FRANCIS GALTON ON MARS

blank

Francis Galton on Mars

The 'Discontinuous Variation' Notebook

Edited by Gavan Tredoux

galton.org
2018/11/05: 12:16

http://galton.org

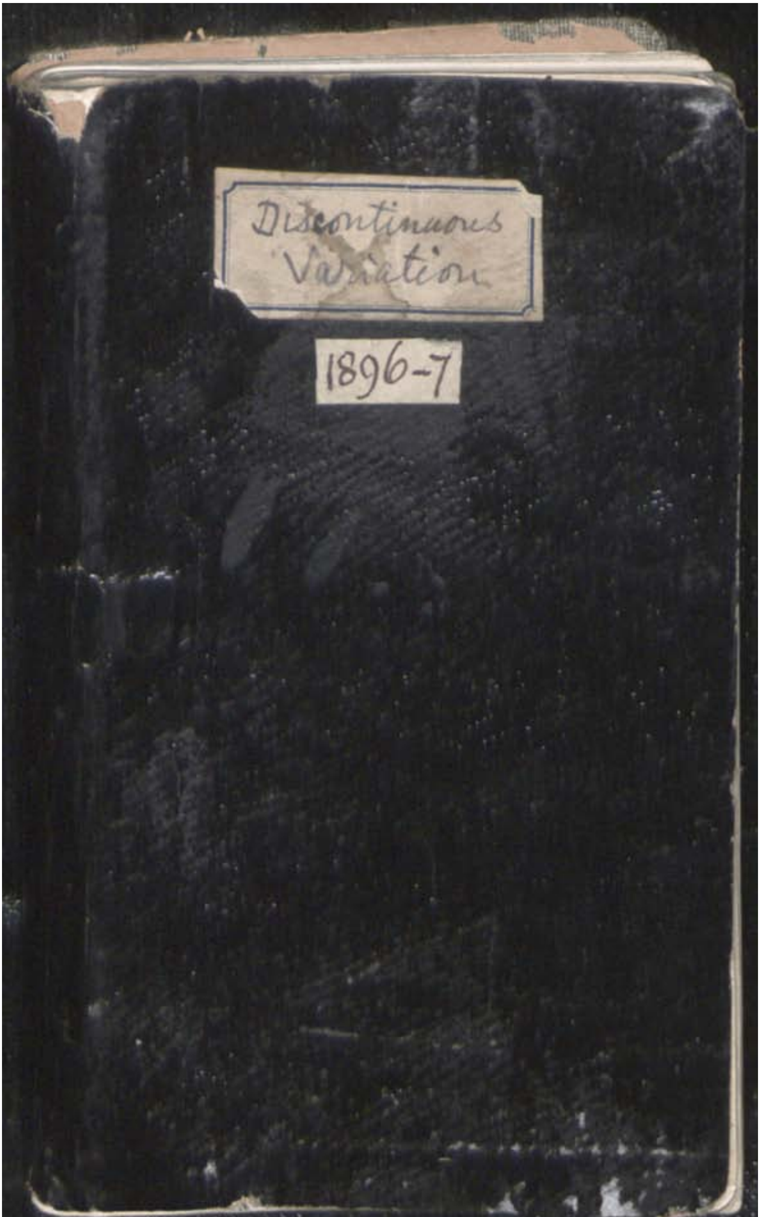


Figure 1: The 'Discontinuous Variation' Notebook which contains the Mars story.

Preface

Among the Galton papers, housed in the Special Collections Department of University College London, many notebooks survive, recording his explorations of things that amused him or took his fancy. Much of this material never saw print. The pages teem with ideas, often skipping around without warning.[1]

One of these notebooks is titled 'Discontinuous Variation: 1896-7'. The first page leads with 'Clear mind from cant' and contains ruminations about moral philosophy and religion. 'Ideals may well be elusive'. Several of the subsequent pages reflect the title, dealing with the ways in which change in a continuous characteristic can eventually produce a discontinuity, so that a different class is called for. By the twenty-second page, the subject has jumped to free will, a recurring theme for Galton, prompted by his researches into heredity. Three pages later, the subject switches abruptly to an encoding scheme for representing mathematical operations. Seventeen pages of rough notes follow, in which the scope of the encoding expands to include instructions for reproducing pictures. Encoding of pictures forms a link to 'Discontinuous variation', since at a certain point a series of dots is perceived as a line. On the forty-second page of the notebook, Galton lays out the skeleton of a story involving Mars, sun signals flashed from Earth, and eugenics among intelligent Martians, who are said to be

[1] For an overview of Galton's career and legacy, see `http://galton.org`.

descended from Ants by natural and artificial selection. It is only on page 79—three from the end, dated May 1897—that the subject switches once again, to the mathematics of descent.

The semi-comical 'short story' that lies between God and the beginnings of mathematical genetics was born in 1892, only to be more or less abandoned by 1896, when it was suddenly taken up again. Then, some ideas from it were transformed for use in 'Intelligible Signals between neighbouring stars', which was published in 1896 in the *Fortnightly Review*, alongside Olive Schreiner and Edward Dicey on the Jameson Raid, E. Ray Lankester on 'The Present Evolution of Man' and Alfred Russel Wallace on the Swiss Gorge of the Aar. But the published version left out many of the best bits.[2]

Intriguingly, sections of the unpublished story anticipate Galton's lost comic dystopia, *Kantsaywhere*, where procreation depends on rigorous eugenic examinations. Quite possibly he thought that the Victorian reading public was not ready for this in 1896—the editors of the *Fortnightly* accepted his story as it was submitted to them, so they were not to blame. Aside from leaving out the eugenic details and humorous Martian anthropology—or rather, entomology—the focus of the action was shifted 180°. In the unpublished original, it is the Martians who receive the glimmering signals, and they dictate the point of view of the narrative. In the parts that survived selection for the *Fortnightly*, it is Earth that receives the signals, and so a lot of diverting humour is lost.

Astronomy was more than a passing interest for Galton. On the board the *Dalhousie* to South-West Africa, in April of 1850, he had learned the use of the sextant and how to take latitudes. He fell in love with the instrument and the activity itself. In the field, taking readings occupied a great deal of his time, and the record of his trip was remarkable for its accurate surveying and painstaking observations, with multiple levels of redundancy to allow for error correction. Later, in

---

[2] Galton 1896a. See Chapter A, p. 47.

successive editions of his *vade mecum* for explorers, *The Art of Travel*, Galton took care to cover navigation by the stars. 'It requires very great practice to steer well by stars, for, on an average, they change their bearings even faster than they change their altitudes. In tropical countries the zodiacal stars, as Orion and Antares, give excellent east and west points. The Great Bear is useful, when the North Pole cannot be seen, for you may calculate by the eye whereabouts it would be in the heavens when its "pointers" were vertical, or due north; and the Southern Cross is available in precisely the same way.'[3]

On his return to England from Africa, fêted by the Royal Geographical Society, Galton often dined with Lord Rosse, an old friend of his (deceased) father Samuel Tertius, who had abiding interests in amateur astronomy. Rosse had built the world's largest telescope, the six-foot 'Leviathan', at his estate in Parsonstown Ireland. Despite his unpromising location, Rosse discovered what were later recognized to be remote galaxies using it. The intricate engineering problems solved by the versatile peer surely intrigued Galton.

Galton had also accompanied George Airy's expedition to Spain in 1860, to witness that year's solar eclipse from the clear-skied valley of the Ebro. The large and delicate thermometer he had taken with to record changes in temperature—an instrument designed by J. W. F. Herschel—had been broken in transit, freeing him to make his own observations by eye. He was one of the first to notice the curvature effect at the perimeter of the sun, and the watercolour he painted of the view was reprinted more than once, though only in monochrome.[4] Whenever he had the opportunity to record the paths of meteors, he was suitably equipped with a compact travelling altizimuth, which he seems to have carried around with him on

[3]Galton 1856b, 127.

[4]Galton 1861; Galton 1879. For full details on this expedition, see Tredoux 2018.

Figure 2: Lord Rosse's Leviathan of Parsonstown.

the off chance that it would prove useful.[5] But these interests, unlike his ethnological and geographical concerns, did not rise to an active role in bodies like the Astronomical Society.

The use of sunlight for signals was familiar to Galton from a much earlier date. In the Lake District in 1841, he noticed the (cumbersome) heliostats then in use. 'I found a small encampment of ordnance surveyors with theodolite and heliostat. Their immediate object was to obtain by direct observation the bearing of Snowdon, ninety-six miles off (as I think they said), to form the side of one of their principal triangles. A corresponding station was set up on the top of Snowdon, whence after many days' waiting in vain the long-wished-for star of light reflected from the sun by the mirror on Snowdon, became

[5]Galton 1866.

faintly but clearly visible through the telescope at Scawfell.'[6] C. F. Gauss invented one of the early heliographs from that period.

In 1856, in a letter to the *Times*, 'Signals Available to Men who are Adrift on Wrecks at Sea', Galton suggested that shipwrecked sailors might carry a mirror to attract the attention of passing ships—notoriously blind to their presence. He carefully described how the challenging task of aiming the flash might be accomplished even in a lifeboat, by scratching a small hole in the backing of the mirror to look through: 'a man sitting low down in the stern could direct the glitter of his looking glass by watching its play upon the bows of the boat at the moment when he could just catch sight of the ship over them. If a looking glass be used without first cutting a hole in its back in the way I have mentioned it is necessary to hold it close up under the eye, and to make more careful allowance for the height of the eye above it than a person who has not had a good deal of practice is likely to succeed in accomplishing.'[7]

Within two years, Galton had gone much further and invented a portable 'pocket' heliostat, which included a simple and reliable mechanism for visually aiming the instrument, through mirrors, which showed the user a 'mock sun' where the light would fall. Successive editions of Galton's *Art of Travel* described the instrument and the general problem of signalling in the wild.[8]

The invention eventually proved to be a success, after some refinements. It was initially manufactured by Troughton and Sims, then by other makers like John Dennett Potter, and widely used in practice by the Hydrographic Office. Galton carried one himself on his travels, and enjoyed whiling away

[6] Galton 1908, 61.

[7] Galton 1856a. See Appendix B, p. 65. Galton had taken in the Naval Review on the 23rd.

[8] Galton 1858; Galton 1855; Galton 1856b; Galton 1860; Galton 1867; Galton 1872.

Figure 3: Galton's Sun Signal.

the hours practicing its use in the mountains, and calibrating its visibility under different conditions. William Wharton was still recommending it at the turn of the century. 'A better instrument is the excellent and convenient Galton's Galton's Sun Signal, now also supplied. This is fitted with a telescope, by looking through which and adjusting the mirror, a dim image of the sun is seen covering the object required to flash to. Nothing can be better adapted to the purposes of the nautical surveyor's work than this (when he is once accustomed to it, as at first it is a little awkward to manage), and when obtainable they should always be used.'[9] In 1911, the *Encyclopedia Britannica* noted that Galton's sun signal was the most convenient of the heliostats used for surveying. The instrument was certainly widely used for coastal surveys.[10]

Mars had drawn Galton's attention as early as 1892, when

---

[9] William Wharton *Hydrographical Surveying* (1898), 35.

[10] *Encyclopedia Britannica*,Vol. 26, 'Surveying', 154. See also the *Official Catalogue and Guide* for the Naval Exhibition (1891).

he wrote a letter to the *Times* ruminating on the possibility of flashing sun signals at the planet, in the hope that Martians with telescopes might see the glimmering.[11] The planet was much in the news at that time. It was set to be unusually close to Earth that year, and there had in the past been reports from Giovanni Schiaparelli in Italy, and Camille Flammarion in France, among others, that canal-like structures were clearly visible on its surface.[12] Various observers even claimed that lights had been seen twinkling on the planet.

> SUN SIGNALS TO MARS.
> TO THE EDITOR OF THE TIMES.
>
> Sir,—Two facts appear in the papers—the one that an old French lady bequeathed a considerable sum for attempts to communicate with the planets, which has been perhaps rashly rejected; the other is that the planet Mars is now so near as that the exceptionally large magnifying power usable at the Lick Observatory[13] brings it optically to within 50,000 miles. To these I will add a third fact, derived from my own experiences in sun-signalling many years ago by a method described in the "Art of Travel." It then appeared that a reflected beam of sunlight sent through a hole in a plate in front of the mirror was just distinctly visible as a faint glint at a distance of ten miles when the hole was a square of one-tenth of an inch in the side. The amount of fog and haze that beam of light would traverse between us and Mars when the planet was high above our horizon could not exceed that along a terrestrial base of ten

[11] Galton 1892.
[12] Percival Lowell pursued this idea vigorously in the United States from 1893 onward.
[13] In California, near San Jose.

> miles; consequently the same proportion between the size of mirror and the distance would still hold true. It follows that the flash from many mirrors simultaneously, whose aggregate width was 15 yards, and whose aggregate length (to allow for slope) was, say, 25 yards, would be visible in Mars if seen through a telescope such as that at the Lick Observatory. With funds and good will, there seems no insuperable difficulty in flashing from a very much larger surface than the above, and sending signals that the inhabitants of Mars, if they have eyes, wits, and fairly good telescopes, would speculate on and wish to answer. One, two, three, might be slowly flashed over and over again from us to them, and possibly in some years, to allow time for speculation in Mars to bear practical fruit, one, two, three, might come back in response. Dr. Whewell, if I recollect right, wrote a paper on the possibility of coming to an understanding with lunar inhabitants, if there were any. He would begin from the mathematical side.
>
> The practical difficulty is by no means insuperable of enabling many independent observers (who need not be near together) to direct their flashes aright. If mirrors could be mounted without much cost as heliostats (and perhaps they can be) it would be easy enough to do this. My own method is not practicable, at least without considerable addition and modifications, as it requires the object to be visible towards which the flash is directed, but Mars is not visible to the naked eye at day.
>
> FRANCIS GALTON.

An anonymous writer in the *Sheffield Independent* demurred. ‘For my part, I confess, a gentlemen in Mars might signal to me from morning to night without my having the least idea not only of what he wanted, but that he was signalling.' And, slyly, that although canals were detected on Mars by an American observer, the fact that boats were not seen on them may have been due to the destructive effects of competition from the railways.[14] Likewise the killjoy *Spectator* insisted that mankind had no idea whether 'Martials' existed in the first place, whether they could see or what they might look like, and doubted whether any common language could be found to allow one party to understand the other.[15]

On September the 8th, Norman Lockyer took up the idea in *Nature*, repeating the contents of the *Times* letter, and contrasting it to a proposal put forward by the Rev. Hugh Reginald Haweis, who suggested using a giant battery of London's electric street lights in concert to send signals. The drawback of using sunlight would be that Mars would see the earth lit by the sun, without the desired contrast. Electric lights seemed more promising to Lockyer.[16]

Galton 'dashed off' a response to the discussion his letter had sparked off. A draft survives in the Galton Papers at University College London, and for once really is entirely on the back of an envelope.[17] It is prefaced by a note added by Galton much later. 'Interplanetary language. Draft of a letter to *Spectator*, they sent me a proof but did not eventually publish it'. However, the contents show that this is an error—see the reference to 'yours' below. The letter was probably intended for Galton's old sub-editor from his *Reader* days, Norman Lockyer, and his journal *Nature*.

> Being at some distance from London, I have of late seen & shall see few newspapers, but have noticed in the *Spectator* of last week a reference to previous

---

[14] *Sheffield Independent*, Wednesday 24 August 1892, 4.

[15] See Appendix D, p. 71.

[16] J. Norman Lockyer, 'The Opposition of Mars', *Nature* 46, 08 September 1892, 443–448.

[17] GALTON/2/10/9.

remarks of yours on the narrowness of the possible communication with Mars, supposing free communication by flashes to be feasible. It would seem that you limited it to the response of the 3 flashes suggested by myself as a mere illustration in a letter to the Times. But very much more than this would be possible, under the supposed circumstances. It is an interesting subject & worth writing a few lines about. We could literally probe their knowledge of algebra & the civil service. [I discuss what Whewell proposed as unsuitable to the easy] [... geometrical problems] Examiners could examine them, if both parties were pleased to take the trouble of acting as examiners and examinees. We could teach advanced mathematics to them, and learn from them. To simplify the explanation of how this [is done] let a dot · mean a flash followed by an interval, and let any word in brackets signify some appropriate combination of dot and dash symbols that would always be used by us to signify the sense of word or phrase, but which is supposed as yet to be unknown to the people in Mars. When it is known let it be written in italics.

First experiment (a) Flash (plus) Flash (equal) Flash Flash. (b) Flash (plus) Flash Flash (equal) Flash Flash Flash. (c) Flash Flash (plus) Flash (equal) Flash Flash Flash

Anybody in Mars with the smallest algebraic knowledge would understand that (plus) meant Plus, and (equal) meant equal, & would respond by analogous signals such as Flash Flash (plus) Flash (equal) Flash Flash Flash &c. To this we should send back (right)

By an analogous fashion (minus) would be understood & after a while (wrong).

So we have already got plus minus equal [...] right wrong

> Next might come fl: fl: (multiplied into) fl: fl: (equal) fl: fl: fl: fl: then ... (divided by) ... (equal) .... Then square & cube; square root & cube roots. The knowledge of the symbol for equal would enable (symbolic) names of the numbers to be communicated thus dot dot = dot dot dot − dot = dot plus dot = (two) & so on. Next the symbol for (raised to the power of) 2 = 4.
>
> Next try binomial expansions $(2 + 1)^2 = 4+4+1$ $(2 + 2)^2 = 4 + 8 + 4$ $(2 + 1)^2$ $(2 + 2)^3$ &c. & finally when that was quite clearly taken $((a)+(b))^{(n)}$. Every one of which unknown symbols after so much preparatory leading, the Martials would make out. Sine & cosine &c would be conveyed by their algebraical expressions and by running algebraic expressions side by side with their geometric equivalents, a considerable number of useful words would be in time determined: circle, line, intersection, angle, perpendicular, square, rectangle &c. Then the formulae for gravity & the numerical values that we know, for that at the surface of Mars to which they w^{d} respond to. Give that at the surface of Venus [...][18]

In January of 1893, Galton developed his information encoding and transmission ideas in the second part of a public lecture at the Royal Institution, on the 'Just Perceptible Difference'.[19] Even though it was held on a Friday evening, it was well-attended. The cyclostyle was then in wide use for creating copies of documents using a stencil, on the principle that discrete dots of ink placed sufficiently close to each other appeared to be continuous. Experimentally it had been found that at the reading distance of one foot, 300 dots per inch (an angle of one minute of a degree) appeared to be continuous.

[18] Cut off here.

[19] Galton 1893.

However the cyclostyle economised at a 'good enough' 140 dots per inch.

