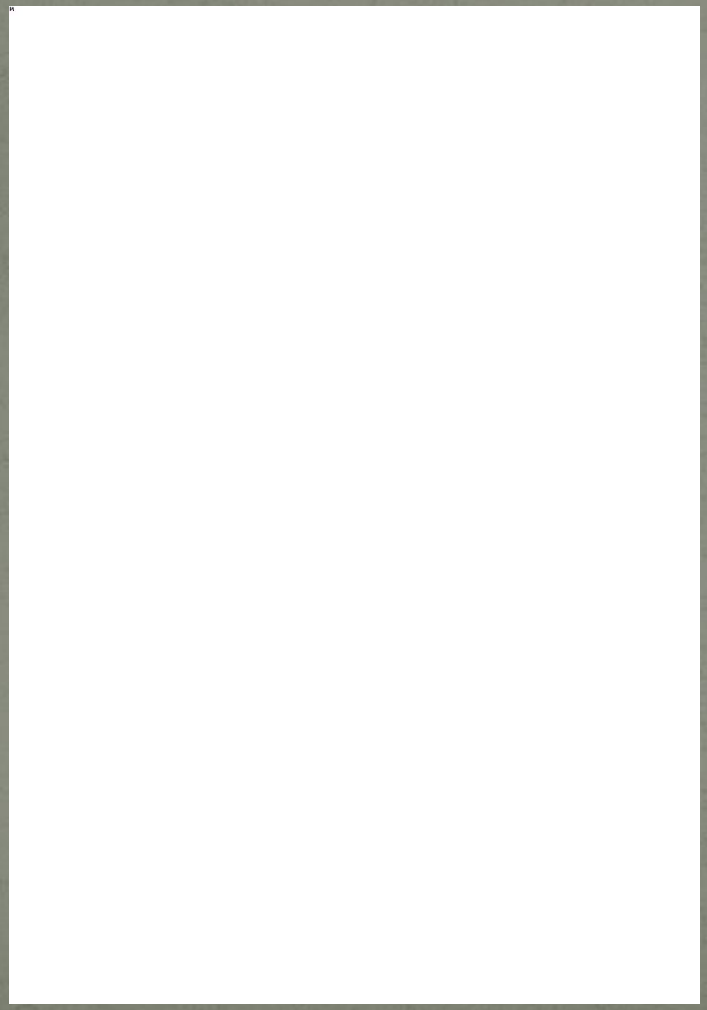


PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

Vol I.
For Anno 1665, and 1666.

In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane, Printers to the Royal Society.
Presented by the Author May 30th 1667.

Титульная страница и одна из страниц оглавления номера журнала Philosophical Transactions.



CONTENTS.

PHILOSOPHICAL TRANSACTIONS.

February 19. 167$\frac{1}{2}$.

The CONTENTS.

A Letter of Mr. Isaac Newton, *Professor of the Mathematicks in the University of Cambridge; containing his New Theory about* Light *and* Colors: *sent by the Author to the Publisher from Cambridge, Febr.* 6. 167$\frac{1}{2}$; *in order to be communicated to the* R. Society.

SIR,

TO perform my late promise to you, I shall without further ceremony acquaint you, that in the beginning of the Year 1666 (at which time I applyed my self to the grinding of Optick glasses of other figures than *Spherical,*) I procured me a Triangular glass-Prisme, to try therewith the celebrated *Phænomena* of

Colours. And in order thereto having darkened my chamber, and made a ſmall hole in my window-ſhuts, to let in a convenient quantity of the Suns light, I placed my Priſme at his entrance, that it might be thereby refracted to the oppoſite wall. It was at firſt a very pleaſing divertiſement, to view the vivid and intenſe colours produced thereby; but after a while applying my ſelf to conſider them more circumſpectly, I became ſurpriſed to ſee them in an *oblong* form; which, according to the received laws of Refraction, I expected ſhould have been *circular*.

They were terminated at the ſides with ſtreight lines, but at the ends, the decay of light was ſo gradual, that it was difficult to determine juſtly, what was their figure; yet they ſeemed *ſemicircular*.

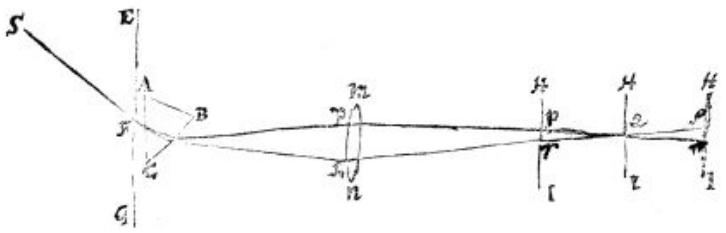
Comparing the length of this coloured *Spectrum* with its breadth, I found it about five times greater; a diſproportion ſo extravagant, that it excited me to a more then ordinary curioſity of examining, from whence it might proceed. I could ſcarce think, that the various *Thickneſs* of the glaſs, or the termination with ſhadow or darkneſs, could have any Influence on light to produce ſuch an effect; yet I thought it not amiſs, firſt to examine thoſe circumſtances, and ſo tryed, what would happen by tranſmitting light through parts of the glaſs of divers thickneſſes, or through holes in the window of divers bigneſſes, or by ſetting the Priſme without ſo, that the light might paſs through it, and be refracted before it was terminated by the hole: But I found none of thoſe circumſtances material The faſhion of the colours was in all theſe caſes the ſame.

Then I ſuſpected, whether by any *unevenneſs* in the glaſs, or other contingent irregularity, theſe colours might be thus dilated. And to try this, I took another Priſme like the former, and ſo placed it, that the light, paſſing through them both, might be refracted contrary ways, and ſo by the latter returned into that courſe, from which the former had diverted it. For, by this means I thought, the *regular* effects of the firſt Priſme would be deſtroyed by the ſecond Priſme, but the *irregular* ones more augmented, by the multiplicity of refractions. The event was, that the light, which by the firſt Priſme was diffuſed into an *oblong* form, was by the ſecond reduced into an *orbicular* one with as much regularity, as when it did not at all paſs through them. So that, what ever was the cauſe of that length, 'twas not any contingent irregularity.