Galton described a scheme for encoding pictures using 26 alphabetical characters. Letters a to p gave compass directions from reference points, starting from north, clockwise. Z is used to signal 'end' (of the segment from the current reference point). To allow movement with no corresponding marks, to capture isolated parts of a figure, R and S could be used to delimit the invisible moves. The remainder of the letters were reserved for establishing and then moving the reference points. In this way a sequence of letters, grouped for convenience into words of at most 5 letters, could be used to encode a picture, transmit it by telegraph, and reconstruct it on the other side. A fragment of a picture might look like the following, which draws the eye of a Greek portrait of a girl (see Figure 4). The encoding starts from the reference point U on the brow, and makes the sequence of invisible moves between R and S, before outlining the eye from the new reference point V:

> URkkk kklll mSVap pomnn mralmm mhnlm llmZZ VnTnn mnmmm mmmlm mmnZZ Tjjjj jjkkc chmm mnnn onoo

A second encoding scheme was also described, using a numerical grid of coordinate moves, centered at (4,4), or 44. This allowed for finer control, with 63 moves from each successive dot, up to 3 spaces at a time—but at the expense of a longer encoding (see Figure 5). This come closest to what modern readers will recognize as a digital encoding of an analog picture, e.g. 21, 31, 62, ...

In private, Galton worked out the preliminary details of Martian signalling, but put the work aside when general enthusiasm for the remote planet temporarily faded. Nevertheless, the reading public had been following the conversation. In 1895, in the short story 'Message from Mars', a professor of mechanical engineering at Bristol University again took up

Figure 4: Profile of a Greek Girl from a Medallion, for Encoding.

11	21	31	41	51	61	71
12	22	32	42	52	62	72
13	23	33	43	53	63	73
14	24	34	**44**	54	64	74
15	25	35	45	55	65	75
16	26	36	46	56	66	76
17	27	37	47	57	67	77

Figure 5: Grid-based Moves. Each successive dot is re-centered at 44 for the next move.

the idea of communications with Mars by means of light. Few technical details were given, though the possibility of communicating shapes and numbers by spectra was mentioned.[20]

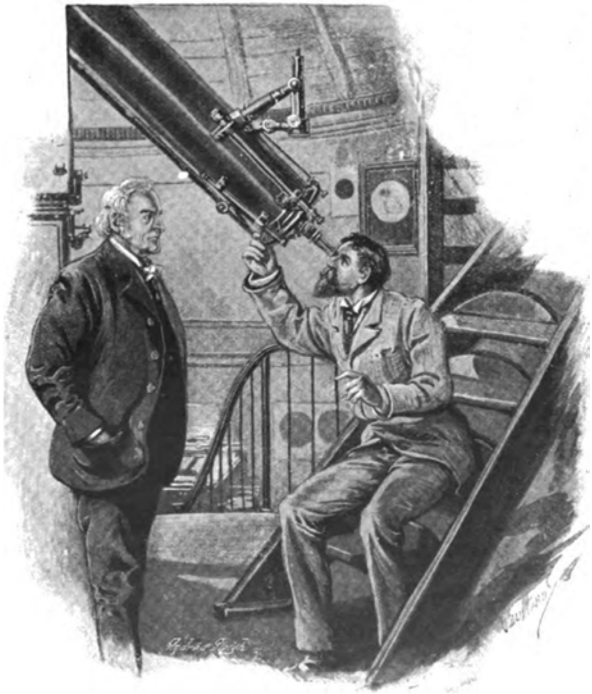


Figure 6: Peering at Mars, as imagined by Cassell's Family Magazine *in 1895.*

In the following year, 1896, Galton was taking one of his annual continental soaking cures, this time in Germany at the Wildbad spa. On the 19th of June he had suffered another attack of 'gastric catarrh' (most likely what is now called gastritis), and was packed off to the spa on July the 10th by the family physician of long-standing, Dr. Dobrée Chepmell.[21] Finding himself with time to spare, as the rain had set in gen-

[20] John Munro (1849–1930), 'Message from Mars' in *Cassell's Family Magazine*, 1895, 292.

[21] Dr. Isaac Dobrée Chepmell (1828–1919), educated at Elizabeth Col-

erally, for weeks, he picked up the notebook again. Increasing deafness meant that other distractions were limited anyway. Internal evidence from the notebook implies that he was working on the Martian theme again by July the 29th of 1896, and that all the text in the notebook related to this dates from that period.

Now Galton placed his bootstrapping information encoding scheme within a science-fiction vehicle, letting his imagination loose. The residents of Mars, who it so happens are the descendants of Ant-like creatures, with faces like diving helmets, are startled to see flashes from Earth. Newspaper controversy ensues in the *Bellona Gazette*. Speculation about the nature of the earthlings runs rife. An expensive telescope is constructed despite budget hardliners. The messages are decoded using the bootstrapping principle, starting from elementary arithmetic. As an introduction to these events, the narrator describes the morphology of the Martians, and their eugenic practices, whereby natural selection has been enhanced.

According to Louisa's yearly record, the Galtons were back in England by September the 7th—by way of Oberstdorf, Davos, Zurich, Freiburg, Strassbourg & Rheims—so Frank had about a month and half all told to work on the story. Back in England, or perhaps even earlier on the continent, after Wildbad, Galton rewrote and edited the piece down to the form it took in the *Fortnightly*, where it appeared in the November issue. Correspondence with the editor, W. L. Courtney, shows that the piece must have been submitted in September at the latest, as it was accepted by October the 2nd. The manuscript of the neutered version, with its inversion of the roles of Martians and 'earthlings', has not survived.

But before Galton's piece was even published, the news-

lege and Kings College, and for at least 8 years the travelling personal physician of Lord Hollond. He was forced to retire in 1897, due to acute glaucoma. His other patients included Lady Gregory. See *Lancet*, Feb. 6, 1897, 394 papers managed to garble the details, drawing the following testy complaint.

> SIGNALLING FROM MARS.[22]
>
> TO THE EDITOR OF THE STANDARD.
>
> Sir,—ln the Article in *The Standard* on my paper in the forthcoming "Fortnightly," you say: "The result in his imaginary case was that, in the course of about three and a-half years, the terrestrial astronomers had been taught a code ..."[23] I said and showed that three and a-half hours would suffice, which makes much difference in the interest of what I endeavoured to explain. I am, Sir, your obedient servant, FRANCIS GALTON. 42, Rutland-gate, S.W., October 28.

Still, the advance notice in the *Evening Standard* shows how seriously the thoughts of Galton, as a leading member of the Royal Society and other bodies, were taken even on topics as remote from his usual remit as interstellar communication.

The *Globe*, the *Illustrated London News* and the Guernsey *Star* were enthusiastic about Galton's proposition and flights of fancy.[24] For skepticism one had to go further north, to Sheffield, where the *Independent* was not impressed. 'To attempt to communicate with Mars would leave the combined millionaires of the world out at elbows, and might in the end be as much use as an oration to an ash-heap. On the whole, in spite of learned articles in half-crown reviews, it is wiser to wait until our planetary neighbours begin.'[25]

The Mars notes and all their elaborations show the inventiveness, the broad reach and the all too often neglected comic side of Galton, a man who could turn his attention to almost any subject and get interesting results. Previously only a few fragments of the text have appeared in Derek Forrest's

---

[22] Galton 1896b.

[23] See *London Evening Standard*, Wednesday 28 October 1896, 5.

[24] Wednesday 28 October 1896, 1; Saturday 12 December 1896, 19, 20; Saturday 31 October 1896.

[25] *Sheffield Independent*, Wednesday 04 November 1896, 4.

biography of Galton.[26] The full text is reproduced here for the first time, reconstructed from Galton's very rough form, along with the *Fortnightly Review* version and other interesting pages from the notebook, on subjects such as discontinuous variation, classification, religion and moral philosophy.

Uncertain constructions appear in square brackets, e.g. [doubtful], whereas occasionally illegible sections appear in ellipsis, e.g. [...]. Illustrations in the text are taken from the images of the notebook to be found in the Galton Papers in the Wellcome Collection, following the terms of the 'Creative Commons Attribution 4.0 International licence' appearing there.[27]

Gavan Tredoux / November 2018.

[26] Forrest 1974, 237–240.

[27] See `https://wellcomelibrary.org`.

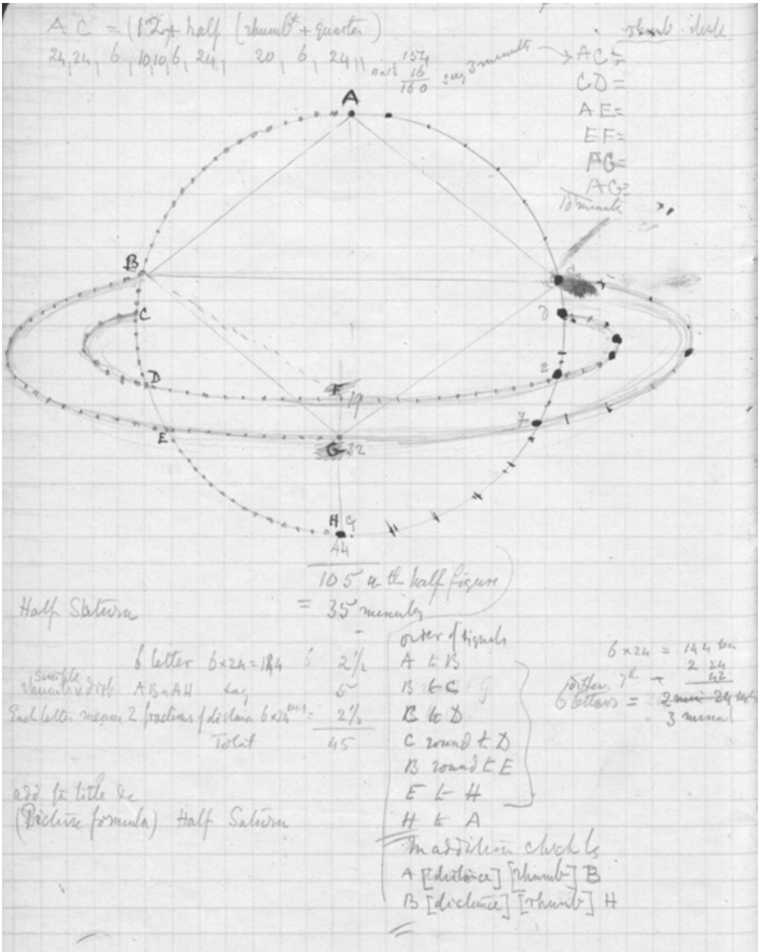


Figure 7: Encoding a picture of Saturn for transmission to Mars.

Contents

List of Figures

Chapter 1

Rough Outline

Opportunity approaches shd be seized (letter by an Amateur) Optimist

Letter by Optimist

Newspaper commentary we are ants, Earth Folk may be quite different, even developed vertebrates without antennae / no intelligible signals possible—just an answering flash, no more useless attempt and very costly as communicated by official astronomer who grumbles

Amateur astronomer. letter. twinklings from bright crescent of Earth like to but more intense than the sun on [blue] they have a [purposive] appearance - request for telesc. 3 times more effective Newsp. after a year or so happy announce that by [bounty] of rich canal proprietor telescope is got mounted & is [nearly] ready for use

Another astron.: there is no doubt now of the telegraphic characters – but no clue yet to their meaning. Each message lasts for about an hour. Signals are made only from one point in the earth & are so timed that none are sent when sun is less than 20°above horizon at that point. Apparatus to record is in hand

Amateur Astron: Frequent failures owing to various accidents including earth clouds &c. but it appears that [the] whole communication consists of different messages one of which is sent every 4 days the others have each one day to themselves. By accumulating the records of 2 or 3 their several deficiencies will soon be made good

Amateur Astron.: Hurrah—the first 2 sets are quite made out & the first gives a clue to all the rest. The results will be communicated today, to the A Soc. The rest is under earnest consideration but puzzles at present.

Newspapers of next day, popular account of numerals & signs & decimal point

Official Astron.: grumbles at decimal system & speculates on its cause

Amateur astron.: announcement of drawing. much remains to be deciphered errors in long series

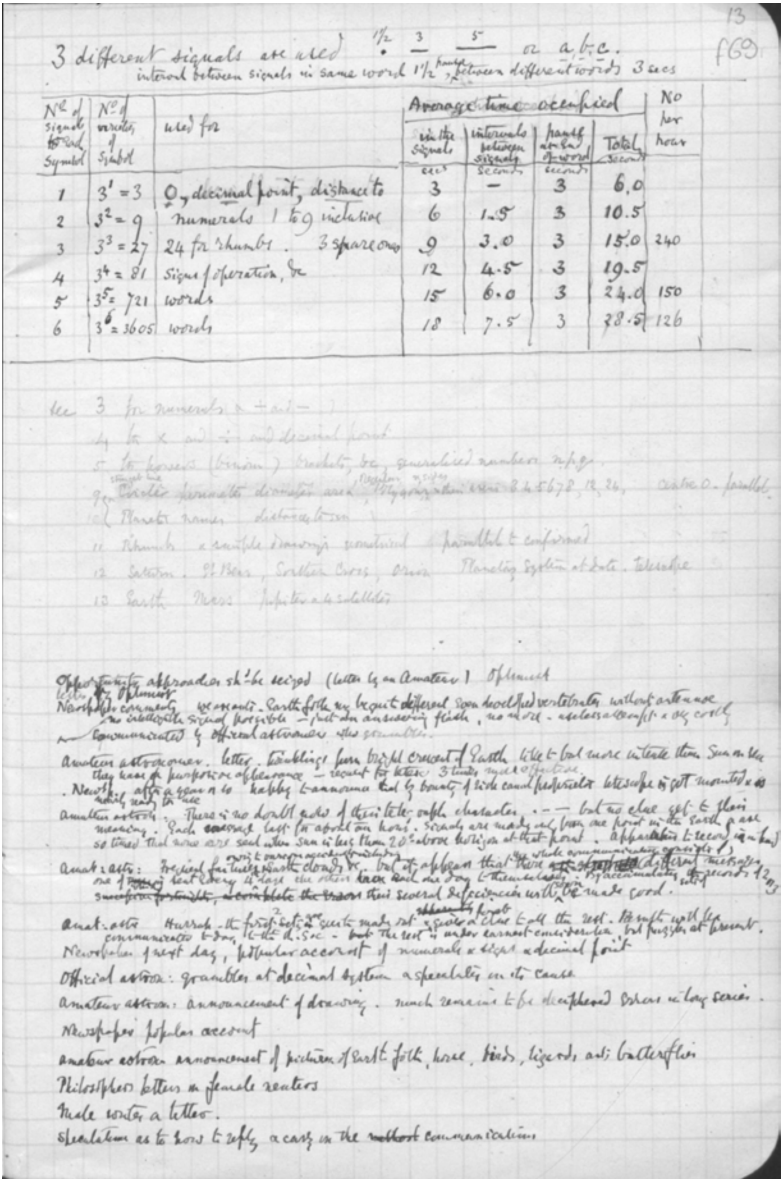
Newspaper popular account

Amateur astron. announcement of pictures of earth fish, horse, birds, lizards and butterflies

Philosophers letters on female neuters

Male writes a letter

Speculations as to how to reply & carry on the communications



13

f69

3 different signals are used ⁝ 1½ 3 — 5 — or a, b, c.
interval between signals in same word 1½, between different words 3 secs

No of signals to each symbol	No of varieties of symbol	used for	Average time occupied: in the signals (secs)	intervals between signals (seconds)	pause at end of word (seconds)	Total (seconds)	No per hour
1	$3^1 = 3$	0, decimal point, distance to	3	—	3	6.0	
2	$3^2 = 9$	numerals 1 to 9 inclusive	6	1.5	3	10.5	
3	$3^3 = 27$	24 for rhumbs. 3 spare ones	9	3.0	3	15.0	240
4	$3^4 = 81$	Signs of operation, &c	12	4.5	3	19.5	
5	$3^5 = 721$	words	15	6.0	3	24.0	150
6	$3^6 = 3605$	words	18	7.5	3	28.5	126

Newspaper next day, popular account of numerals & signs & decimal point

Official astron: grumbles at decimal system & speculates on its cause

Amateur astron: announcement of drawing. much remains to be deciphered others in long series.

Newspaper popular account

Amateur astron: announcement of pictures of Earth folk, horse, birds, lizards, ants, butterflies

Philosopher letters on female writers

Male writes a letter.

Speculations as to how to reply & carry on the [illegible] communications

Figure 1.1: Page 13 of the Notebook.

Chapter 2

Introduction

In the following pages will be found a free translation of a series of letters which will appear about the middle of the approaching century in the *Bellona Gazette*, which is the leading newspaper of the planet Mars. The translation is as faithful as practicable, considering the very great differences in conditions of light on Mars and here. The numerical system of the Mars folk, their measures. dates & so forth, are translated into our own. Alas many expressions, which would otherwise be misinterpreted or altogether unintelligible without voluminous explanations, have been terrestialised, so to speak.

This book will of course be of interest to students of the occult sciences and it will also be of great service to them. They have hitherto been unable to satisfy the legitimate demand for proofs of their high professions. That deficiency is here supplied with fullest measure. How indeed, may they triumphantly say, would it be possible to anticipate, by half a century, occurrences on a scene some hundreds of millions of miles away from the earth, without methods which according to the incorrect phraseology of the present day are termed supernatural?

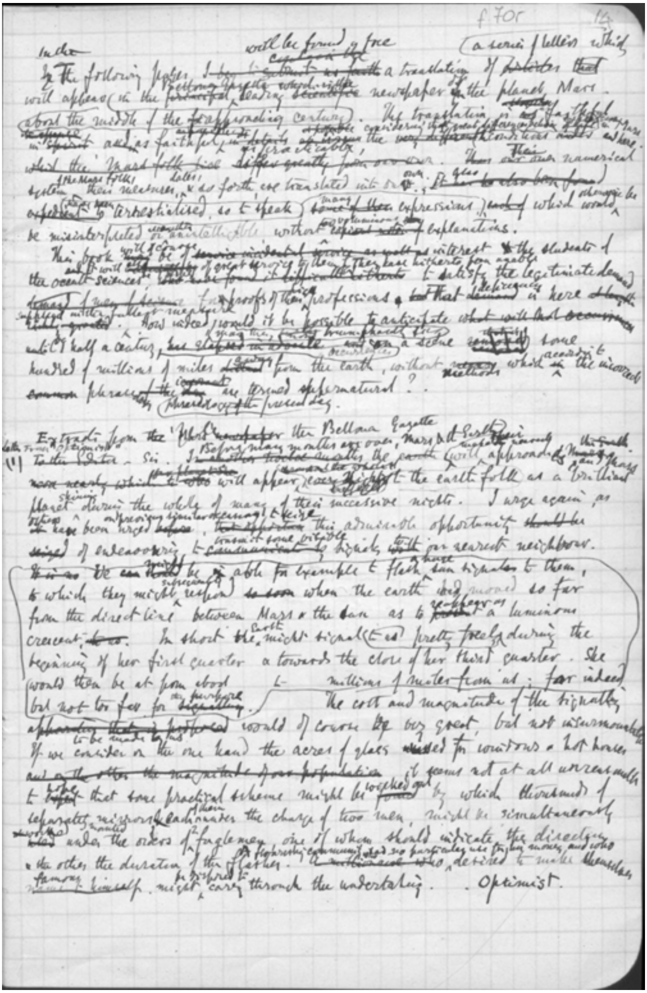


Figure 2.1: Page 14 of the Notebook.

2.1 Preliminary

- 6 legs like centaurs 15 hands high, faces like diver's costume—no hearing—antennae

- Gesture communication like deaf mutes—Oxford chapel[1]—middle limbs
- Neuter females—passion for routine work like women knitting & sewing, love of eggs & larvae—aversion to males, but [cowed] by them also [conscious] of their supremacy all round. Great fear of & respect for fertile females
- Males vivacious warlike, only jealous during brief season of love—chivalrous all poetry, eloquence with gesture, art resided with them. Loyal to fertile females. Indifferent to [undermen] of the neuters
- Fertile females about 1 to 10 males—House wifery—lay numerous eggs at one season of the year. No care for them—the neuter females do that—They select their males & mate
- Egg for a short time—then [labor] for 6 months—are watched & tended much as growing crops not loved. A provisional selection of about 1 in 10 is made. The rest killed [survivors] allowed to pupate & the neuters have same passion for the pupae that ants have for theirs. Emergence full grown but soft great anxiety & interest—going to school & college
- The social system [is] full of interest but will not be touched on here—Many communities, usually at war
- Mars [Moon] Bellona war battle warrior arms sword spears lance dagger club mace arrow bow sling archer bayonet mail broadsword spur trumpet dram murder homicide fury, [...], hate despair groans, agony, shriek yell blood slaughter wound gash victory conqueror

[1]Oxford Street chapel for deaf mutes, see below.

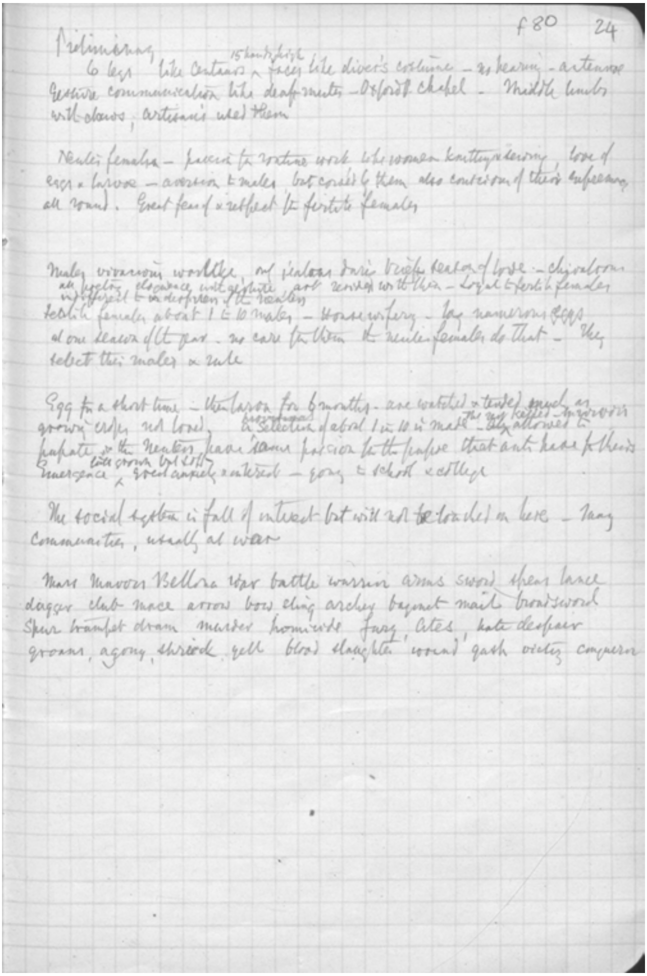


Figure 2.2: Page 24 of the Notebook.

2.2 Ethnography

The Mars folk resemble ants in many particulars, though far larger and more highly developed. Their fore pair of limbs are equal to any hands in their power of grasp and delicacy of touch, though of course they differ greatly from them in shape.

The Mars folk, as quadrupeds, walk on the middle & hind pairs of limbs with their heads erect & arms fore, bearing a resemblance to small, slightly made & very agile centaurs the same height as the back of a chair. Each of the middle pair of limbs is furnished like those of ants, with a powerful pair of claws. These are of much use to artisans, who rest themselves on the tripod formed by the end of the body & the two hinder limbs, then grasping any object between the claws of the middle pair, as between two vices, their hands are free to operate upon it. Their skeletons are wholly external like a panoply of heavy armour, but its weight is unimportant since the force of gravity on M is only a third of that on the E. Their sense of hearing is almost deficient but their eye power is acute and ample. Their lateral eyes as in ants, are of the mosaic type consisting of a vast number of facets each of which admits a beam of light so narrow that objects are in focus at all ranges, with the result that almost the whole panoramic area is simultaneously in view and no change can occur in the surrounding objects without attracting attention. The folk are therefore even more alive to what is going on around them than our deaf-mutes. They have 3 frontal eyes like ants, of the same order as our own, one of which is highly myopic & serves as strong lens. They are highly developed. In short the optics of the M folk are much more efficient than our own, both in respect to the acuteness of vision, and in the width of their field of view. They see minute & distant objects with the keenness of eagles & squirrels and their unaided eyesight is quite as good as ours when we are aided by an opera glass.

Their senses of taste & especially that of smell are highly discriminative and so is that of the touch in the hand & certain parts of the body, principally through the medium of bristles and hairs which pass through holes in the external armour to the sensitive flesh behind it. But above all the rest in sensitivity of touch are the antennae which [during] conversation between social equals and friends are in constant movement and touch. They convey not only as much as ordinary men & women can convey by grasp, squeezes and gentle pressures of the hand, but quite as much as any 'thought' reader or rather any gesture interpreter can make out from them. Their peculiar power leads to curious customs, one is that in diplomatic conferences where whatever is 'said' (i.e. conveyed by signs) at the council table must be spoken to all, the members are to wear official costume consisting of a sort of helmet with hollow horns to contain & conceal the antennae. Their public utterances are also gesture language like that of deaf mutes, which may be seen in operation any Sunday in the pulpit in the Deaf Mute chapel in Oxford street. It is easily understood that their [physiognomies] & faces are not in the least what we should call beautiful; they roughly resemble that of a diver in full costume.

The people are divided, as ants are, into 3 principal groups: the fertile females, males, and neuter females, but their proportionate numbers differ considerably. In the same community there are usually many fertile females, which is rarely the case in ants (——[2] being one of the few exceptions) and attached to each of these there [are] half a dozen or a dozen males. The season of love is of brief duration and at other times of the year social life proceeds calmly even among the males, though they are always apt to fight on slight questions of honour.

Life is begun in the form of an egg the size of that of a hen or a crocodile which is laid about a fortnight after the close of the mating season. Each fertile female lays a large number of them in rather quick succession with small strain to her health & strength. Afterwards she cares no more about the eggs, but returns to her usual & queenly & housewifely life, while they are looked after by the neuter females. In another week's time, the larvae are hatched which are about 6 inches long at first. They are tended with great care by the neuters

[2] Omitted by Galton.

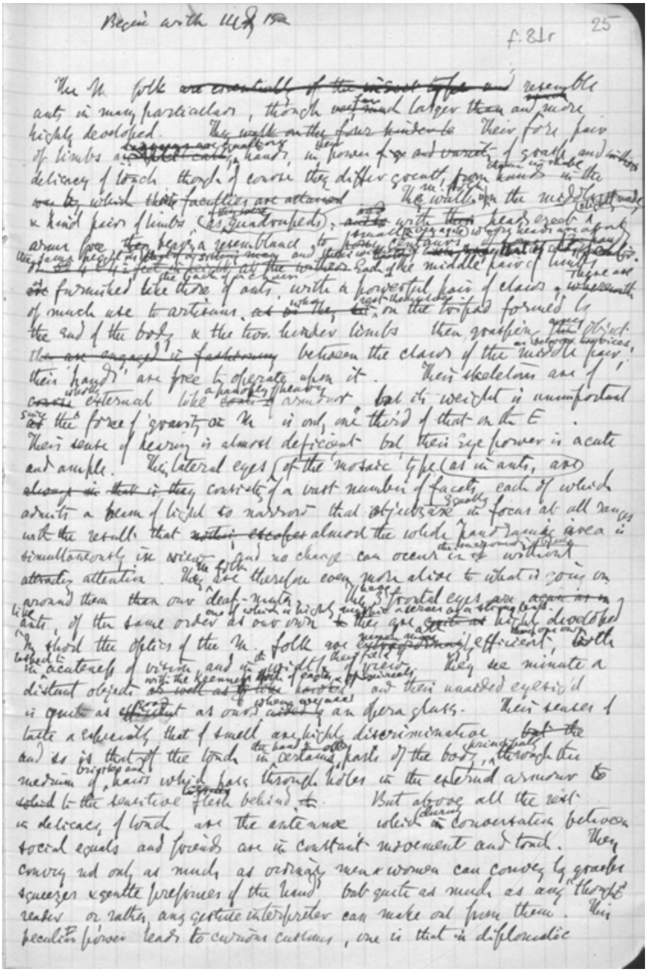


Figure 2.3: Page 25 of the Notebook.

who assiduously note & record [the] physical & instinctive peculiarities of each larva, with the view of determining which should ultimately preserved and which destroyed. Perhaps 20 times as many larvae [leave] the egg as are allowed to pupate. The attachment of the neuter nurses to the larvae is of a curious business-like kind, there is no love in it, for these neuter females seem incapable of true affection. Anyhow they nurse, watch & observe the larvae sedulously, and from time to time a formal consultation takes place between the queen & males, after which the neuters kill quite coolly those of their growing charges who it has been judged undesirable to preserve.

Some few unpromising larvae are always kept for scientific investigation, to see how they will turn out in after life, it being of obvious importance to the community that the selected larvae should really be the fittest and it is only by careful test experiments that the value of the rules under which the selection takes place can be confirmed & the rules themselves gradually improved. The larvae lead a purely animal existence feeding & fattening enormously; their numbers are from time to time reduced as above described until at the time of pupation 12 months after they began to live; there remain but only nine that are intended to live, each being a huge grub some 4 feet long & six or 7 inches thick.

When the larvae show signs of approaching pupation they are placed into separate cells where they weave a cocoon about themselves. There they lie, with little help, outwardly impassive but inwardly undergoing rapid & continuous changes, until the time comes that they burst their cases, aided by anxious neuters, and emerge feeble & limp but as perfectly good M folk, so far as physical form is concerned. There follows a long period of hardening and what may be called school & college life, after which certain probationary tests with accompanying ceremonies are gone through, and the probationaries receive the full rights of citizenship.

It w^{d} take far more space than can now be spared to describe the social life, so different from our own, of these communities, whose stability rests largely on the division of their constituents. The fertile females queen it over the males. They are superior to any one of them in size & strength and such is the constitution of the sexes that while their figures & de-

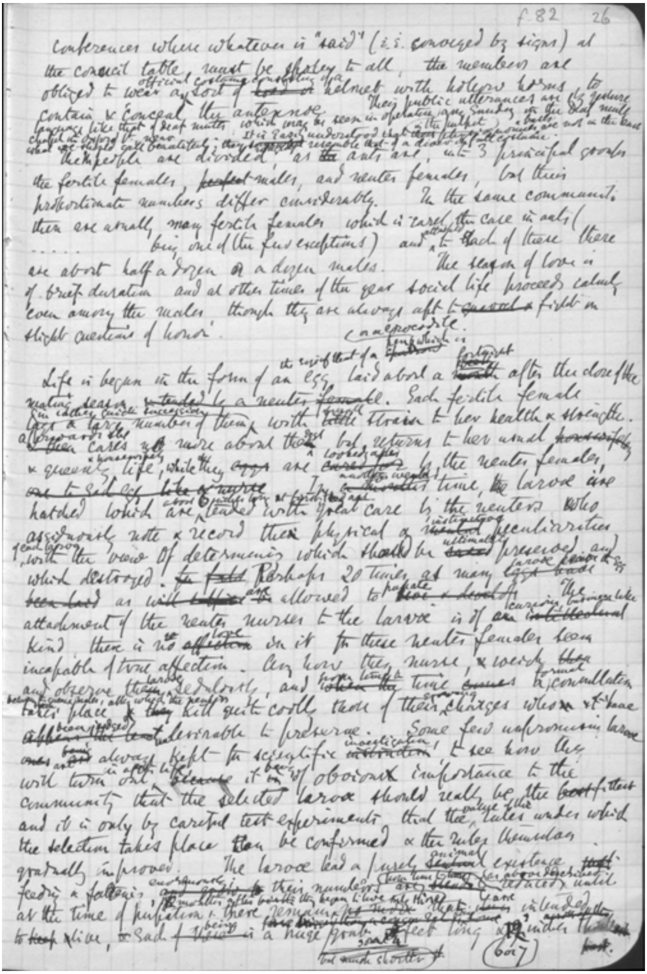


Figure 2.4: Page 26 of the Notebook.

meanour excite some fear in the weaker males, they also evoke their chivalrous loyalty and attachment The fertile females rarely associate; they do not necessarily dislike one another but they are too jealous & self-contained for mutual friendship. Each keeps her own court and they intercommunicate by usually neuter agents.

The neuter females possess no [quality] that we should call loveable; they are devoid of heart & generosity & they have but little originality—but they continually occupy themselves with work of some sort however [measly] & cannot keep still for a moment. Whatever passion they possess is socialistic—they certainly care little for themselves and much for the community, and though very obstinate in small things are practically directed by the males, with the concurrence of the queens, towards whom their attitude of mind is [...] It is one neither of personal love nor of personal loyalty, but rather one of respect for the temporary representatives of a [caste] which prevents the community from becoming extinct, by replenishing it through their eggs.

The males are warriors. They have all of the truly male virtues and all the manly defects of our race; they are the salt of the community both morally & intellectually. They look on the neuters as 'hands' in a factory, not particularly disliking or contemning them, but as members of a different social stratum, who have to be dealt with in matters of business, but not as friends. In the course of history, rebellions of the neuters have occurred, nearly all of which the rapid and concentrated action of the warlike males have achieved [...] often bloody victories over, with the result that queens & males have taken good care that the number of neuter pupae should be kept as low as national convenience would permit, for future generations.

That part of their civilization which will chiefly concern us is the mechanical & mathematical side which is fully as much developed among their professionals as among our own. As the laws & materials of nature are much the same throughout the solar system, their inventions are to a considerable extent parallel to our own though different in details, but their ethics are altogether of another kind. Their consciences are not like ours, nor are their chief pleasures & ambitions like those by which we are moved. They are far more alien to us than the

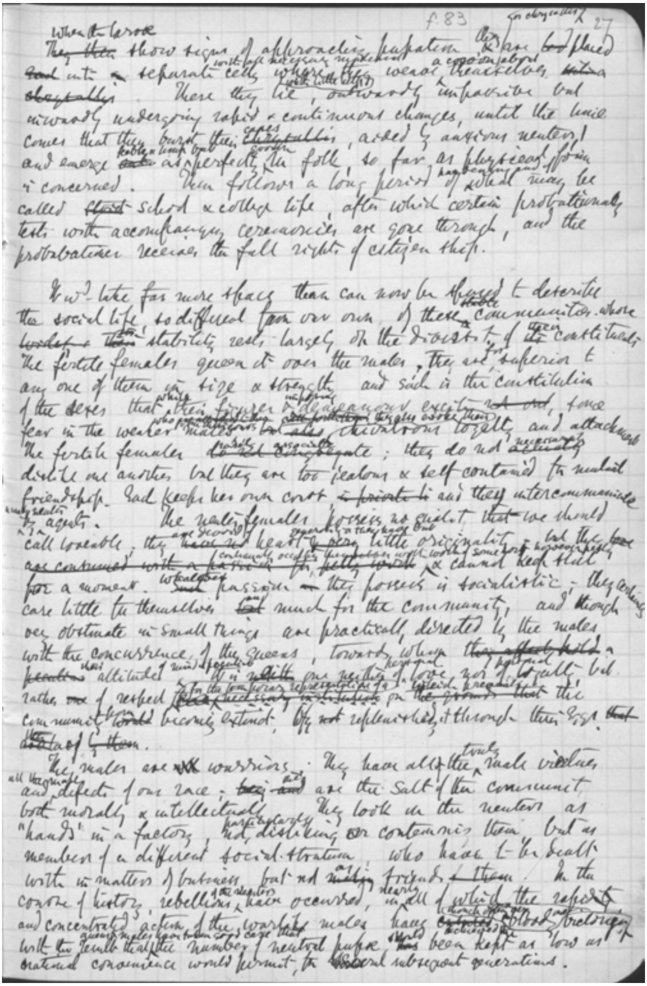


Figure 2.5: Page 27 of the Notebook.

Chinese & that is saying not a little. Into these interesting psychological topics we must not enter now, for they have no direct bearing on the work before us.

Chapter 3

Extracts from the *Bellona Gazette*

3.1 Letter from Optimist

Sir. Before many months are over, Mars & the Earth will make their nearest approach & Mars will appear to the earth folk as a brilliant planet, shining during the whole of many of their successive nights. I urge again, as others have urged on previous similar occasions, to seize this admirable opportunity of endeavouring to transmit some visible signals to our nearest neighbour. We might be able for example to flash a huge sun signal to them, to which they might subsequently respond when the earth had moved so far from the direct line between Mars & the sun as to re-appear as a luminous crescent. In short the Earth might signal to us pretty freely during the beginning of her first quarter & towards the close of her third quarter. She would then be at from about —— to —— millions of miles from us; far indeed but not too far for the purpose. The cost and magnitude of the signalling would of course be very great, but not insurmountable. If we consider on the one hand the acres of glass used for corridors of hot houses it seems not at all unreasonable to hope that some practical scheme might be worked out by which thousands of separated mirrors, each of them under the charge of two men, might be simultaneously worked [...] under the orders of 2 fuglemen,[1] one of whom should indicate the direction & the other the duration of the flashes. Men [who] a flourishing community had no particular use for [...] and who desired to make themselves famous, might be disposed to carry through the undertaking.

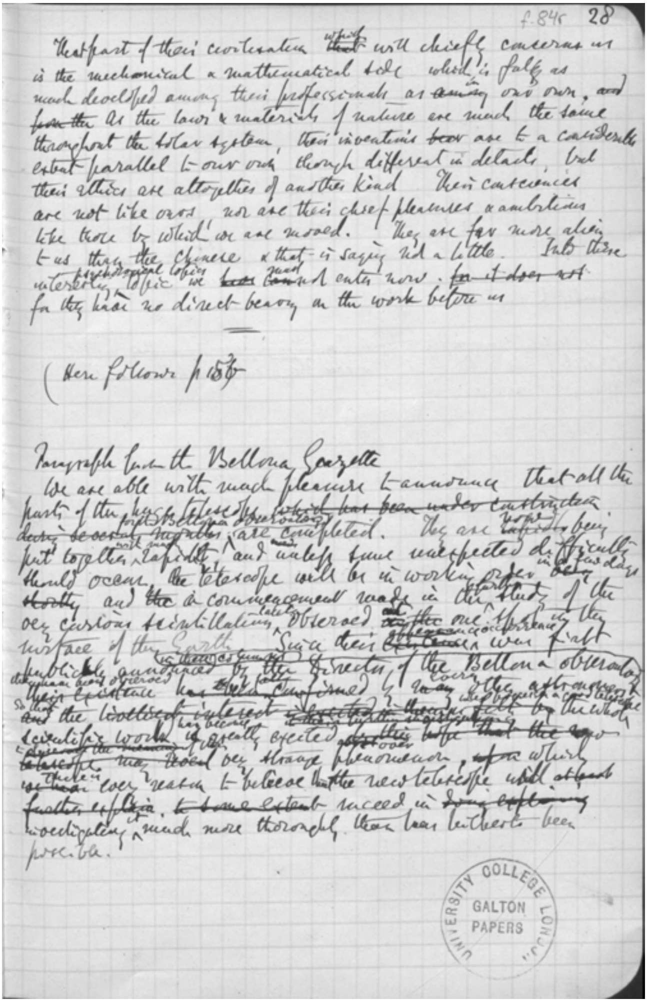
Optimist.