I

about three foot radius (ſuppoſe a broad Object-glaſs of a three foot Teleſcope,) at the diſtance of about four or five foot from thence, through which all thoſe colours may at once be tranſmitted, and made by its Refraction to convene at a further diſtance of about ten or twelve feet. If at that diſtance you intercept this light with a ſheet of white paper, you will ſee the colours converted into whiteneſs again by being mingled. But it is requiſite, that the *Priſme* and *Lens* be placed ſteddy, and that the paper, on which the colours are caſt, be moved to and fro; for, by ſuch motion, you will not only find, at what diſtance the whiteneſs is moſt perfect, but alſo ſee, how the colours gradually convene, and vaniſh into whiteneſs, and afterwards having croſſed one another in that place where they compound Whiteneſs, are again diſſipated, and ſevered, and in an inverted order retain the ſame colours, which they had before they entered the compoſition. You may alſo ſee, that, if any of the Colours at the *Lens* be intercepted, the Whiteneſs will be changed into the other colours. And therefore, that the compoſition of whiteneſs be perfect, care muſt be taken, that none of the colours fall beſides the *Lens*.

In the annexed deſign of this Experiment, A B C expreſſeth the Priſm ſet endwiſe to ſight, cloſe by the hole F of the window



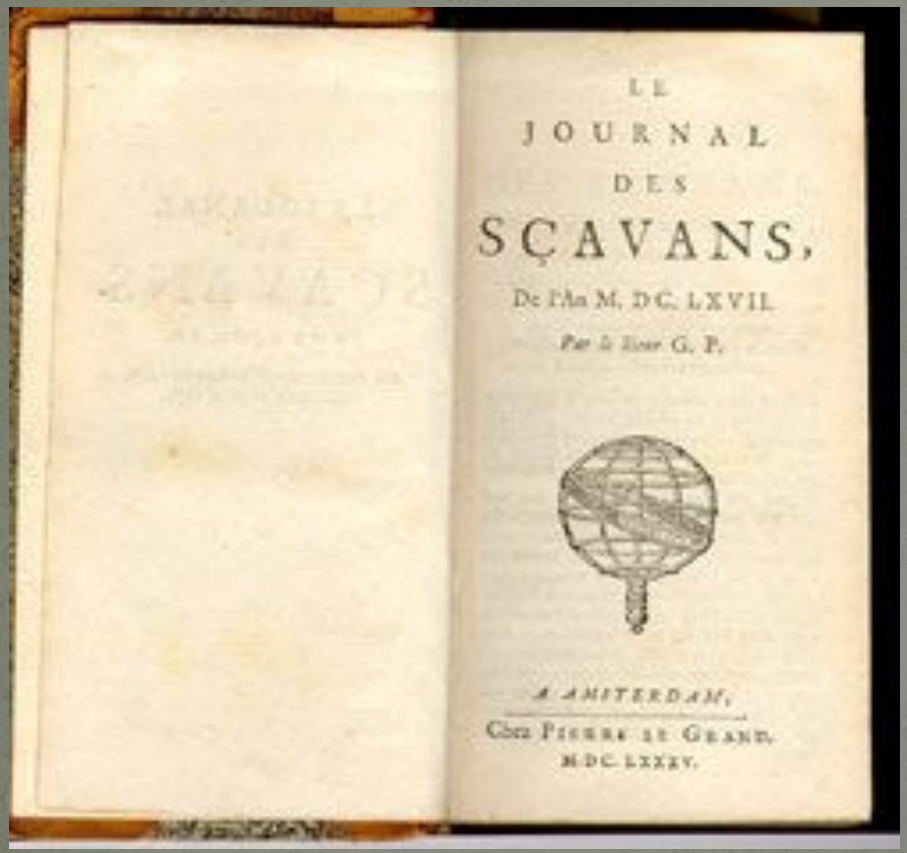
E G. Its vertical Angle A C B may conveniently be about 60 degrees: *M N* deſigneth the *Lens*. Its breadth 2½ or 3 inches. S F one of the ſtreight lines, in which difform Rays may be conceived to flow ſucceſſively from the Sun. F P, and F R two of thoſe Rays unequally refracted, which the *Lens* makes to converge towards Q, and after decuſſation to diverge again. And H I the paper, at divers diſtances, on which the colours are projected: which in Q conſtitute *Whiteneſs*, but are *Red* and *Yellow* in R, r, and ϱ, and *Blew* and *Purple* in P, p, and π.

If

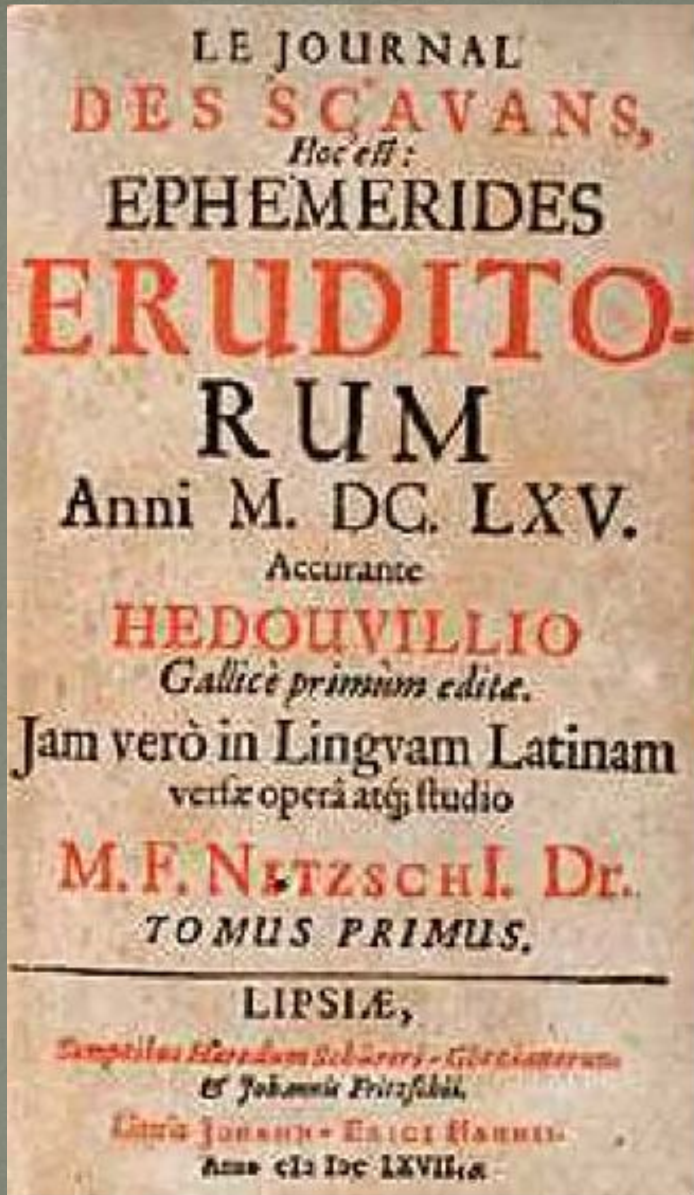
Титульная страница

Journal des scavans, Volume 2, 1667.

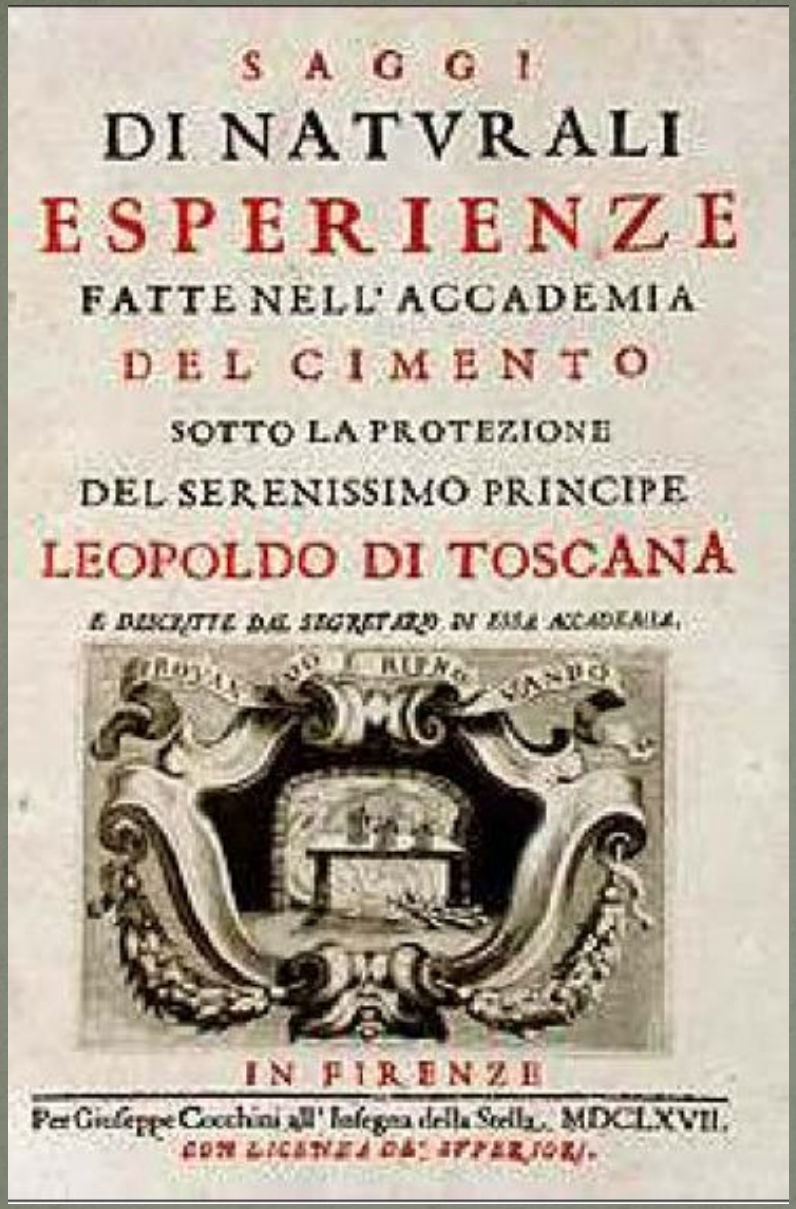
Amsterdam: Pierre LeGrand, 1685. Collection of the University of British Columbia


LE
JOURNAL
DES
SÇAVANS,
De l'An M. DC. LXVII.
Par le Sieur G. P.
A AMSTERDAM,
Chez PIERRE LE GRAND.
M DC LXXXV.

- Каталог и краткие описания книг
- О знаменитых людях
- Описание экспериментов по физике, химии, астрономических наблюдений
- Анатомические открытия
- Описания полезных машин
- Печатные решения трибуналов и университетов
- Текущие события в академии