3.2 Letter from *Respice Finem*[2]

I will not enter in to the [imperfect] consideration whether the proposed signals could really as explained be made, but wish to point out that at the best [their] value would be very small. The result could only be that we had made a signal & that the Earth had reciprocated it, proving that the earth was inhabited by observant & intelligent beings. Very probably it is [so] but the fact would be placed beyond doubt by this experiment. This however is the sum total of what we could possibly learn. We & the Earth folk have no common language or means of forming one & consequently no means can exist for rational communication. We could never learn what we most want to know such as the forms & features of the inhabitants of the earth, their industries and inventions, their social life, the exact amount of their intelligence & so forth. If it were possible to learn all or a part of this, a costly experiment might be reasonably undertaken by zealous men, but all the knowledge that we could achieve is so ludicrously inferior to this that the proposed experiment could not be other than a piece of wasteful folly.

Respice Finem.

[1] Drill models for showing how things are to be done.
[2] Consider the consequences.


f.845 28

That part of their conversation which will chiefly concern us is the mechanical & mathematical side which is fully as much developed among their professionals as among our own, and as the laws & materials of nature are much the same throughout the solar system, their inventions are to a considerable extent parallel to our own though different in details, but their ethics are altogether of another kind. Their consciences are not like ours nor are their chief pleasures & ambitions like those by which we are moved. They are far more alien to us than the Chinese & that is saying not a little. Into these interesting psychological topics we need not enter now for they have no direct bearing on the work before us

(Here follows p 186)

Paragraph from the Bellona Gazette

We are able with much pleasure to announce that all the parts of the large telescope ... are completed. They are now being put together rapidly, and unless some unexpected difficulty should occur, the telescope will be in working order in a few days and a commencement made in the study of the very curious scintillations lately observed on the surface of the Earth. Since their existence was first publicly announced by the Director of the Bellona observatory ... the scientific world is greatly excited ... very strange phenomenon, and there is every reason to believe that the new telescope will succeed in investigating it much more thoroughly than has hitherto been possible.

Figure 3.1: Page 28 of the Notebook.

3.3 Letter from "Common Sense"

Sir. A prospect such as that in the letter of Optimist is almost too absurd for a philosopher to notice, but as enthusiasm is catching, and as you have probably many readers who are both ignorant & of an enthusiastic temperament I beg to submit a few common sense considerations before they are led away by [foolish] [notions].

First, supposing the [unnecessarily] costly apparatus to have been made and the double thousands of men to have been obtained, paid for & instructed to work it, and again that the Earth folk would follow suit, what at the best could it lead to? We should learn that Earth was inhabited by observant mechanical creatures, having some understanding; but beyond that nothing. Mars would have, so to speak, waved something; Earth after the lapse of some weeks or months would have waved in reply.

Our knowledge of the Earth folk would go no further. It would clearly be impossible to communicate further in an intelligible way, even if signalling [to & fro] were prompt, for we can invent no common language. Even under the most favourable suppositions the costly undertaking would lead to almost nothing. On the other hand the probability that the earth is inhabited by creatures who could & would reply is infinitesimally small. Its animals and plants must differ wildly from our own and however various & numerous they may be, it is scarcely likely that any one of them should have arrived at the mental stature of Mars folk, who are the Lords of all living things in their planet. Yet the students of evolution prove that we Mars folk are mere varieties of the common ant and collateral descendants from a common stock. Ants have six limbs like ourselves, though their middle pair are shorter, the hard skeleton that supports their frame like ours is external; their populations are divided into fertile females, males, and working neuters and so are ours, though by no means in the same proportions. The only really novel point in our structure is the arrangement for expelling air through a reed like structure in various ways, that is capable or producing a variety of sounds combined with a complex auditory apparatus by which those sounds can be heard & distinguished.

We and the ants are alike provided with at least five principal senses, that is we see, feel, taste and smell; and the antenna-tact. Therefore although we are vastly larger than they are, measuring fully 4 feet in height when we assume the ordinary posture of the insect, and although our mouths are far less prognathous than theirs & shapely & expressive and although our fore pair of limbs are furnished with delicate apparatus for touch and handling & our middle pair are reduced to powerful [holders] these details do not affect the essential similarity. When one of our artisans sits on the ground, stayed by his [diverging] legs, and [grasps] an object between the claws of his middle limbs, as in a vice, while he operates upon it with his hands, he looks at a distance very like an ant. How can we expect that the evolution of the Earth folk should have followed the same particular line as that of our ancestors? Nay, why should this structure have originated in an insect form? It is conceivable for instance that the vertebrate class of animals may have capacities for development and that the ruling earth folk may be related to the agile & mischievous monkey or to the slow obstinate ass. Any how it is most improbable that the ruling Earth Folk, if such there be, should have any features, thoughts & feelings in common with ourselves that would make rational intercommunication possible. If a community of Mars Folk runs mad & chooses to spend their [overplus] fortune in carrying out the proposal of "Optimist" then the name of that community will undoubtedly be handed down in future generations as the perpetrators of a most egregious piece of folly.

Yours &c. Common Sense.

3.4 Letter from Bellona Observatory

Certain phenomena on the surface of the earth have been under careful observation by my assistants for some time past, signs

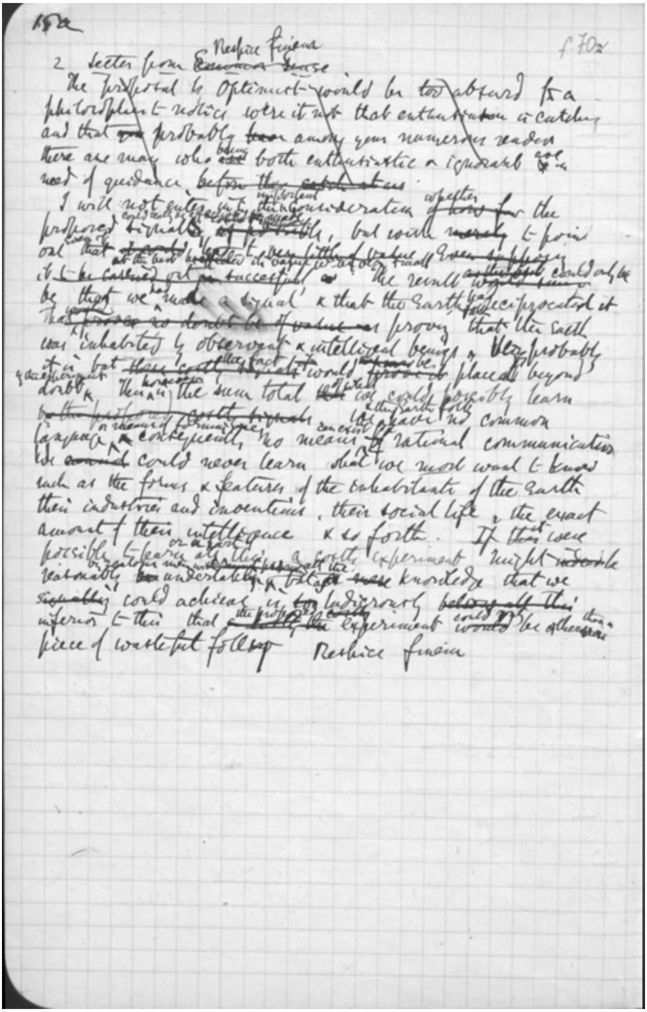


Figure 3.2: Page 15a of the Notebook, Part 1.

which require very careful investigation with a more powerful telescope than this observatory has at its disposal. It is well known that a small luminous spot is often visible on the globe of this planet, caused by the reflection of the sun from the face

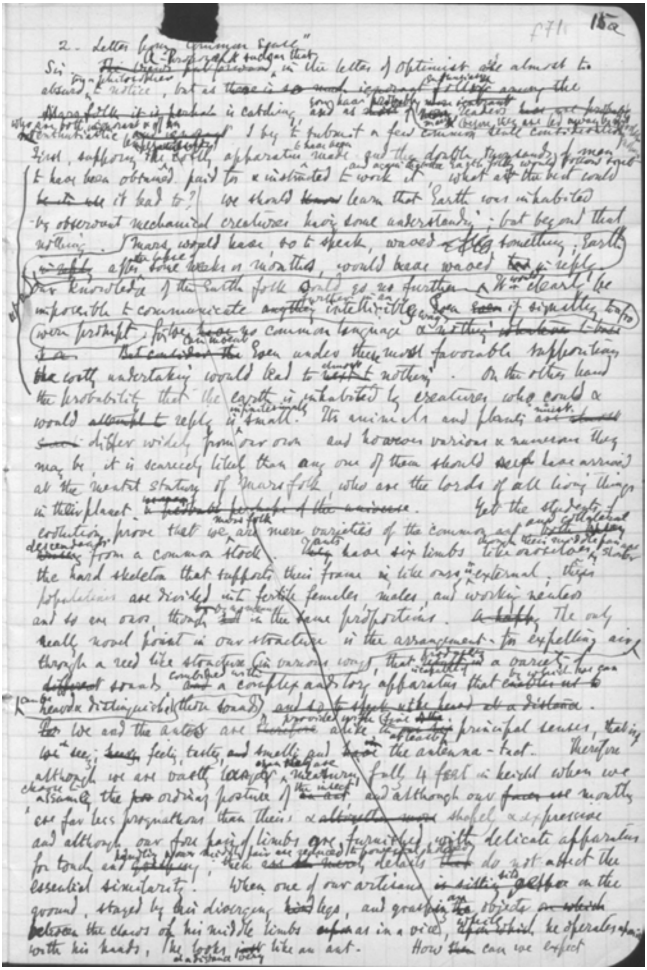


Figure 3.3: Page 15a of the Notebook, Part 2.

of one of the seas when the water is calm, and the sky clear. The phenomenon about which I am about to speak is also a luminous speck but distinctly smaller & more intense. It proceeds from the same definite part of the Earth's surface which is certainly not sea, on apparently a high plateau situated in the neighbourhood of what appears to be tracts of snow in the subtropical region. It is also noticeable that the point in question is one that for a long time past has been described by astronomers as rarely hidden by clouds, and therefore may have been selected as appropriate for making these signals. This luminous speck flickers at various rates and apparently in a purposive way, just as though an attempt were being made by the Earth folk to attract our notice by flashing sun signals. It appears to me, from experiments I have made on the visibility of sun signals, that a telescope of double, preferably of treble, the efficiency of the largest under my control would be adequate to carry out the desired investigation. I am doing my best to obtain funds for the construction of such a telescope. It would not be extremely costly as some delicacy of definition might be sacrificed in order to procure the needful amount of illumination and magnifying power.

Bellona Observatory

3.5 Paragraph from the *Bellona Gazette*

We are able with much pleasure to announce that all the parts of the huge telescope are completed. They are now being put together with much rapidity, and unless some unexpected difficulty should occur the telescope will be in working order in a few days and a commencement made in the study of the very curious scintillations lately observed at one spot in the surface of the earth. Since their occurrence was first publicly announced in these columns by the Director of the Bellona observatory they have been observed by every other astronomer who possesses a good telescope so that the scientific world has become greatly excited by this very strange phenomenon, which there is every reason to believe that the new telescope will succeed in investigating it much more thoroughly than has hitherto been possible.

3.6 Editor of the *Bellona Gazette*[3]

We are pleased to announce that all the parts of the huge telescope that has been under construction for the Bellona Observatory during several months are made. They are [rapidly being tried] and promise to give every satisfaction. The telescope will very shortly be in readiness for investigating the curious scintillations on the surface of the Earth which still continue. They have been observed by numerous astronomers since their existence was first pointed out in these columns by the Astronomer Royal. The results to be desired from the new telescope are awaited with the keenest anxiety by all scientific men, and will from time to time be announced in these columns.

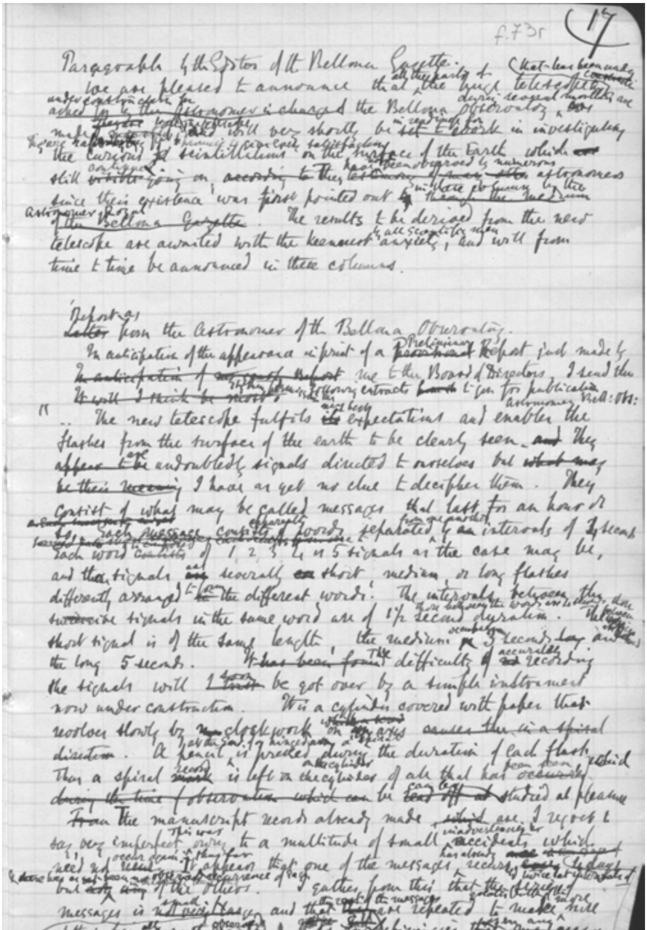
3.7 Report (a) from the Astronomer of the Bellona Observatory

In anticipation of the appearance in print of a preliminary report just made by me to the Board of Directors, I send by their permission the following extracts to you for publication.
Astronomer, Bell: Obs:

The new telescope fulfils my best expectations and enables the flashes from the surface of the earth to be clearly seen. They are undoubtedly signals directed to ourselves but I have as yet no clue to decipher them. They consist of what may be called messages that last for an hour or so. Each message consists apparently of words, separated from one another by intervals of 4 seconds. Each word is composed of 1,2,3,4 or 5 signals as the case may be, and these signals are severally short, medium, or long flashes differently arranged to form different words. The intervals between these signals in the same word are of

[3] Paragraph by the ...

$1\frac{1}{2}$ second duration. Those between the words are 4 seconds, the short signal is of the same length, the medium occupies 3 seconds and the long 5 seconds. The difficulty of accurately recording the signals will soon be got over by a simple instrument now under construction. It is a cylinder covered with paper that revolves slowly by clockwork on an axis. A pencil at the end of a hinge is pressed during the duration of each flash. Thus a spiral record is left on the cylinder of all that has been seen, which can be studied at pleasure. The manuscript records already made are, I regret to say, very imperfect. This was owing to a multitude of small inadvertent accidents which need not occur again. Thus far it appears that one of the messages has already recurred twice [at intervals of] 4 days, but there has as yet been no observed recurrence of each of the others. I gather from this that the series of messages is small and and that the rest of the messages are repeated to make more sure of their being all observed & that the one which is the most often repeated contains the clue to deciphering others. Deficiencies in any record of a message will probably be made good when it is seen a second & third time, so the records of the frequently repeated message will be quite ready for study, and the remainder will be equally well revised & corrected before long.


f.73r

17

Paragraph by the Editor of the Bellona Gazette.

We are pleased to announce that the telescope ... the Bellona Observatory ... will very shortly be ... in investigating the curious ... scintillations on the surface of the Earth which still ... going on ... astronomers since their existence was first pointed out ... of the Bellona Gazette. The results to be derived from the new telescope are awaited with the keenest anxiety, and will from time to time be announced in these columns.

Report from the Astronomer of the Bellona Observatory.

In anticipation of the appearance in print of a Preliminary Report just made by me to the Board of Directors, I send the following extracts to you for publication ...

" .. The new telescope fulfils ... expectations and enables the flashes from the surface of the earth to be clearly seen. They are undoubtedly signals directed to ourselves but I have as yet no clue to decipher them. They consist of what may be called messages that last for an hour or so. Each message consists of words separated by intervals of ... seconds. Each word consists of 1, 2, 3, 4 or 5 signals as the case may be, and these signals are severally short, medium, or long flashes differently arranged to form the different words. The intervals between the successive signals in the same word are of 1½ second duration. The short signal is of the same length, the medium ... 3 seconds and the long 5 seconds. The difficulty of accurately recording the signals will I hope be got over by a simple instrument now under construction. It is a cylinder covered with paper that revolves slowly by clockwork on its axis ... A pencil is pressed during the duration of each flash. Then a spiral record is left on the cylinder of all that has ... which can be ... studied at pleasure.

The manuscript records already made are, I regret to say, very imperfect owing to a multitude of small accidents which need not ... It appears that one of the messages recurs ... but ... of the others. I gather from this that the ... messages is small ... and that ... are repeated to make ... of their being ... deficiencies ...

and that the one which is the most often repeated contains the clue to deciphering others

Figure 3.4: Page 17 of the Notebook.

Chapter 4

Deciphered Messages

4.1 Editorial Paragraph in 2nd Edition Special

A meeting of the Bellona physical society has been hastily convened this evening, the prospect of which is exciting the most extraordinary interest. It is alleged that [the] message that has been the most frequently repeated has been completely deciphered & that [a] full description of the sparkles & of their meaning will be given tonight by the Communal Astronomer.

4.2 Decipherment of a message from the earth[1]

The wildest anticipations of the scientific men who attended the meeting of last night were fully realised. The room was crowded to excess and the antennae of all present were in the most restless agitation. The illustrations by the lanthorn showed [that] every one of the phrases in the first message, which were so distinctly & yet [simply] arranged that their interpretation was obvious, is necessary. The result is that the symbols are positively determined which the earth folk use to express any desired numeral, for that of equal and for the several operations of addition, subtraction, multiplication &

[1] Article newspaper (Large type heading).

division. The method employed by the Earth Folk is simple & best explained as below, in which the word that apparently corresponds to any given signal is printed in italics & brackets. There is no need to puzzle the reader by printing all the symbols in their actual form, a sample of them will suffice. Thus '....' is found to stand for 4. Each message has a heading, which for the moment we will [ignore] This heading is followed in the first message by (this takes 10 minutes not more)

.	(equal) (one)	.	=	..
..	(equal) (two)	..	=	.-
...	(equal) (three)	...	=	.—
		....	=	-.
		.....	=	- -
	&c up to 10			

The desire to satisfy the eagerness of the public to hear of any results obtained by the new telescope justifies the recent preliminary account, after only [...] day's experience. It will be shown [...] what has been thus far ascertained with certainty concerning the scintillations and what little has been inferred as to their motive & meaning.