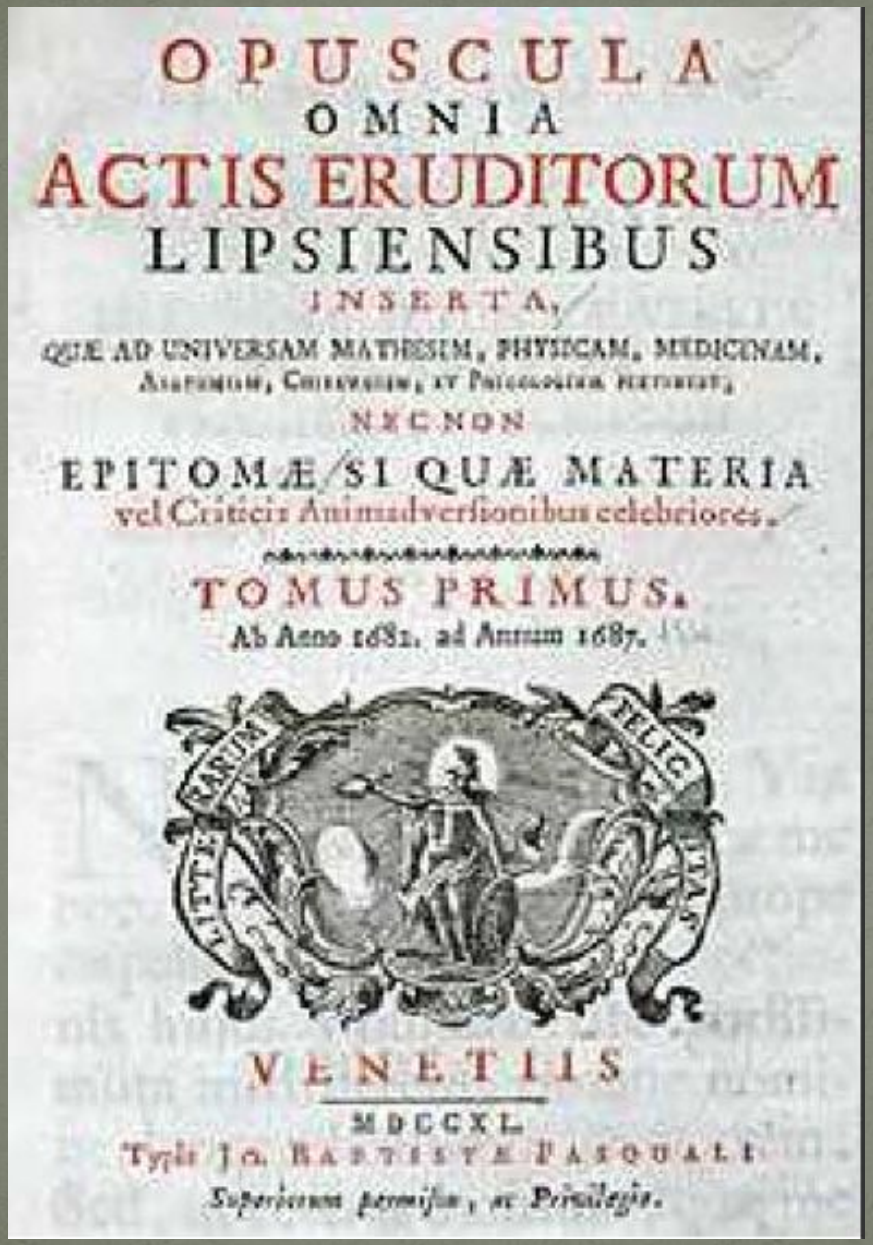
Le Journal des sçavans was first published in 1665 by Denis de Sallo. The journal included a mix of content, not all of which was scientific, including book reviews, obituaries, the results of experiments and observations of natural phenomena, and recent court decisions. At right is the Latin edition of the journal which covers the years 1665-67.



SAGGI
DI NATVRALI
ESPERIENZE
FATTE NELL' ACCADEMIA
DEL CIMENTO
SOTTO LA PROTEZIONE
DEL SERENISSIMO PRINCIPE
LEOPOLDO DI TOSCANA
E DESCRITTE DAL SEGRETARIO DI ESSA ACCADEMIA.

IN FIRENZE
Per Giuseppe Cocchini all' Insegna della Stella. MDCLXVII.
CON LICENZA DE' SUPERIORI.

Saggi di naturali esperienze recorded the instruments, methods and results of experiments conducted by the Accademia del Cimento in Florence. The academy established one of the first physical sciences laboratories in Europe in order to test the discoveries of such noted scientists as Galileo and Evangelista Torricelli. "LEOPOLDO DI TOSCANA," whose name appears in red on the title page of the *Saggi* (right), was the Grand Duke Leopold of Florence, one of the society's founders.