In the first place they are unquestionably made by reasonable beings not by only chance action. There are 3 and only 3 variations of flashes that is of what may be inferred letters which are of short, medium, and long duration, lasting respectively $1\frac{1}{2}$, 3 & 5 seconds. These are formed into what may be called words consisting of 1,2,3,4,5 letters each, the pause between each letter in the same word being $\frac{1}{2}$ second & that between two succeeding words being 3 seconds. Thus sentences are formed, separated by pauses of 5 seconds or more. Lastly a group of sentences make the nightly message, which lasts about an hour. The messages differ on successive nights and appear to form a cycle. Some [of] the messages certainly recur, but it is premature to say whether all do. The records of

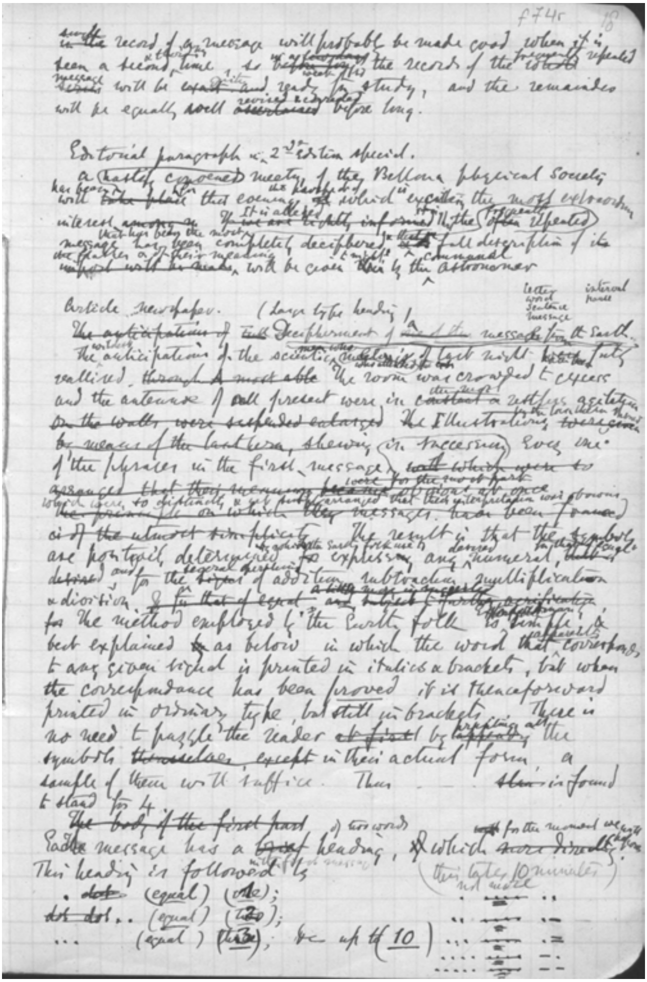
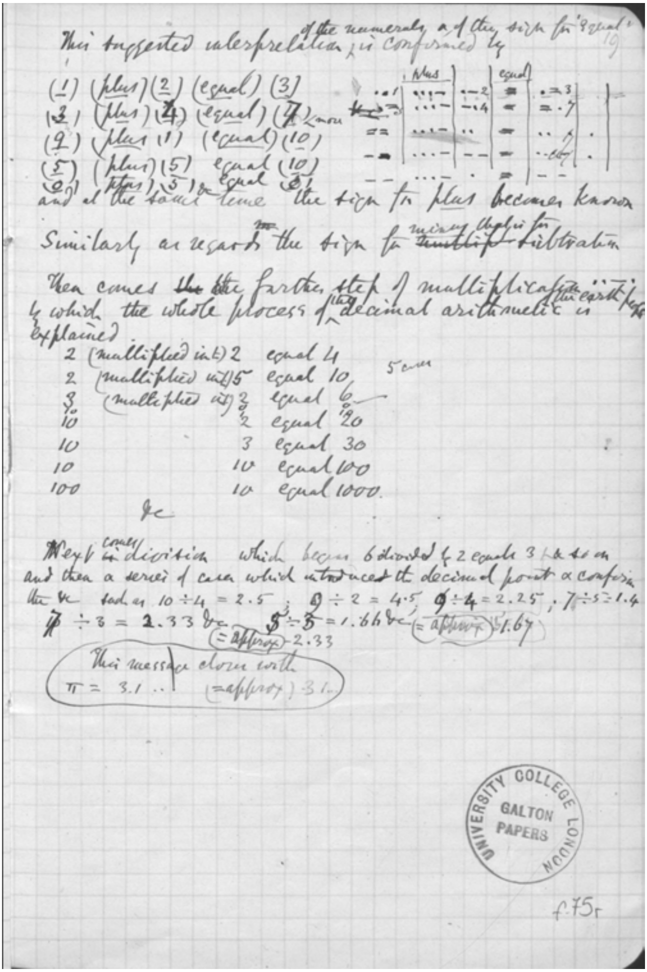


Figure 4.1: Page 18 of the Notebook.

what was observed at first are not so trustworthy as is desirable; different plans have been tried with varying success, now however a recording apparatus has been constructed which works quite satisfactorily & gives a duplicate copy. A cylinder covered with two sheets of paper, with carbonised paper in-


This suggested interpretation of the numerals and of the sign for 'equal' is confirmed by

(1) (plus) (2) (equal) (3)
(3) (plus) (4) (equal) (7)
(9) (plus) (1) (equal) (10)
(5) (plus) (5) (equal) (10)

and at the same time the sign for plus becomes known

Similarly as regards the sign for minus which is for subtraction

Then comes the further step of multiplication by which the whole process of decimal arithmetic is explained

2 (multiplied into) 2 equal 4
2 (multiplied into) 5 equal 10
10 2 equal 20
10 3 equal 30
10 10 equal 100
100 10 equal 1000.
&c

Next comes division which begins 6 divided by 2 equals 3 & so on and then a series of cases which introduced the decimal point & confirms the &c such as 10 ÷ 4 = 2.5 ; 9 ÷ 2 = 4.5 ; 9 ÷ 4 = 2.25 ; 7 ÷ 5 = 1.4
7 ÷ 3 = 2.33 &c (= approx) 2.33 5 ÷ 3 = 1.66 &c (= approx) 1.67

This message closes with
π = 3.1 .. (= approx) 3.1..

f.75r

Figure 4.2: Page 19 of the Notebook.

terposed revolves by clock work on a long screw for its axis so that a pencil pressed steady on it would leave a continuous spiral trace. The pencil is however mounted on a spring, so that when the finger ceased to press no mark is left. The [observer] has merely to apply his finger whenever & for so long as he sees a flash & the result is a perfect record in the language of dot dash & line.

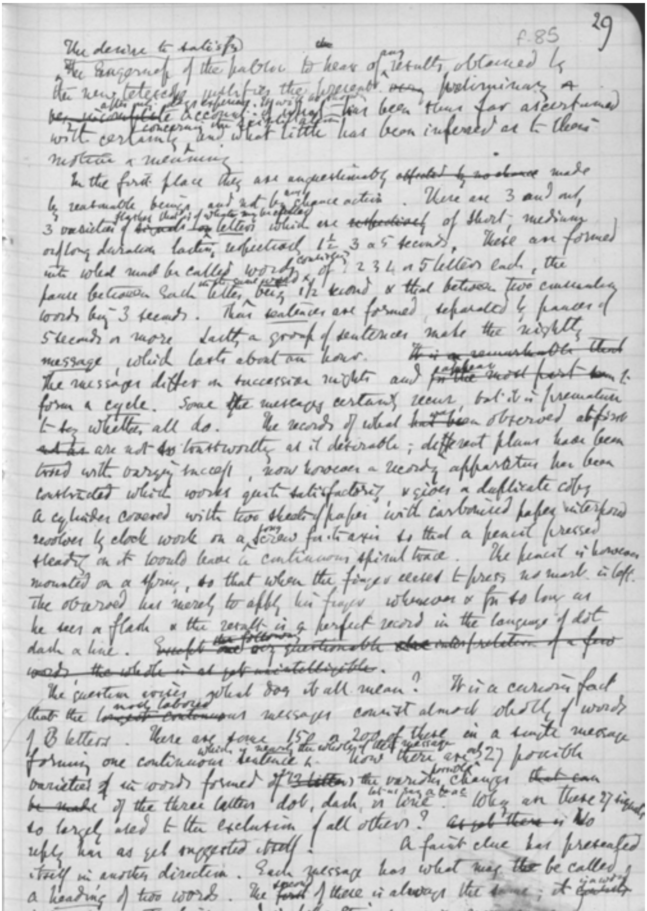
The question arises what does it all mean? It is a curious fact that the most labored messages consist almost wholly of words of 3 letters. There are some 150 or 200 of these in a single message forming one continuous sentence which is nearly the whole of the message. Now there are only 27 possible varieties of the words formed of the various possible changes of the three letters dot, dash & line (let us say a, b & c). Why are these 27 signals so largely used to the exclusion of all others? No reply has yet suggested itself. A faint clue has presented itself in another direction. Each message has what may be called a heading of two words. The second of these is always the same; it is a word of four letters. The first word differs in successive messages and always consists of two letters. These disyllabic words so far as they have been recorded formed part of an orderly series of permutations, as follows in which the missing observations are supplied by hypothesis and are for distinction sake printed in italic letters

aa, ab, ac, ba, bc, bd, ca, cd, cd, aa, ab, ac, ba

It certainly looks as though they stood for numerals and that the headings should be read as 'first message', 'second message', 'third message' &c. If this be true, the imperfection of the record [is] the cause why a decipherment of the rest seems impossible. In due course the first message will be repeated in a few days after which we shall be in a better position to theorize than we are at present.

4.3 Complete decipherment of Message 1 from the Earth

It was mentioned in my last letter that imperfections in the record of what was supposed & is now known to be message no.



The desire to satisfy the eagerness of the public to hear of results obtained by the new telescope justifies the present very preliminary & incomplete account. Very little has been thus far ascertained with certainty and what little has been inferred as to their nature & meaning.

In the first place they are unquestionably made by reasonable beings and not by chance action. There are 3 and only 3 varieties of letters which are of short, medium and long duration lasting respectively 1½ 3 & 5 seconds. These are formed into what must be called words consisting of 2 3 4 or 5 letters each, the pause between each letter being 1½ second & that between two consecutive words being 3 seconds. Then sentences are formed, separated by pauses of 5 seconds or more. Lastly a group of sentences make the nightly message which lasts about an hour.

The messages differ on successive nights and form a cycle. Some of the messages certainly recur, but it is premature to say whether all do. The records of what has been observed are not so trustworthy as is desirable; different plans have been tried with varying success, now however a recording apparatus has been constructed which works quite satisfactorily & gives a duplicate copy. A cylinder covered with two sheets of paper with carbonized paper interposed revolves by clock work on a long screw fixed axis so that a pencil pressed steadily on it would leave a continuous spiral trace. The pencil is however mounted on a spring, so that when the finger ceases to press no mark is left. The observer has merely to apply his finger whenever & for so long as he sees a flash & the result is a perfect record in the language of dot dash & line.

The question arises what does it all mean? It is a curious fact that the most laboured messages consist almost wholly of words of 3 letters. There are some 150 or 200 of these in a single message forming one continuous sentence. Now there are 27 possible varieties of such words formed by the various possible changes of the three letters dot, dash, or line. Why are these 27 signals so largely used to the exclusion of all others? No reply has as yet suggested itself! A faint clue has presented itself in another direction. Each message has what may be called a heading of two words. The second of these is always the same; it consists of four letters; the first word is different in successive messages and always consists of two letters. The records

Figure 4.3: Page 29 of the Notebook.

1 were the reason why the meaning of the signalling generally was at that time undecipherable. The message has again been sent & accurately observed & recorded & its signification is now thoroughly established, and we are already in possession of the meaning of no less than —— different words used by the

Earth people.

The bases of their first message are the plain facts of simple arithmetic, by means of which the names of the numerals are defined and the usual symbols of equal, plus, minus, multiplication, addition & the like are fixed. Any misgiving that may remain about the true interpretation of any of these will almost certainly be cleared away as the decipherment of the remaining messages proceeds.

Suppose a person first to make one flash, then after a pause to make two flashes, then three, & so on; there could be little doubt that he was following the numerals in their natural order of 1 2 3 &c. This with a little variation from the beginning of the first message [is] as follows

.	-	. .
. .	-	. -
. . .	-	. -
. . . .	-	- .
. . . . .	-	- -
. . . . . .	-	- —
. . . .	-	— .
. . . .	-	— -
. . . .	-	— —

The '-' in the middle of each entry stands we may presume for 'equal to' and the last word for the numeral. This presumption is turned into certainty by the next group of sentences. Here & for the future in order to avoid puzzling the reader with dots, dashes & lines, the presumed word or phrase will be printed in italics within brackets. When the word or phrase has been established it will be printed in ordinary type within brackets.

The second group of sentences is of this form, a new word of 4 letters which is interpreted as plus makes its appearance in them.

(1) (plus) (1) (equal to) (2); (2) (plus) (3) (equal to) (5); & so on for—— sentences. There can now be no doubt as to the

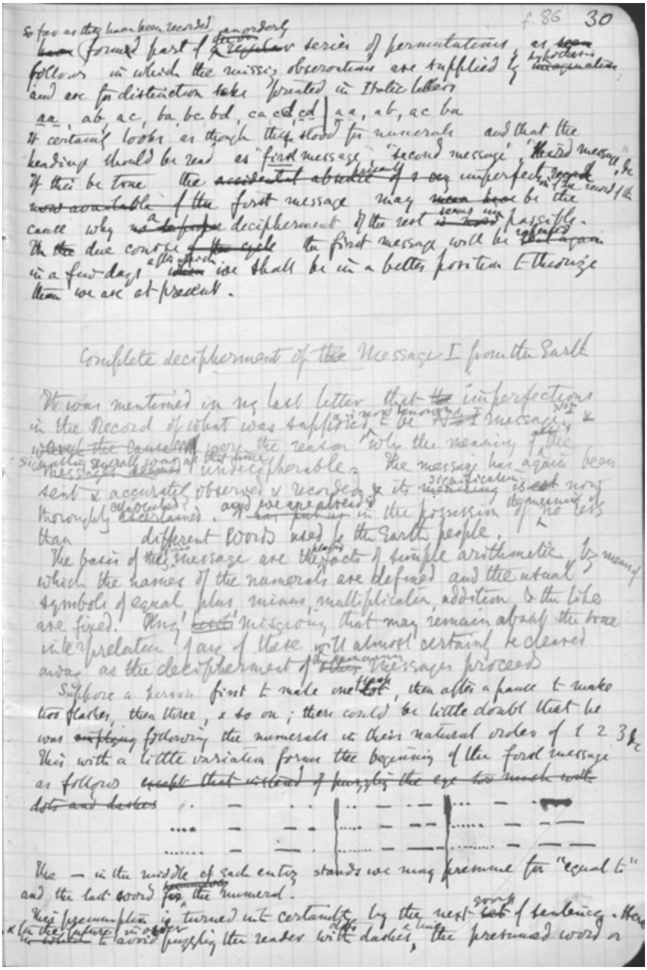


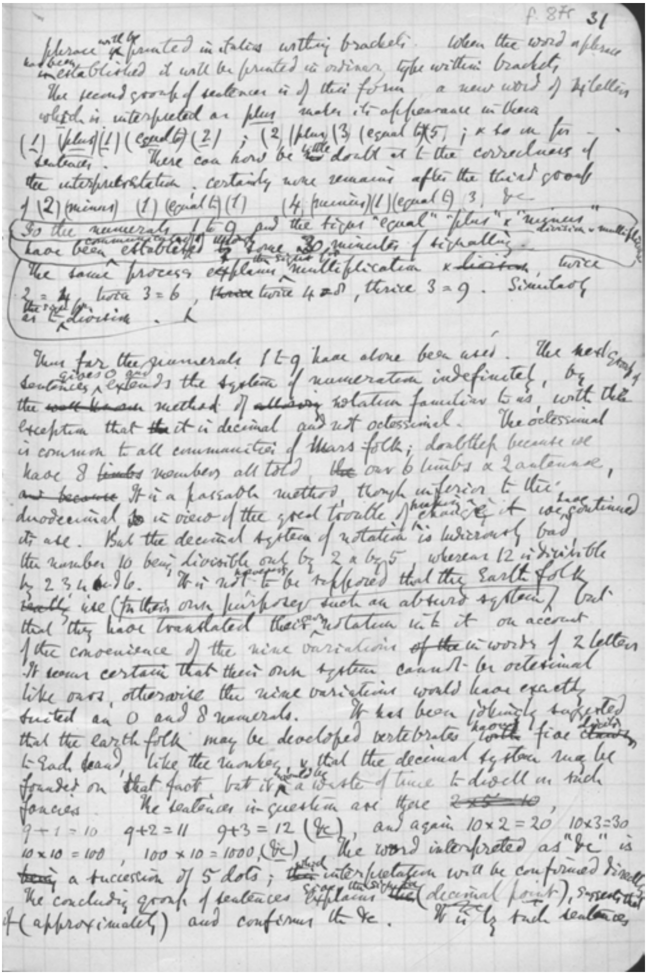
Figure 4.4: Page 30 of the Notebook.

correctness of the interpretation; certainly none remains after the third group of (2) (minus) (1) (equal to) (1); (4) (minus) (1) (equal to) (3) &c.

So the numerals 1 to 9 and the signs 'equal', 'plus' & 'minus' have been communicated & established through some 30 minutes of signalling. The same process explains the signs for multiplication, twice 2 = 4, twice 3 = 6, twice 4 = 8, thrice 3 = 9. Similarly as to the sign for division.

Thus far the numerals 1 to 9 have alone been used. The next group of sentences gives 0 and extends the system of numeration indefinitely, by the method of notation familiar to us, with the exception that it is decimal and not not octessimal. The octessimal is common to all communities of Mars folk; doubtless because we have 8 members all told, our 6 limbs & 2 antennae. It is a passable method, though inferior to the duodecimal; in view of the great trouble of making a change to [it] we have continued its use, but the decimal system of notation is ludicrously bad, the number 10 being divisible only by 2 & by 5, whereas 12 is divisible by 2, 3, 4 & 6. It is not however to be supposed that the earth folk use such an absurd system for their own purposes, but that they have translated their own notation into it on account of the convenience of the nine variations in words of 2 letters. It seems certain that their own system cannot be [octessimal] like ours, otherwise the nine variations would have exactly suited a 0 and 8 numerals. It has been jokingly suggested that the earth folk may be developed vertebrates [having] five digits to each hand, like the monkey, & that the decimal system may be founded on that fact, but it would be a waste of time to dwell on such fancies.