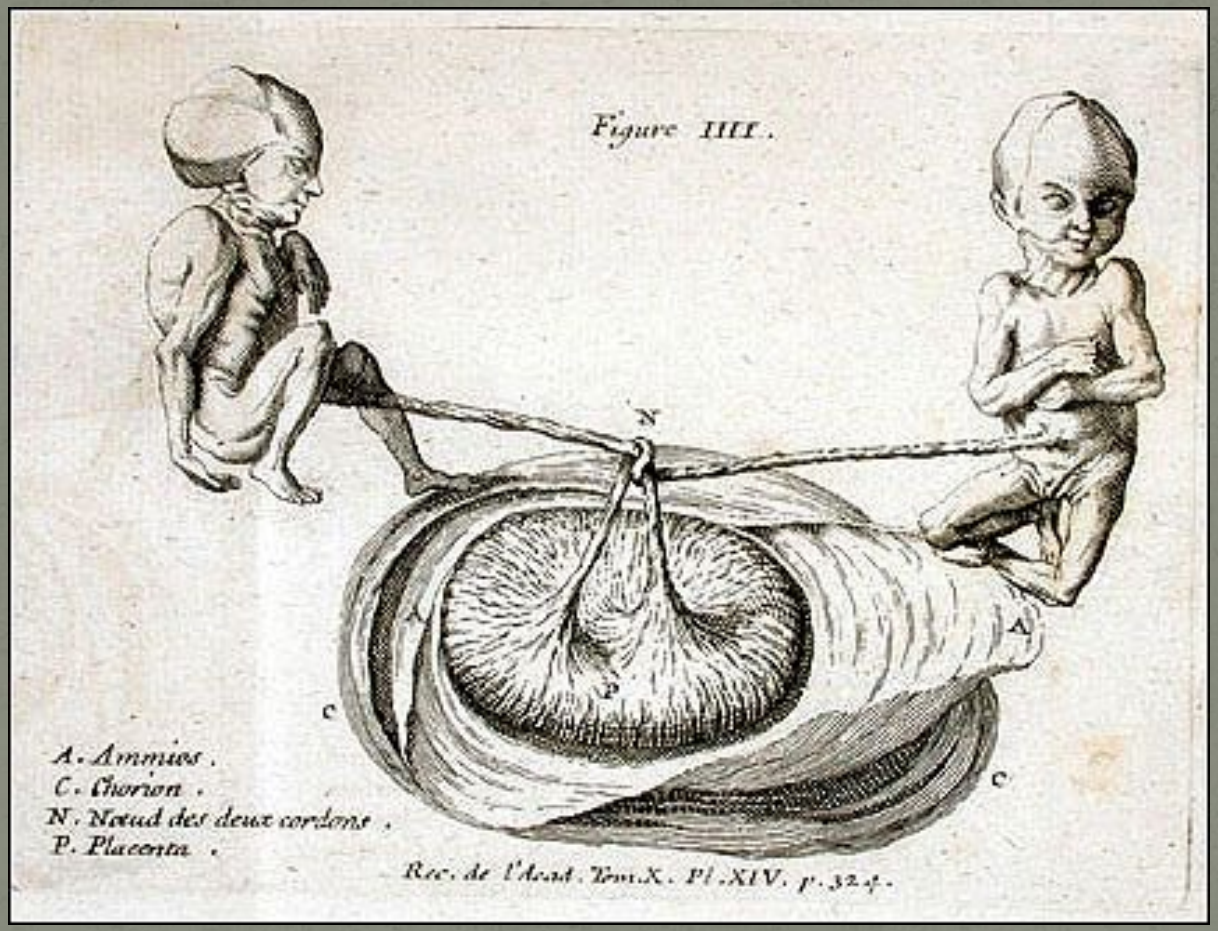


OPUSCULA
OMNIA
ACTIS ERUDITORUM
LIPSIENSIBUS
INSERTA,
QUÆ AD UNIVERSAM MATHESIM, PHYSICAM, MEDICINAM,
ANATOMEN, CHIRURGIAM, ET PHILOLOGIAM PERTINENT,
NECNON
EPITOMÆ SI QUÆ MATERIA
vel Criticis Animadversionibus celebriores.
TOMUS PRIMUS.
Ab Anno 1682. ad Annum 1687.
VENETIIS
MDCCXL.
Typis Jo. BAPTISTÆ PASQUALI
Superiorum permissu, ac Privilegio.

Acta eruditorum was one of the first scientific journals from Germany. Although based in Leipzig, the journal was published in Latin, rather than German, in order to reach a broader international audience. The title page at right is from a bound volume of *Acta* editions from 1682-87. The text lists a few of the topics covered in the journal, among them mathematics, physics, medicine and anatomy.

- In the middle of *July*, I drew and gathered of the Milk of *Lactuca syl. Costa spinosa*, C.B. and of all our *English* Plants, that I have met with, this most freely and plentifully affords it. It springs out of the Wound thick as Cream and Ropes, and is White, and yet the Milk which came out of the Wounds, made towards the top of the Plant, was plainly streaked or mixt with a purple Juice, as though one had dashed or sprinkled Cream with a few drops of Claret. And indeed, the Skin of the Plant thereabouts was purplish also, perhaps with Veins. Again, in the Shell I drew it, it turned still yellower and thicker, and by and by curdled, that is, the white and thick caseous part did separate from a thin purple Whey. So the Blood also of Animals, whilst warm remains liquid and alike, but so soon as cold, it cakes and has a *Serum* or Whey separated from it; the Cake is made of glutinous Fibers, and therefore if the hot or new drawn Blood be well stirred or beaten, it will not break.

"Observation of two fetuses enclosed in the same membrane"
in Mémoires de l'Académie Royale des sciences , 1693.

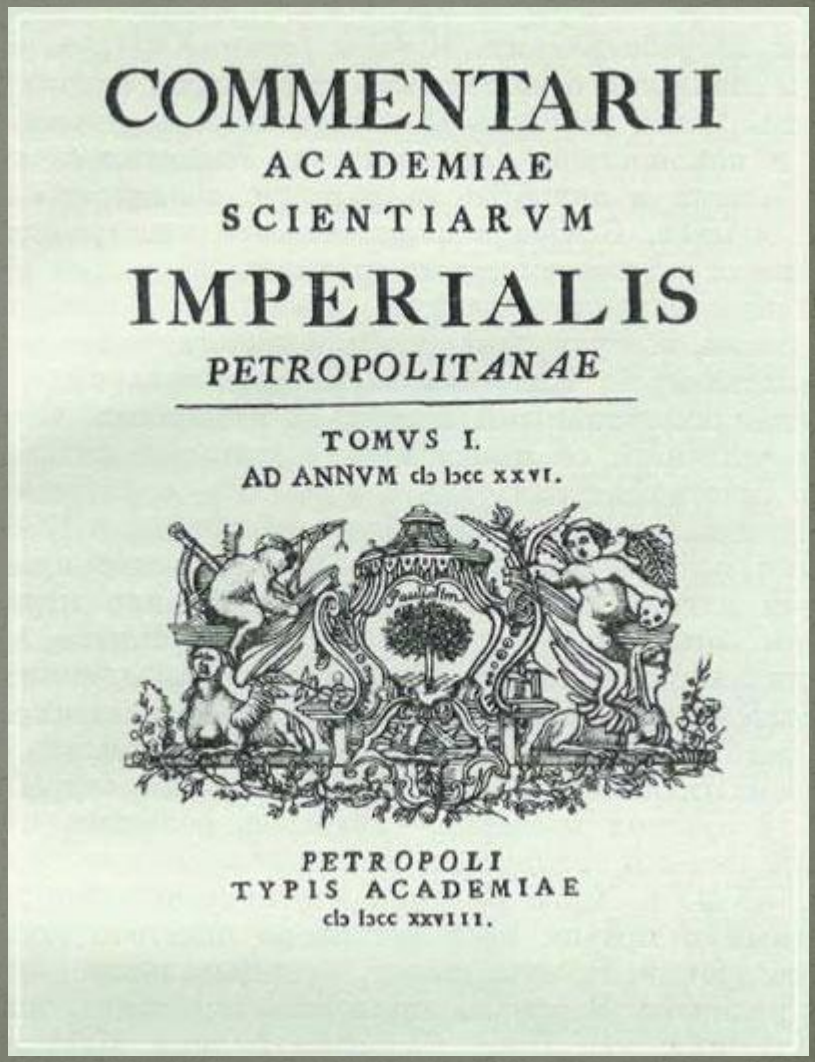


- The letter never really disappeared as a medium of scientific communication: personal letters between scientists remain a vital element in any historical reconstruction of their science. And as indicated by the letters in *Nature, Science, Physical Review Letters*, and other contemporary journals, the published letter is still a significant medium of scientific communication. Moreover, the link between the learned letter and the article is direct: many of the articles in the very first journals are learned letters lightly revised for publication by an editor. This was the case with Newton's famous first article on optics, published in the 1672 *Philosophical Transactions*. Also important during the seventeenth and eighteenth centuries were books containing collected letters or short articles on technical matters by a single author, as exemplified by Leeuwenhoek's published letters to the Royal Society of London and Hooke's splendidly illustrated *Micrographia*.

- In the later decades of the eighteenth century, scientists along with their societies and publications became more specialized as a means of coping with the flood of technical knowledge, particularly in the fields of physics and chemistry. The age of the generalist and inspired amateur of science was in decline.
- One of the first general scientific journals aimed at serious researchers was the *Observations et mŭmoires sur la physique, sur l'histoire naturelle et sur les arts*, founded in 1773 by Fran3ois Rozier. As Rozier eloquently, if brusquely, put it in the preface to the first volume: "We will not offer to idle amateurs purely agreeable works or the sweet illusion of believing themselves to be initiated into science of which they know nothing...We offer this collection to the truly knowledgable." He further asserted that the journal itself would "reject everything that is nothing more than undigested compilation and that is wanting in new and useful views." At the founding of the British Association for the Advancement of Science in 1831, William Whewell suggested that membership be restricted to those "who have published *written papers* in the memoirs of any learned society." He wanted to exclude as members those who were not, as one critic of the Royal Society put it, "labourers in the vineyard" of science. This general desire for higher professional standards in science led to an influx of individual articles primarily aimed at subject-matter experts. It also spawned the first great specialty journals in the natural and physical sciences from Germany, France, and England.

Первый русский научный журнал

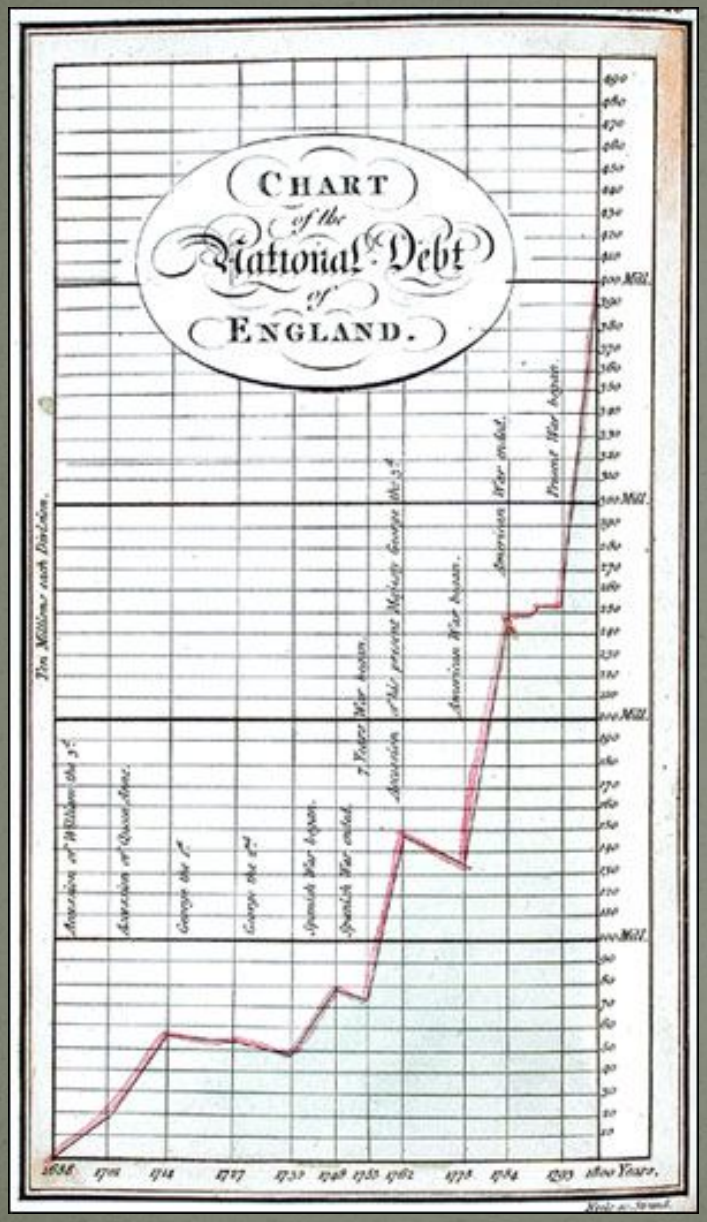
- «*Комментарии Петербургской академии наук*»
- С 1728 г.
- на латинском языке.


COMMENTARII
ACADEMIAE
SCIENTIARVM
IMPERIALIS
PETROPOLITANAE
TOMVS I.
AD ANNVM cIↃ IↃcc xxvi.
PETROPOLI
TYPIS ACADEMIAE
cIↃ IↃcc xxviii.