The sentences in question are these $9+1=10$, $9+2=11$, $9+3=12$, (&c), and again $10\times2=20$, $10\times3=30$, $10\times10=100$, $100\times10=1000$, (&c). The word interpreted as '&c' is a succession of 5 dots; which interpretation will be confirmed directly. The concluding group of sentences given the significance (decimal point) suggests that of (approximately) and confirms the &c. It is by such sentences as 7 (divided by 2 = 3.5; 7 divided by 3 2.33333 (&c) =2.3 (approximately), 5 divided by 4 = (1.25) 8 (divided by) 3 = 2.66666 (&c) = 2.7 (approximately)



phrase will be printed in italics within brackets. When the word or phrase has been established it will be printed in ordinary type within brackets.
The second group of sentences is of this form: a new word of 2 letters which is interpreted as plus makes its appearance in these (1) (plus) (1) (equals) (2) ; (2) (plus) (3) (equals) (5) ; & so on for ... sentences. There can hardly be doubt as to the correctness of the interpretation. certainly none remains after the third group of (2) (minus) (1) (equals) (1) (4) (minus) (1) (equals) 3, &c.
So the numerals 1 to 9 and the signs "equal" "plus" & "minus" division & multiplication have been established by some 30 minutes of signalling. The same process explains multiplication & division, twice 2 = 4, twice 3 = 6, twice 4 = 8, thrice 3 = 9. Similarly as to division.

Thus far the numerals 1 to 9 have alone been used. The next group of sentences gives 0 and extends the system of numeration indefinitely, by the method of notation familiar to us, with the exception that it is decimal and not octessimal. The octessimal is common to all communities of Mars folk; doubtless because we have 8 numbers all told, our 6 limbs & 2 antennae. It is a passable method though inferior to the duodecimal in view of the great trouble of changing it we continued its use. But the decimal system of notation is hideously bad the number 10 being divisible only by 2 & by 5, whereas 12 is divisible by 2 3 4 and 6. It is not to be supposed that the Earth folk really use (for their own purposes) such an absurd system, but that they have translated their notation into it on account of the convenience of the nine variations in words of 2 letters. It seems certain that their own system cannot be octesimal like ours, otherwise the nine variations would have exactly suited as 0 and 8 numerals. It has been jokingly suggested that the earth folk may be developed vertebrates having five digits to each hand, like the monkey, & that the decimal system may be founded on that fact, but it would be a waste of time to dwell on such fancies. The sentences in question are these, 9+1=10 9+2=11 9+3=12 (&c), and again 10×2=20 10×3=30 10×10=100, 100×10=1000 (&c). The word interpreted as "&c" is a succession of 5 dots; the interpretation will be confirmed directly. The concluding group of sentences explains the (decimal point), suggests that of (approximately) and confirms the &c. It is by such sentences,

Figure 4.5: Page 31 of the Notebook.

A final sentence defines briefer symbols for $\frac{1}{2}$ & $\frac{1}{4}$, they are of 3 letters each and become of use later on. This concludes the first message which occupies a little less than 1 hour in its delivery. It is obvious that if we in Mars were in position to flash back replies to the earth, the foundation is laid for any amount of algebraic intercommunication, but let it not be supposed for a moment that the earth can talk to us only about arithmetic & algebra. There is much more coming upon which I hope to make a further communication very shortly The sentences in the earlier message consist usually of five words only several occupy on the average about $1\frac{1}{4}$ minute, thus between 40 & 50 of them are transmitted in one hour.

It is a curious feature that some of the messages consist mainly of words of only 2 letters & others of words of only 3 letters, though from the nature of the case there can be but 6 varieties of the former & 27 of the latter.[2]

4.4 Decipherment of the second message from the earth

In this message certain names are established apparently for further use in building up a common language. The first group of sentences give the names of the sun & principal planets, namely Venus, Earth, Mars, Jupiter & Saturn, by a method that every astronomer would quickly discover. Their relative mean distance from the sun, their diameters, time of revolution round their several axes are familiar data, as well as much else, but the earth signals are only concerned with these. They are as follows (diameter of) (Sun) & ... & (diameter of) (Venus) (diameter of) (Mars) & ... & (diameter of) (Earth) & ... & (diameter of) (Jupiter) ... ; (diameter of) (Saturn)

Their sequence of numbers is sufficient to establish the words in brackets [as] the names of the planets again appear in similar sentences referring to their mean distances from the sun, all in terms of the earth's diameter as a unit. Our astronomers of course know the length of this in our own measures, so a unit of length is established between us and the earth. The sentences seen thus (Sun) (mean distance from of)

[2]Stray text: The messages.

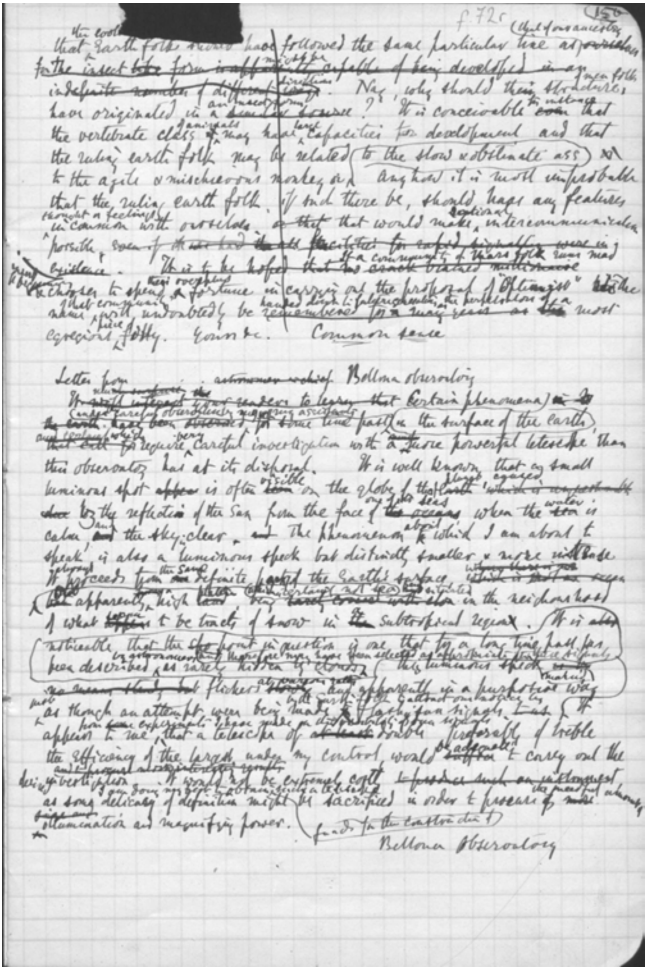
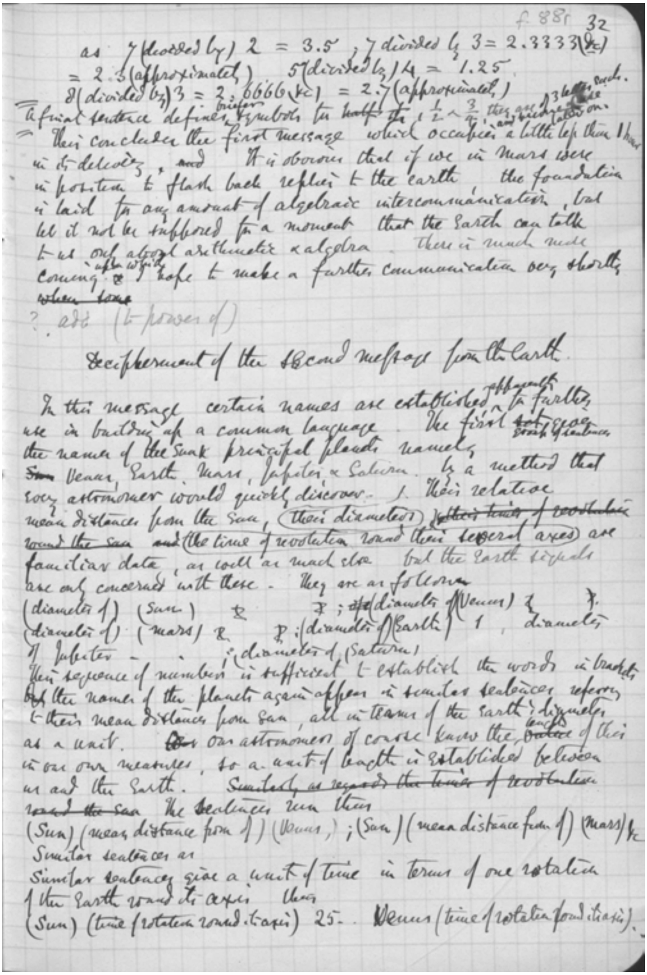


Figure 4.6: Page 15b of the Notebook.

(Venus); (Sun) (mean distance from of) (Mars) &c. Similar sentences give a unit of time in terms of one rotation of the earth round its axis thus (sun) (time of rotation round its axis) 25 .. (Venus) (time of rotation round its axis). This group of sentences occupies 24 minutes



f. 88r 32

as 7 (divided by) 2 = 3.5 ; 7 divided by 3 = 2.3333 (&c)
= 2.3 (approximately) 5 (divided by) 4 = 1.25
8 (divided by) 3 = 2.6666 (&c) = 2.7 (approximately)
A final sentence defines briefer symbols for half the 1/2 ^ 3/4 [illegible]
This concludes the first message which occupies a little less than 1 hour in its delivery, and it is obvious that if we in Mars were in position to flash back replies to the earth the foundation is laid for any amount of algebraic intercommunication, but let it not be supposed for a moment that the Earth can talk to us only of arithmetic & algebra. There is much more coming after which I hope to make a further communication very shortly
~~when some~~
? add (to power of)

Decipherment of the second message from the Earth

In this message certain names are established [illegible] for further use in building up a common language. The first [illegible] the names of the Sun & principal planets namely, Venus, Earth, Mars, Jupiter & Saturn. By a method that every astronomer would quickly discover. 1. Their relative mean distances from the Sun, (their diameters) ~~their times of revolution round the sun~~ ~~and~~ (the time of revolution round their several axes) are familiar data, as well as much else but the Earth signals are only concerned with these. They are as follows
(diameter of) (Sun) [illegible] ; (diameter of Venus) [illegible]
(diameter of) (Mars) [illegible] ; (diameter of Earth) 1, diameter of Jupiter [illegible] ; diameter of (Saturn)
This sequence of numbers is sufficient to establish the words in brackets but the names of the planets again appear in similar sentences referring to their mean distances from Sun, all in terms of the earth's, namely, as a unit. Our astronomers of course know the length of this in our own measures, so a unit of length is established between us and the Earth. ~~Similarly as regards the time of revolution round the sun~~ The sentences run thus
(Sun) (mean distance from of) (Venus) ; (Sun) (mean distance from of) (Mars) &c
Similar sentences as
Similar sentences give a unit of time in terms of one rotation of the Earth round its axis thus
(Sun) (time of rotation round its axis) 25. Venus (time of rotation round its axis).

Figure 4.7: Page 32 of the Notebook.

The next group in the second message occupies 25 minutes [and] is comparatively uninteresting in itself, but is a necessary step towards the extraordinary information that we shall have to describe in the next letter & which is not yet wholly deciphered. The delay is not owing to want of clue, but simply to want of time, just as a long despatch in cipher requires time to write out & verify. The data we are now speaking of are the names of a circle and of regular polygons of 3, 4, 5, 6, 7, 8, 9, 10, 12, & 24 sides respectively, including the words circumference, area of (radius of)

The first sentence shows the well-known relation of the circumference of a circle to its diameter, commonly written π thus $(\pi) = 3.1415927$

(circle) (circumference of)	=	2π r (area of)	=	π x r x r
(triangle) (circumference of)	=	3s (area of)	=	0.433 &c
(square) (circumference of)	=	4s	=	1.000
		5s	=	1.720
		6		2.598
		7s		4.828
		9		6.181
		10		7.694
		12		11.196
		24		45.68 about

It is perhaps needless to say that the sides of the figures are in each case taken as units, otherwise of the side be s the above well-known figures have to be multiplied by s^2

4.5 Decipherment of the third message

Strange as it may seem, the earth folk have actually contrived a plan of communicating drawings. They have converted the

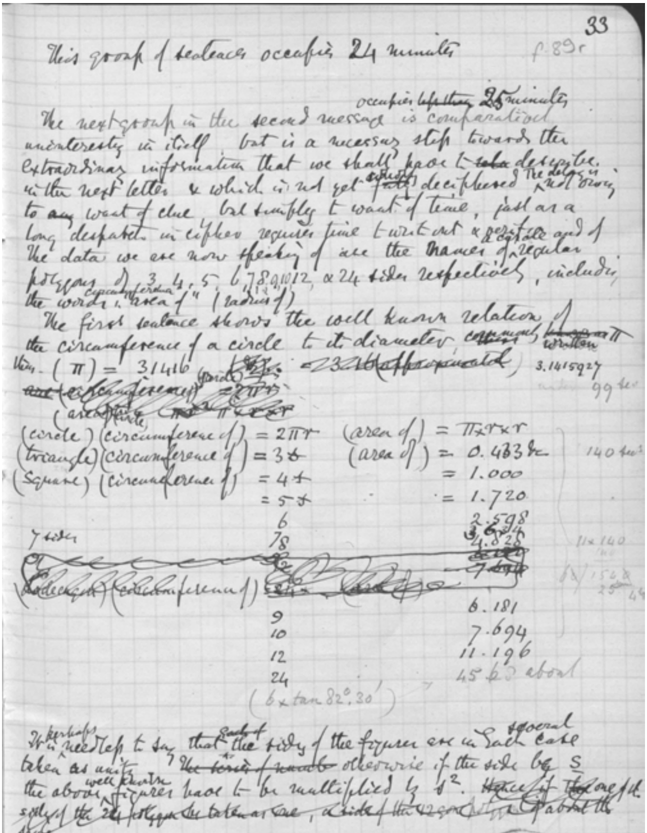


Figure 4.8: Page 33 of the Notebook.

elements of units in the third message and have sent an excellent drawing of Saturn with 5 rings. It is to these drawings that one half of the long sentences refer which, consisting of words of 3 letters. There are 27 different combinations of the letters but of these the first 24 are alone used, the [last] 3 namely (— — ·) (— — -) (— — —) being omitted.[3]

The 24 are used to specify lines that are respectively parallel and equal to those of a regular polygon of 24 sides, or let us say stitches of equal length such as are used in embroidery, which are parallel to those sides, and inclined each to its predecessor by successive steps of the 24th part of a circle, that is of 15°. Thus (· · ·) may be supposed to represent a stitch directed to the North, the next stitch (· · -) is directed 30 ° to the East side of North, (· · —) is 45° on the East side of North, & so on, until we come to the 23rd side which is (— - —) After which the cycle recommences at the 24th or the 0th side whichever we please to call it & which is as already said (· · ·) The number 24 has unquestionably been selected by the Earth folk on account of its divisibility by many different factors, namely by 2, 3, 4, 6, 8 & 12, whereas 27 is divisible only by 3 and 9 and is not capable of the expressing of a right angle. The division of a circle [into] 24 parts is delicate enough for ordinary purposes but occasionally a decimal may be used to divide the angular interspaces into parts of 1°30'. Again the stitches may when desired be reduced one quarter, one half, or three quarters of their lengths by adding one or other of the 3 omitted symbols. The power of doing this is [...] the contour takes a quick turn, too quick to be expressed by stitches of the same length as those used for the rest of the drawing.

The method by which the process is explained is by signalling (24-gon) (· · ·) (· · -) (· · —) (· - ·) (· - —) & so on to the 23d or 0th side then follows (12-gon) (· · ·) (· · -) (· · —) (· - ·) & so on round to (· · ·), then (8-on) (6-gon) (4-gon) & (3-gon) all in the same way. After this varieties are given of the (3-gon) a few of the (4-gon) fewer of the (6-gon) &c (thus for under 1/2 hour) Here follows 1/2 Saturn [...].[4] 38 minutes

[3]Ed. The last three words are used as length fractions. Brackets have been added to delimit signal words from punctuation more clearly in the text.

[4]Ed. See the picture of Saturn in Figure 7 on page xx.

letters & all.[5]

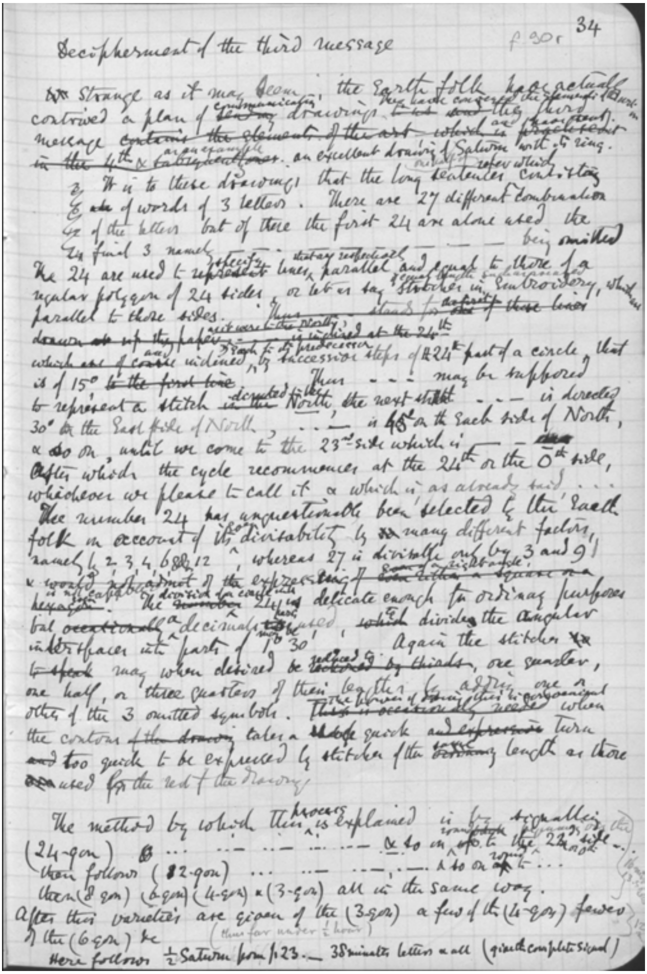


Figure 4.9: Page 34 of the Notebook.

[5]Ed. Transmission time. Annotated by Galton: 'give the complete signal'.

Appendix A

Intelligible Signals Between Neighbouring Stars.[1]

Considerable interest attaches itself to methods of communication which have been devised under the pressure of necessity, to take the place of speech and writing. Many memoirs have, consequently, been written on such topics as the gesture language of savages, or that of deaf mutes, or on the alphabetical tappings of prisoners upon the walls that divide their solitary cells, or on Laura Bridgeman[2] and a few like her, who, though destitute of all other senses, have, nevertheless, been educated to a high level of accomplishment by touch alone. In most of these cases the method of instruction is by "trial and error." The pupil makes many guesses, the wrong ones are negatived by his teacher with a gesture of impatience, the right one is welcomed approvingly. But no help can be obtained from this method in the task I have set myself to perform. Signals have to be devised that are *intrinsically* intelligible, so that the messages may be deciphered by any intelligent man, or other creature, who has made nearly as much advance in pure and applied science as ourselves. It may seem at first sight almost

[1]Published in the *Fortnightly Review*, see Galton 1896a. This is a reworked version of the text in previous chapters, written from the point of view of Earth, with all the eugenic and other details about Martians omitted.
[2]Laura Dewey Lynn Bridgman (1829 –1889), a victim of scarlet fever.

impossible to do this, but it is quite otherwise, and the reader will probably feel surprised at the unexpected simplicity of this curious problem.