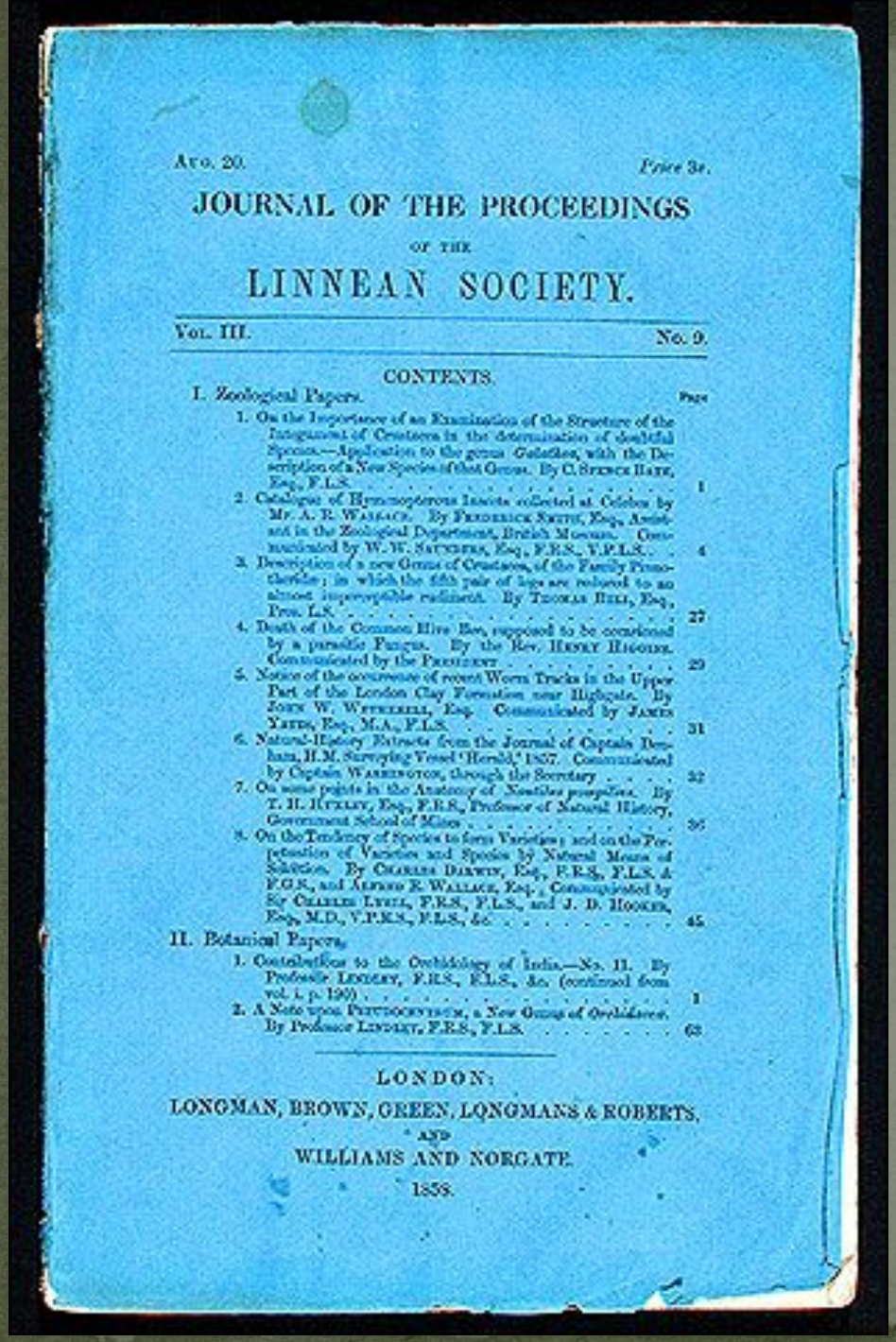
Типы научных статей (articles, papers)

- Теоретические (theoretical)
- Экспериментальные (experimental)
- Наблюдения (observational)
- Методические (methodological)
- Обзорные (review)

William Playfair



First printed in 1786, William Playfair's *The Commercial and Political Atlas: Representing, by Means of Stained Copper-Plate Charts, the Progress of the Commerce, Revenues, Expenditure and Debts of England during the Whole of the Eighteenth Century* contains the first known use of color graphs. This image is from the third edition of the economics text, printed in 1801. The chart plots time on the abscissa, pounds (in increments of 10 million) on the ordinate, and includes major events of the eighteenth century--including the coronation of monarchs, the Seven Years' War, and the American Revolution--in the body of the chart.



Aug. 20. *Price 3s.*

JOURNAL OF THE PROCEEDINGS OF THE LINNEAN SOCIETY.

Vol. III. No. 9.

CONTENTS.

LONDON:

LONGMAN, BROWN, GREEN, LONGMANS & ROBERTS,

AND

WILLIAMS AND NORGATE.

1858.

In 1858, the *Journal of the Proceedings of the Linnean Society* published brief articles by Charles Darwin and Alfred Russel Wallace in the same issue, under the title "On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection." Darwin noted that "This sketch is *most* imperfect; but in so short a space I cannot make it better. Your imagination must fill up very wide blanks."

Луи Пастер

Появление процедуры рецензирования

- *Ethics of the Physician* written by Ishaq bin Ali al-Rahwi (854–931) of al-Raha, Syria
- *Medical Essays and Observations, 1731,* published by the Royal Society of Edinburgh

1905 - год чудес

- 1.«К электродинамике движущихся тел» (нем. *Zur Elektrodynamik bewegter Körper*).
- 2. «Об одной эвристической точке зрения, касающейся возникновения и превращения света» (нем. *Über einen die Erzeugung und Verwandlung des Lichts betreffenden heuristischen Gesichtspunkt*).
- 3. «О движении взвешенных в покоящейся жидкости частиц, требуемом молекулярно-кинетической теорией теплоты» (нем. *Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen*)

tiven Konstanten der Energien H und E abhängt. Wir können also setzen:

$$H_0 - E_0 = K_0 + C,$$
$$H_1 - E_1 = K_1 + C,$$

da C sich während der Lichtaussendung nicht ändert. Wir erhalten also:

$$K_0 - K_1 = L\left\{\frac{1}{\sqrt{1-\left(\frac{v}{V}\right)^2}} - 1\right\}.$$

Die kinetische Energie des Körpers in bezug auf (ξ, η, ζ) nimmt infolge der Lichtaussendung ab, und zwar um einen von den Qualitäten des Körpers unabhängigen Betrag. Die Differenz $K_0 - K_1$ hängt ferner von der Geschwindigkeit ebenso ab wie die kinetische Energie des Elektrons (l. c. § 10).

Unter Vernachlässigung von Größen vierter und höherer Ordnung können wir setzen:

$$K_0 - K_1 = \frac{L}{V^2}\frac{v^2}{2}.$$

Aus dieser Gleichung folgt unmittelbar:

Gibt ein Körper die Energie L in Form von Strahlung ab, so verkleinert sich seine Masse um L/V^2. Hierbei ist es offenbar unwesentlich, daß die dem Körper entzogene Energie gerade in Energie der Strahlung übergeht, so daß wir zu der allgemeineren Folgerung geführt werden:

Die Masse eines Körpers ist ein Maß für dessen Energieinhalt; ändert sich die Energie um L, so ändert sich die Masse in demselben Sinne um $L/9.10^{20}$, wenn die Energie in Erg und die Masse in Grammen gemessen wird.

Es ist nicht ausgeschlossen, daß bei Körpern, deren Energieinhalt in hohem Maße veränderlich ist (z. B. bei den Radiumsalzen), eine Prüfung der Theorie gelingen wird.

Wenn die Theorie den Tatsachen entspricht, so überträgt die Strahlung Trägheit zwischen den emittierenden und absorbierenden Körpern.

Bern, September 1905.

(Eingegangen 27. September 1905.)

A. Einstein

ÄTHER
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RELATIVITÄTSTHEORIE

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GEHALTEN AM 5. MAI 1920
AN DER REICHS-UNIVERSITÄT ZU LEIDEN

VON

ALBERT EINSTEIN

BERLIN
VERLAG VON JULIUS SPRINGER
1920

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

1 Young, F. B., Gerrard, H., and Jevons, W., *Phil. Mag.*, **40**, 149 (1920).
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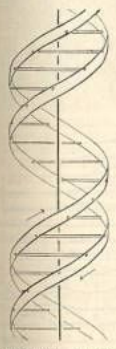
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

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

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

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



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

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the *z*-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

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

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

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

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

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

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

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

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

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

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. WATSON
F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems, Cavendish Laboratory, Cambridge.
April 2.

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Molecular Structure of Deoxypentose Nucleic Acids

WHILE the biological properties of deoxypentose nucleic acid suggest a molecular structure containing great complexity, X-ray diffraction studies described here (cf. Astbury[1]) show the basic molecular configuration has great simplicity. The purpose of this communication is to describe, in a preliminary way, some of the experimental evidence for the polynucleotide chain configuration being helical, and existing in this form when in the natural state. A fuller account of the work will be published shortly.

The structure of deoxypentose nucleic acid is the same in all species (although the nitrogen base ratios alter considerably) in nucleoprotein, extracted or in cells, and in purified nucleate. The same linear group of polynucleotide chains may pack together parallel in different ways to give crystalline[1–3], semi-crystalline or paracrystalline material. In all cases the X-ray diffraction photograph consists of two regions, one determined largely by the regular spacing of nucleotides along the chain, and the other by the longer spacings of the chain configuration. The sequence of different nitrogen bases along the chain is not made visible.

Oriented paracrystalline deoxypentose nucleic acid ('structure *B*' in the following communication by Franklin and Gosling) gives a fibre diagram as shown in Fig. 1 (cf. ref. 4). Astbury suggested that the strong 3·4-A. reflexion corresponded to the internucleotide repeat along the fibre axis. The ~ 34 A. layer lines, however, are not due to a repeat of a polynucleotide composition, but to the chain configuration repeat, which causes strong diffraction as the nucleotide chains have higher density than the interstitial water. The absence of reflexions on or near the meridian immediately suggests a helical structure with axis parallel to fibre length.

Diffraction by Helices

It may be shown[5] (also Stokes, unpublished) that the intensity distribution in the diffraction pattern of a series of points equally spaced along a helix is given by the squares of Bessel functions. A uniform continuous helix gives a series of layer lines of spacing corresponding to the helix pitch, the intensity distribution along the nth layer line being proportional to the square of J_n, the nth order Bessel function. A straight line may be drawn approximately through

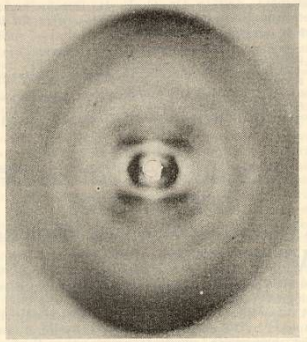

Fig. 1. Fibre diagram of deoxypentose nucleic acid from *B. coli*. Fibre axis vertical

the innermost maxima of each Bessel function and the origin. The angle this line makes with the equator is roughly equal to the angle between an element of the helix and the helix axis. If a unit repeats n times along the helix there will be a meridional reflexion (J_0^2) on the nth layer line. The helical configuration produces side-bands on this fundamental frequency, the effect[5] being to reproduce the intensity distribution about the origin around the new origin, on the nth layer line, corresponding to C in Fig. 2.

We will now briefly analyse in physical terms some of the effects of the shape and size of the repeat unit or nucleotide on the diffraction pattern. First, if the nucleotide consists of a unit having circular symmetry about an axis parallel to the helix axis, the whole diffraction pattern is modified by the form factor of the nucleotide. Second, if the nucleotide consists of a series of points on a radius at right-angles to the helix axis, the phases of radiation scattered by the helices of different diameter passing through each point are the same. Summation of the corresponding Bessel functions gives reinforcement for the inner-

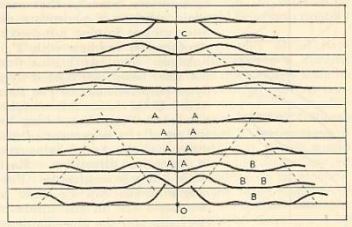

Fig. 2. Diffraction pattern of system of helices corresponding to structure of deoxypentose nucleic acid. The squares of Bessel functions are plotted about 0 on the equator and on the first, second, third and fifth layer lines for half of the nucleotide mass at 20 A. diameter and remainder distributed along a radius, the mass at a given radius being proportional to the radius. About C on the tenth layer line similar functions are plotted for an outer diameter of 12 A.

- В 1665 году : французский ***Journal des Scavans*** и **английский *Philosophical Transactions*.**
- **Начало XIX века – сотня журналов**
- **Начало XX века – около 10000**
- **Сейчас?**