I may as well mention how it came into my thoughts. Some four years ago the planet Mars made a near approach to the earth, and presented a splendid spectacle at night. The possibility of exchanging visible signals with Mars was then discussed in the newspapers, apparently with the result that it was not altogether inconceivable that signals might be sent, though the difficulties of doing so would be enormous. Then the very different question arose of "cui bono?" to which there was a general response that nothing more could possibly be learnt on either side than that intelligent folk existed on the other planet, who were observant, mechanical, and capable of acting in unison upon large undertakings. For my part, I considered that limitation unjustified, and amused myself with thinking out the ground-plan of the present article. In the meantime the craze about Mars died away; the planet ceased to be particularly conspicuous, people grew tired of the topic, and the heated thoughts of many writers were cooled by copious douches of astronomical common sense. The subject having ceased to interest others, I laid up my ideas presumably for perpetuity, but an accident revived them. I was compelled last summer to spend a somewhat dreamy vacation, beginning with a course of hot baths at Wildbad, and its relaxing accompaniments (for the good effects of which I am truly grateful), when being unable to occupy myself otherwise than in a desultory way, I did so by developing my previous notions.

The simplest way of explaining my method is to suppose that Mars began to signal, to the wonderment of our astronomers, who sent descriptive letters to the newspapers from day to day, out of which the following imaginary extracts are taken:—

> 1. Astronomers in various observatories have been much excited of late by the sight of minute scintilla-

tions of light proceeding from a single well-defined spot on the surface of Mars, and they are becoming greatly perplexed as to the significance of this strange phenomenon. It is hoped that the Director of the X. high level observatory, where the atmosphere is singularly transparent, which is favourably situated for now observing the spot in question, and which is furnished with a telescope peculiarly well suited for examining Mars, will soon be able to tell us something more about it. In the meantime it is well not to indulge too freely in wild speculation.

2. The Director of the X. observatory is, at last, strongly disposed to believe that the scintillations are purposive; that they are really intended as signals from the Mars-folk to the earth. He suspects that their signalling apparatus is not yet in working order, that adjustments are being verified, and that what we now see resembles the tuning of instruments before the opera begins. If the signals are produced as they seem to be, by an immense assemblage of large heliographs, the difficulty would be great in drilling the multitude of operators engaged in working them simultaneously.

3. The scintillations from Mars show more firmness and power, but the signalling is still in the earlier stage of preliminary trials. Enough has, however, been seen to show that three and only three different signals are employed, differing in their lengths, and which for brevity may be called *dot*, *dash*, and *line*. The dot lasts $1\frac{1}{4}$ seconds, the dash $2\frac{1}{2}$, and the line 5 seconds; consequently the mean length of a signal is a trifle under 3 seconds. There have been a few well marked successions of "dot, dash, line", "dot, dash, line," in which the interval between the several letters, so to speak, is $1\frac{1}{2}$ seconds; those between

words, one of which is here represented by a short bar, are 3 seconds; those between paragraphs are 6 seconds. This may be accepted as a good estimate of the future speed of signalling, though, of course, the exigencies of experience may show that a slower rate will be needed, or, again, the drill may hereafter be so smartly performed, that the rate will be increased. As there are three varieties of signal, the total number of different words of one letter is 3; of two letters, 9; of three letters, 27; of four letters, 81; of five letters, 243, and so on. Also the average times occupied in signalling these words, including the 3 seconds' pause at the end of each, are 6, 10, 15, 20 and 24 seconds respectively. Whatever the Marsfolk may have to say must be briefly expressed, and it seems incredible under these conditions that anything could be communicated by them to us which shall be intelligible and of value. Some persons are disposed to ascribe this immense undertaking to the caprice of a mad millionaire in Mars, or rather to a mad billionaire. There have been instances in the past history of our earth of many gigantic follies, without counting the traditional Tower of Babel.

A recording apparatus is now constructed for our use here, which acts well. A long strip of telegraph paper is slowly drawn by clockwork under a hinged pencil on which the observer rests his finger. When a flash is on, he presses with his finger and the pencil leaves a mark; when the flash is off, he ceases to press, a spring lifts the pencil, and a blank is left on the travelling slip of paper.

4. The signals have improved considerably in regularity and power, and occasional sequences of them have been gone through in a masterly way. So the drilling of the operators appears to be nearly com-

plete, and we may expect soon to see what the system is intended to show. The phenomenon is most extraordinary. If it be effected through the money of a mad millionaire, he must have had the sense to subsidise an uncommonly intelligent director of works.

5. A most eventful night has been passed at the X. observatory. At first the sky was hazy and partly clouded, so Mars was, at the best, but imperfectly seen, and was often quite invisible; then, at half-past nine, all cloudiness disappeared, and the flashes were observed to be proceeding from Mars with greater power and precision than ever before. The whole assemblage of their heliographs must have been simultaneously at work, and the drill was excellent. The signalling continued off and on for more than three hours. The recorder being kept at work the whole time, every signal then made is preserved in a permanent form, of course including occasional mistakes. The records are as yet totally unintelligible, possibly owing to the loss of the first part of the communication, which may have contained the key to what followed. It is noticeable that during the last two hours the signals consisted almost wholly of three-letter words; in the earlier part there was a preponderance of two-letter words, some of four and of five letters, but none of three.

6. A large typed telegraphic dispatch appeared in all the evening newspapers—

COMPLETE DECIPHERMENT OF THE FIRST PART OF THE MESSAGE FROM MARS. Full particulars tomorrow.

(Signed) Director of the X. Observatory.

7. The evening was serene, and the whole of the night continued to be beautifully clear. The experiences of previous days enabled every preparation

to be made for the expected event. And it came. First there was a succession of “lines” with intervening pauses, evidently as a note of preparation, and then after a longer pause the message began with the accompanying sentence, which occupied less than six minutes in transmission.

No. of dots		is equal to	Symbols for numerals
1	.	-	. .
2	. .	-	. -
3	. . .	-	. —
4	. . . .	-	- .
5	. . . . .	-	- -
6	. . . . . .	-	- —
7	. . . .	-	— .
8	. . . .	-	. . — -
9	. . . .	-	. . . .
10	. . . .	-	. . . -
&c	. . . .	-	. . . .

The headings and the column on the left, did not form part of the signalling, but are introduced for the convenience of the reader. The message is divided into three sub-divisions by means of pauses. Let us consider the first of these, in which there are seven lines. Every line begins with one or more dots; then follows a dash; and then a word of two letters. There is one dot at the beginning of the first line, two at that of the next, and so on regularly up to the seventh. The symbols at the end of the successive lines are those of the successive combinations of *dot*, *dash*, and *line*, taken in order up to the seventh; the eighth which is — -, and the ninth, which is — —, are not used. The arrangement suggests that the dash means "is equal to," and that the symbols are those of numerals, corresponding to the number of dots at the beginning of the line. So we should read the message as (one dot) (is equal to) 1; (two dots) (are equal to) 2, and so on. Accepting this interpretation provisionally, we see in the second subdivision that the symbols for 8, 9, and 10 are respectively represented by two words, thus 1?, 11, 12. The symbol here expressed by ? is the first of the two omissions mentioned above; it stands presumably for 0. This would show that the Mars-folk have not used a decimal system of notation as we do, but one that has 8 for its basis. With much hesitation, we may lastly suppose the four dots at the beginning and end of the line that forms the last subdivision, to mean "&c." so that line should read, &c. = &c.[3]

These provisional hypotheses are so amply confirmed by the next messages that ordinary figures will be used in place of the actual signals, and our own decimal notation will be employed, having first translated the Mars notation into it. Hereafter, Italic numerals and letters will signify suggested interpretations; after these have been confirmed and established, Roman ones will be substituted.

The second message consists of five lines :–

[3] Galton must be indicating by the spacing that there are longer gaps between these dots, otherwise they could be confused with those meaning the numeral 4.

1 plus 1 (equal to) 2; 1 plus 2 (equal to) 3; 2 plus 3 (equal to) 5; 2 plus 5 (equal to) 7; 3 plus 3 (equal to) 6.

This goes a long way towards verifying the numerals, and it suggests the symbol for plus.

The third message is of a similar form, except that minus is substituted for plus, It adds so much confirmation to what has gone before that Italics need not be used for the simple numerals 1 to 7, nor for the words "equal to," "plus," and "minus." Each of these two messages occupied about 6 minutes.

Multiplication follows, by which the supposed system of notation with 8 for its basis is confirmed, and the symbol for 0 is established. The signals were, 2 (multiplied into) 2 (is equal to) 4; 2 (multiplied into) 3 (is equal to) 6. Then, after a double pause, 2 (multiplied into) 0 (is equal to) 0; 3 (multiplied into) 0 (is equal to) 0. This was followed by a series of higher multiples, such as we, writing in the decimal notation, might phrase as follows (the figures really used being different and accordant with a notation having 8 for its basis): 5 x 2 = 10; 10 x 10 = 100; 10 x 100 = 1000; 10 x 2 = 20; 10 x 3 = 30; 10 x 9 = 90; 7 x 3 = 21 ; 5 x 9 = 45; 9 x 9 = 81. Brackets were also expressed by 2 x 2 + 1 = 5; 2 x (2 + 1) = 6, and by two other messages of the same kind; the symbol for each bracket being a "line." The whole of this multiplication message occupied 16 minutes.

Division was then reached, by which the symbol which corresponds to our "decimal" point was established, and the meaning of "&c. was confirmed. The message is of this form: 6 (divided by) 3 = 2; 12 (divided by) 4 = 3. Then, 5 (divided by) 2 = 2.5; 7 (divided 4) + = 1.75; 10 (divided by) 3 = 3.333, &c.

The whole of the division message occupied 15 minutes. Consequently the entire time spent thus far in actual signalling was 49 minutes. Adding about 10 minutes for intervening pauses, and another 15 for a long ... pause at the close, this portion of the communication occupied one hour and a quarter. The records of the previous night agreed in form with these, but the examples chosen for the arithmetical operations differed. A superabundance of evidence is, therefore, already to hand to prove the justice of the interpretations.

It will be observed that the seven numerals, 1 to 7, the 0, and the equivalent to our decimal point, exactly use up the nine words of two letters each. It is, therefore, conceivable that 8 may have been taken by the Mars-folk as the basis of their notation in these signals, on this account alone, and not because it is the system in ordinary use by them. A clever little girl who has helped us much by her quick guesses, intreats me to add her own peculiar view, which is that the Mars-folk are nothing more than highly developed ants, who count up to 8 by their 6 limbs and 2 antennae, as our forefathers counted up to 10 on their fingers. But enough of this.

There are a few apparent imperfections in the ensuing records, so I shall be glad of the experience of a third night, to revise thoroughly what has been already registered, and will, therefore, close my narrative for the present.

8. After the pause of fifteen minutes mentioned above, presumably to give time to the operators to readjust their instruments and to rest, the signals recommenced with the purpose of determining symbols to express the sun and the five principal planets. This was effected by three series of figures relating

successively to nine distances from the sun, to their respective radii, and to times of rotation on their axes. The units of length were such that the earth's mean distance was taken as 100 in the first series, and her diameter as 100 in the second series; similarly her time of diurnal rotation was taken as 100 in the third series. Doubtless the Mars-folk thought that the values under those forms would suggest their meanings the more readily to terrestrial astronomers. I give the messages in a compressed form, thus :— Sun (mean distance from) Sun (equal) 0; Venus (mean distance from) Sun (equal) 72; Earth (mean distance from) Sun (equal) 100; Mars, 153; Jupiter, 520; Saturn, 954.

Similarly, as regards the radii of the several planets :— Sun (radius of), 11,164; Venus, 97; Earth, 100; Mars, 53; Jupiter, 1,127; Saturn, 1004.

Here, however, either "diameter", or "circumference" would suit the context, as well as "radius." The assumed interpretation is confirmed later on, where the word radius is determined through a different connection. Another table of a similar kind refers to the relative periods of revolution on their respective axes.

Very little time was occupied in deciphering the above, as our whole staff were simultaneously engaged upon the records, all of whom were more or less familiar with these sequences of figures. When once the interpretation had been suggested, its truth was quickly seen to be beyond doubt, it being incredible that any other series of values should exist for which the above sequences might be mistaken. This astronomical message occupied twenty-five minutes and was accompanied and followed by a total pause of ten more.

9. Let it not be supposed that the value of the last and of the present message is confined to their intrinsic interests, for they are intended to introduce a descriptive method of a most unexpected and far-reaching character.

The signals recommenced with the series of figures which is perhaps the most familiar of all to mathematicians and astronomers, namely that which expresses the relation of the circumference of a circle to its diameter, or to double its radius. We always symbolise that relation by the Greek letter π, and usually symbolise the radius by r. The signals were — π (equal to) 3.1415592, &c (circle) (perimeter of) (equal to) 2 (multiplied into) π (multiplied into) r.

There cannot be a doubt as to the second pair of these signals meaning π and r and of the first pair meaning "circle" and "perimeter"; which is soon explained. In the first place, these signals are followed by (circle) (area of) (equal to) π (multiplied into) r (multiplied into) r, which is a most familiar formula, and by determining both "circle" and r, it establishes "perimeter" and "π" After this came a series of signals for establishing eight new words, which seeming, at first sight to be little worth the trouble taken about them, are in reality important data. They are the names of the following regular polygons, as determined by their perimeters in one series and by their areas in another: namely, an equilateral triangle, a square, a pentagon, hexagon, octagon, dodecagon, and one with twenty-four sides. The nomenclature of the polygons is contrived to suggest their proper interpretations, by prefacing their names with the number that expresses the number of their respective sides. The first series runs (3-gon) (perimeter) (equal to) 3; (4-gon) (perimeter) (equal to) 4, and so on.

The second series is (3-gon) (area) (equal to) 4.33; (4-gon) (area) (equal to) 1.00; (5-gon) (area) (equal to) 1.72, and so on. The sequence of the first series is obvious; that of the second is fairly well known, otherwise it can be easily calculated. Of course the sides are in each case taken as equal to 1. The time occupied in the actual signalling of the two series was twenty-five minutes, or including short pauses in the middle and a longer one at the end, thirty-five minutes.

10. We now reach the threshold of the final and most marvellous stage, namely that of effective picture-writing in outlines by means of series of words of three letters. It will be shown how names of three letters are assigned to each of the 24 sides of a regular 24-gon, which are of course of the same length and are inclined to the same line (let us say to the north and south line) by successive increments of 15 degrees (the 360° into which we usually divide the circle, when divided by 24 being equal to 15°). Thus, the left-hand side of the 24-gon has a slope of 0, or of 360°, whichever we please to call it; the adjacent side, proceeding upwards, has one of 3°; the next, one of 45°, and so on all round the compass. They would be the same in their directions as the so-called "rhumbs" of a mariner's compass, if sailors divided their cards into 24 and not into 32 "points," If we take every second side of the 24-gon, and bring them together, they form a 12-gon. If we take every third side, the result will be an octagon; similarly for the hexagon and equilateral triangle. The symbols for the 24 sides are, as mentioned already, words of three letters; now there are 27 such words: consequently 3 remain over; one of these was used for "-gon," and another is found to be employed for "picture-writing,"

because it precedes every communication of the kind and is accompanied by a register number, to admit, as we may suppose, of each message being hereafter identifiable. The message by which this information is conveyed is of the following form, in which, for the convenience of the reader, the directions of the several sides are given in degrees of arc of our scale, though the 24 letters, a, b, c, &c., up to x, would more closely represent the actual signals.

It began by (picture formula), followed by a short pause; then—

(Picture formula) (24-gon) (equal to) 0°, 15°, 45°, &c., to 345°

(Picture formula) (12-gon) (equal to) 0°, 45°, 90°, &c., to 315°,

and so on all through the series. We may look on the picture formula as expressing the directions of each consecutive stitch in a piece of embroidery, those stitches being all of equal length.

There was some delay in puzzling out the above interpretation; it was first discovered by the young lady mentioned above, who is more successful than most of her companions in guessing charades and at such like games.

Further messages show that both the length of the stitch and its inclination may be specified more delicately by the help of decimals. Thus let j be the symbol for a stitch in any given direction, then $0.5 \times j$ means at half-length stitch in the direction j. A series of 4 triangles were signalled to explain this, in which the angles corresponded exactly with certain of the rhumbs, while the sides had to be expressed with decimals. Similarly as to the decimal division of the direction between rhumbs; in the first instance the pentagon was described, and then a series of four triangles, in which the sides were integral and the angles decimal. Short stitches are useful where the contour makes a sharp turn; minuteness of direction is sometimes wanted for the long lines in diagrams, but never for the short lines. Decimal directions are distinguished by brackets, thus $(0.3j)$ It will be recollected that the symbols for brackets, which are simply "lines," were determined during the multiplication message. The actual signalling of all the information described in this and the preceding letter occupied one hour and ten minutes, which was increased to an hour and a half by the pauses during its transmission and at its close.

11. A rapid retrospect may now be taken of what has been accomplished by less than two-and-a-half hours of actual signalling, together with pauses occupying a little less than one hour, making a total of three-and-a-half hours altogether. We have been made to completely understand the numerical notation of the Marsfolk, including their equivalent to our decimal point, and we have learnt the following twenty-nine words:—Area, brackets, circle, circumference, distance from, divided by, dodecagon, earth, equal to, etcetera, hexagon), Jupiter, Mars, minus, multiplied into, octagon, " ",[4] pentagon, perimeter of, picture-formula, radius, rhumb, Saturn, square, sun, twelve-sided regular polygon, triangle, equilateral triangle, Venus. We have also learnt how to draw any triangle, and implicitly how to draw any polygon, regular or irregular, from a picture-formula.

We now proceed to the ordinary picture-formulae, of which nine have been received in the six nights

[4] Galton actually has " ," but this is confusing.

during which the signals have been recorded. The power of the method is easily seen by drawing any outline with dots at equal distances apart, and counting those dots. A dozen or fifteen are quite sufficient to indicate a figure, or a letter, or other simple object, and as each dot occupies at quarter of a minute to transmit, as many as 210 can be sent in an hour. A considerable assistance to ensuring the accuracy of the method is given by selecting convenient points of reference in the drawing, which we may call A, B, C, &c., and by giving the distance of each of them from one or more of the others. This divides the drawing into stages, any one of which may be faulty without prejudice to the rest. It also enables detached parts to be drawn, commencing at one of the letters as a point of departure and ending at another. The points of reference are signalled thus:—A (distance to) B 42j; B (distance to) C 36d, and so on. The sign for "distance to" was determined in the letter No. 8.

The first of the pictures selected for decipherment was decided by the odd phrase (picture-formula) 0.5 (Saturn). It proved to be a beautiful representation of *one half* of Saturn and his ring. The other half, being symmetrical, did not need to be signalled. Only 105 "stitches" were employed. Another picture headed "Earth" proved to be a view of the American continent. 52 stitches sufficed for South America; but 88 were used for North America on account of the indentations of its shores; moreover, 16 of these were fractional stitches. A very good map was given of the solar system at the present date, so far as concerns the positions of the five principal planets about the sun. I must not at present speak of the domestic and sociological drawings, of which a new one is received every night, and the question whether or no the Mars-

> folk are glorified ants must remain for a short time longer in abeyance.

It is needless to continue in the same strain. I should say that the elements of the art of drawing outlines from written formulae that admit even of being telegraphed, was explained by me in a Friday Evening lecture, on the *Just Perceptible Difference*, at the Royal Institution in 1893.[5] Many illustrations of the method were then exhibited, one of which appears in the printed report. A large drawing of a Greek head had been made and formularised, then the formula was translated into dots upon paper, on the same large scale; rings were painted round the dots, and, lastly, the original and the copy were reduced by a photo-process to three different sizes. These form the printed illustrations. There were 271 dots, or rather rings, in this very effective picture, which contained the contour of the face, the sweep of the hair, the eyelids, and eyebrows.

It would be easy to enlarge the above vocabulary. Thus water and the metals could be defined by their relative specific gravities and other physical properties; colours by diagrams of the prism and of the rainbow. Units of length and time have been already determined by the diameter of any given planet and the time of rotation on its axis; that of weight on the surface of any named planet could be determined also; and picture-writing would extend the list of named objects indefinitely. But substantives alone cannot form a language; the symbols for other parts of speech must be explained by pictures, those for the past, present, and future tenses by pictures of objects in motion.

It would be tedious, and is unnecessary to elaborate further, for it must be already evident to the reader that a small fraction of the care and thought bestowed, say, on the decipherment of hieroglyphics, would suffice to place the inhabitants of neighbouring stars in intelligible communication if

[5] Galton 1893.

they were both as far advanced in science and arts as the civilised nations of the earth at the present time. In short, that an efficient inter-stellar language admits of being established under those conditions, between stars that are sufficiently near together for signalling purposes.

FRANCIS GALTON

Appendix B

Signals available to men who are adrift on wrecks at sea[1]

TO THE EDITOR OF THE TIMES. Sir —In *The Times* of to-day (Thursday) I have read with deep interest the fearful sufferings endured by a crew who were drifting about the Atlantic upon the wreck of their vessel. There is the old sad story repeated afresh by them, how, after days of anxious watching, first one vessel and then another were seen to approach hopefully, and then how each vessel, like its predecessor, passed by without noticing the low waterlogged wreck in which the sufferers were huddled, almost level with the sea, in the far distance. A distressed crew has little means of rigging up an object of sufficient size to attract the attention of distant ships; but there is one signal, which is often a very practicable one and which seems well worthy of a sailor's notice. I do not for a moment suggest its use to the exclusion of any other methods, but only as a valuable addition to them; and, as the means for making it are simple and accessible, I should think no sailor or passenger should forget them, who, in the moment of impending disaster, makes a hasty rush down below deck to secure such light objects as may appear likely to be of service to him when adrift on a boat, raft, or wreck upon the wide ocean.

[1] Galton 1856a.

All that is wanted is a common looking-glass, even of the smallest size—a broken bit as large as two half-crowns will do—and with this he should glitter the rays of the sun towards the ship whose attention he wishes to attract. Even at a distance of ten miles the glitter from a looking-glass no larger than the mouth of a teacup appears as a radiant and glistering star, and would at once cause many eyes on board ship to be attentively directed upon it. It is a matter of some nicety to direct the glitter from a looking glass either steadily or accurately; and, as a sort of guide to the degree of accuracy required, I may remark that if such a thing were possible as that a man could actually see the glitter of the looking-glass in his hand against the blue vault of the sky, just as he may see it against the walls or ceiling of his room, that it would in all cases appear to him to be (within a most trivial degree of difference) of precisely the same size and shape as the sun itself, though excessively inferior in brightness.

The plan I use for directing the glitter with a just aim is to cut a small hole with a pocket knife in the middle of the board, or, it may be, of thin zinc plate, which forms the back of the looking-glass, and also to scratch away the quicksilver from below it, so as to leave a little round space of clear transparent glass as an eye-hole. Looking through this hole, I direct the centre of the glitter as truly as possible by watching the play of its edge upon some object that may happen to lie on one side or another of a line between the eye and the person I signal to. Thus, if a boat was being rowed in a direction somewhere towards a ship, a man sitting low down in the stern could direct the glitter of his looking glass by watching its play upon the bows of the boat at the moment when he could just catch sight of the ship over them. If a looking glass be used without first cutting a hole in its back in the way I have mentioned it is necessary to hold it close up under the eye, and to make more careful allowance for the height of the eye above it than a person who has not had a good deal of practice is likely to succeed in accomplishing.

Salt water spoils a looking-glass, and it would therefore be necessary to wrap it up well out of harm's way; and, if it were greased thoroughly over its back and edges, it could be carried with still less risk. Finally, the mirror could only be used in moderate and sunshiny weather, but, with these restrictions, I believe it to afford a most valuable signal.

Obediently yours,

FRANCIS GALTON.

April 24.

Appendix C

Meteor[1]

TO THE EDITOR OF THE TIMES.

Sir,—I was at Boulogne this morning at 11 o'clock, when a violent explosion followed by a low and long-continued rumbling, was heard in the Hotel des Bains, where I was then staying. The people in the house ran in alarm from their rooms into the courtyard asking one another what had happened. Then observing through the gateway that similar crowds were also collecting in the street and by the harbour and were equally puzzled as to the source of the noise, I went out, and found myself in ample time to see the long, narrow, smoke-like train of a meteor hanging in the sky. The final puff that indicated the place of explosion was marked with perfect distinctness, but the point where the train first commenced was hidden from my view by a block of houses. I leisurely remarked the necessary bearings and then running back to my room returned with a small travelling "altazimuth" I had by me, and measured them. The results were for the first point in the train that I could see, altitude, 62 deg.; magnetic azimuth, 95 deg; for the final puff, altitude, 40 deg.; magnetic azimuth, 195 deg.

I doubt the error in any of these observations exceeding 1 deg.; I feel sure it does not exceed 2 deg. The average breadth of the train of smoke was about 1 deg. A comparison of these

[1] Galton 1866.

measurements with any set taken elsewhere—and doubtless you will receive some other communication—will at least indicate the path of the meteor, and will accurately fix its height above the earth at the time of explosion.

FRANCIS GALTON.

Appendix D

Telegraphing to Mars[1]

MR. FRANCIS GALTON, in the *Times* of this day week, proposes seriously that our astronomers should agree on an attempt to flash sun-signals to Mars for several consecutive years, in the hope that they might attract attention from the possible inhabitants of Mars, and get us signals back of the same kind.[2] Whether the proposal to send such solar signals to Mars is possible or not can hardly be determined until we have some reason to presume that creatures like ourselves, in something like the same stage of knowledge as ourselves, exist on Mars, and that, we fear, is just what it is quite impossible to conjecture with any confidence sufficiently strong to inspire even a faint hope of success. If there be any truth in the assumption that on the amount of solar heat received at the surface of a planet depends the rate of progress in civilisation, it would be reasonable to suppose that even if such creatures as men exist on the planet Mars, they are not improbably behind us in the stage of their civilisation, and that telescopes may be as unknown to them as they were to our forefathers three or four thousand years ago; while if we assume an analogy of that kind to be illegitimate, then it must be still less legitimate to suppose that there is any analogy at all between our con-

[1]Spectator, August 13, 1892, 218–219
[2]Galton 1892.

dition and theirs, even if they exist. The Martials, if there be Martials in any sense in which there are terrestrials on our own planet, may have no eyes at all; their whole civilisation, if they have any, may depend on senses of which we have absolutely no trace, so that communication between us and them would be a great deal less possible than communication between a fish and a mole, or between a blind man and a deaf mute. The whole idea of communicating with the inhabitants of Mars takes for granted that the Martials are organised more or less like ourselves, and especially in relation to the sense which carries farthest,—that is, the sense of sight. It would be an idle thing to send mere signals for consecutive years to a planet on which, even if there were rational beings, there was no sense of sight; and not very rational if, even though there were a sense of sight akin to our own, there was no power of aiding it by the help of telescopic inventions. Therefore it seems to us that unless the whole conception of communicating with Mars be in the highest degree extravagant, we have some reason to assume that the possible Martials are behind, not before us, in their stage of development and civilisation. We know that the tribes upon our earth which live under the most unfavourable conditions as regards heat,—the Esquimaux, for instance, and the Patagonians,—are far behind the inhabitants of the temperate regions in civilisation, and therefore, if we may draw any inferences at all as to the Martials from our own condition, the more probable inference is that, if they exist under circumstances at all like our own, they are, considering their great distance from the sun, centuries behind us rather than at the same stage of evolution, or still less centuries before us. And if we have no right to draw such an inference, then we have still less to reason with the smallest confidence from our own circumstances to theirs. They may, of course, have senses such as we have not even a dream of; they may be perfectly well acquainted with all that happens not only on our globe, but on all the other planets, and yet quite unable to let us know that they are familiar with our conditions of life, and how they have acquired that knowledge. But if that were so, it would be only too obvious that our conditions of life furnish us with no basis for forming any conjecture at all as to theirs; and in that case it would not only be sanguine, but quite irrational, to attempt to open communications at all. The only shadow of justification for making such an attempt rests on the assumption that we may reason from the. analogy of our own condition to theirs; and on that assumption we think it would be only prudent to assume that if such faculties as ours are already developed on the surface of Mars at all, they are likely to be far behind instead of far before our own.

But there is a further question of still more importance in connection with Mr. Galtons proposal. Let it be granted, for the sake of argument, that the Martials have eyes like ours and telescopes like ours, and that we could make them see our sun-flashes, and at last respond to them—how are we to establish any sort of code of communication without being able to establish any sort of association between our sun-flashes and the ideas we want to express?

Suppose, for example, that we wish to inquire the meaning and character of the long, straight canals on Mars, which have seemed to some of our observers artificial waterways of some kind, if they are not a vast deal too wide to be canals at all, or to ask the origin of those bright protuberances which some of our observers fancy to be artificial lights kindled on purpose to attract the attention of eyes in the nearest of Marss planetary neighbours, how are we to set about asking the question, after we have satisfied ourselves, if we ever can satisfy ourselves, that the Martials see our signals and send us signals in return? When a human being finds himself amongst other human beings of whose language he is profoundly ignorant, he establishes at once some kind of association between sounds and wants, by the free use of signs. He points to his mouth, and makes the movements which accompany eating to express that he is hungry; or the movements which accompany drinking to express that he is thirsty; or he holds up his hands to signify entreaty and supplication; or he points to the East or West to indicate the direction from which he came; and he carefully attends to all the sounds which his hosts make, and so manages to associate one sound with food, another with drink, a third with the threatening or pleased expression of the strangers in whose power he finds himself, and a fourth with the word used for the quarter of space from which he has indicated that he had himself come. In that way, a code of intercourse is soon established, upon which some sort of mutual understanding is gradually built up. But how is any such code to be established with people whom we can neither see nor hear, nor make a Sign to of any kind, except the sign from which we infer that they are watching our sun-flashes as well as that we are watching theirs? Suppose we find that three flashes of ours are answered after a short interval by three flashes of theirs, and that ten flashes of ours are answered after the same interval by ten of theirs, we may then fairly assume that they understand us when we say three or ten, and that they have the faculty of number in common with us. But how are we to get any further? How are we to express a question of any sort, or to indicate the shape of the Martial canals and convey our curiosity, or to ask whether the bright prominences in Mars are artificial lights or glaciers at the tops of mountains catching the sunlight? We do not see how, if Mr. Galton had successfully made his first step, he could get any further, unless he could find the means of magnifying indefinitely, and then illuminating intensely, the face of a human being, so as to render it visible in Mars, with some sort of gesture or expression with which definite sun-signals could be associated. And as that of course is,—at present, at all events,—far beyond the range of scientific possibility, it seems to us that even the first step could not be made in arranging any kind of communication beyond that which assures us that number is common to us and to them. Suppose we telegraph two, and then three, and then are answered by five flashes from Mars, that might go to show that two and three make five in Mars as well as in the earth,—which Mr. J. S. Mill was, we suppose, slightly inclined to doubt, though that appears to us a doubt of the most irrational kind, which might justify a much deeper doubt, namely, whether the Martials had any capacity for either doubt or certainty. But after telegraphing any number of addition sums, and finding them properly answered from Mars, how are we to get as far as applying the conception of number to any concrete thing? How are we to ask if Martials have engineers and ships, and electric lights and glaciers, and five senses, and heads and feet, or to convey that we have them, unless we can contrive to send at least some few pictures to Mars and to get a pictorial reply, which is, we take it, at present beyond hope. We do not believe that astronomers will be content to go on flashing sun-signals for years to come to hypothetical Martial observers, only on the chance that. after the lapse of years or centuries, we may have the satisfaction of ascertaining that the faculty of number exists as much in Mars as it does in the earth, and that addition-sums are the same there that they are here, which seems to us already certain, if they have intelligences at all. It is, of course, barely possible that we may be able to discover for ourselves the nature of the so-called canals, which must be hundreds of miles in width, and whether the bright points are points of natural or artificial illumination; and if that could be discovered, we might then gradually learn more; but until we can clearly discover the form and character of some one Martial structure, living or otherwise, and convey to Mars the impression of some one real object here, we confess that there seems to us very little use in flashing sun-signals on the bare chance of proving that elementary arithmetic is understood in Mars as well as here.

Appendix E

Additional Notes

E.1 Philosophy[1]

Clear mind from cant

What G signifies to different persons

Infinitude is something larger than the largest conceivable—but what is that to different persons?

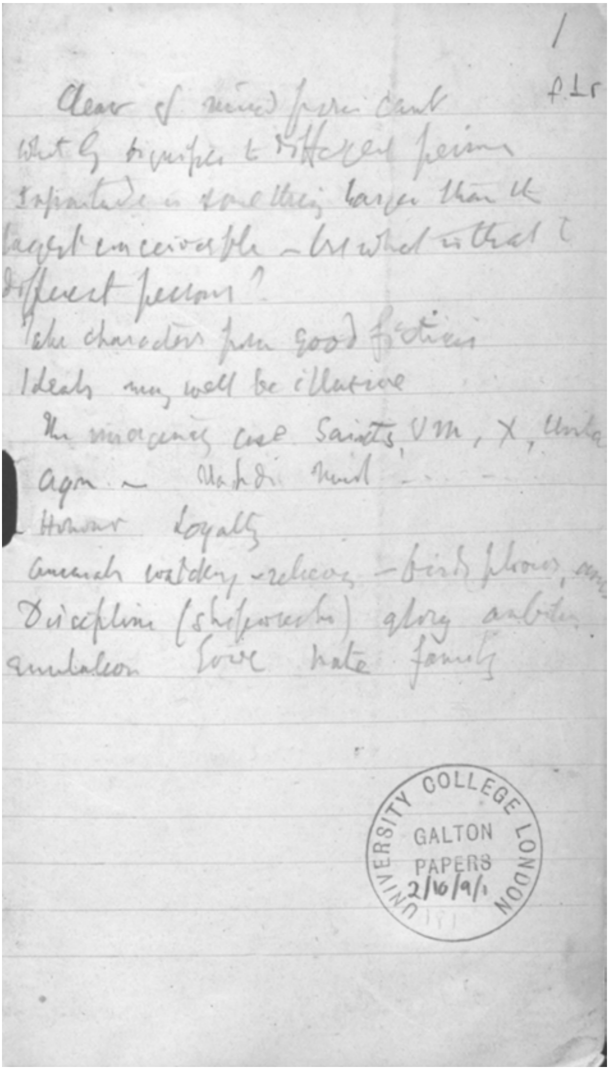
Take characters from good fiction

Ideals may well be elusive

The [imaginary] [case] Saints, VM, X,[2] [unites]
[Agm[3]] Mahdi Mind
Honour Loyalty
[Animals witchery] relieves —bird [plovers] ants

Discipline (shipwreck) glory ambition emulation love hate family

[1]p. f.1r.
[2]Virgin Mary, Christ.
[3]Possibly 'annual general meeting', as in collective mind.


1

f.1r

Clear of mind from cant
What G signifies to different persons
Infinitude is something larger than the
largest conceivable — but what is that to
different persons?
Take characters from good fiction
Ideals may well be illusive
The [illegible] case Saints, V.M., X, [illegible]
[illegible]
Honour Loyalty
[illegible]
Discipline ([illegible]) glory ambition.
emulation love hate family

Figure E.1: Page f1r. Philosophy.

E.2 Classification and Discontinuity[4]

Trustworthiness of classification applied to continuous variables

Small retail—Orange, Egg

Classes in Exam?

Passing recruits

Sentences

Cab fares—busses

Bribery

Estimates of value of property

Doses of medicine

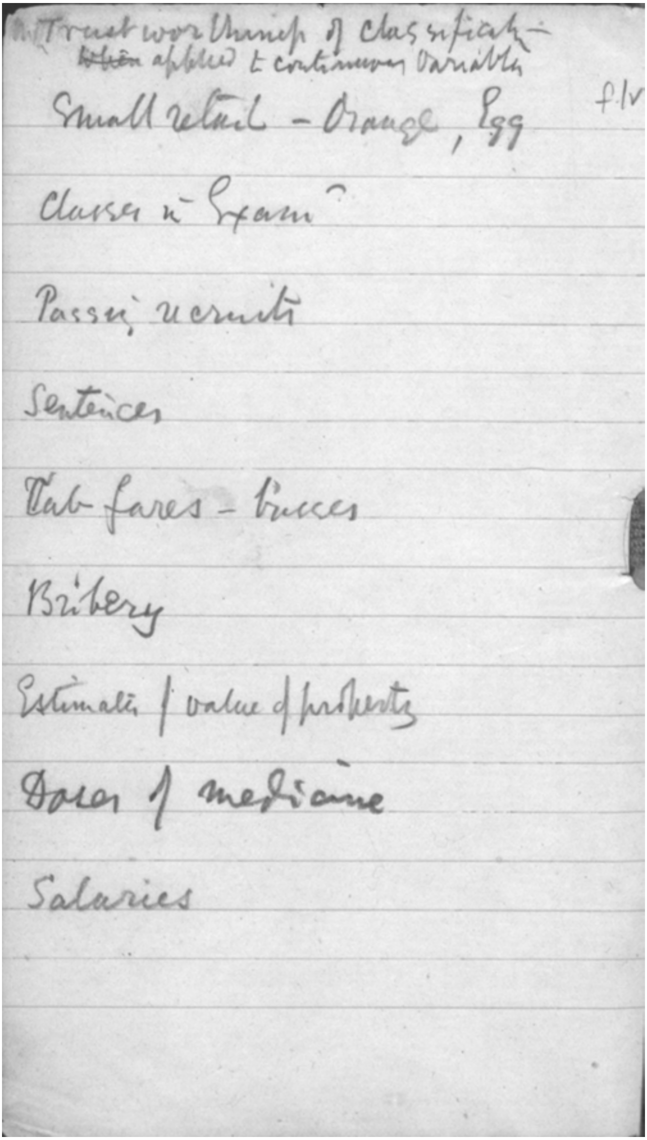
Salaries

E.3 Discontinuity[5]

See Distinction between Compounds & Mixtures by P. J. Hartog[6] with reference to organic stability

Possibilities of forms of [Chemicals]
see address

[4] p. f1.v.
[5] p. f4.
[6] P. J. Hartog 'On the Distinction between Mixtures and Compounds', read before the British Association, 1894.



Trustworthiness of classification – ~~when~~ applied to continuous variables

f.1v

Small retail – Orange, Egg

Classes in Exam?

Passing recruits

Sentences

Cab fares – buses

Bribery

Estimates of value of property

Doses of medicine

Salaries

Figure E.2: Page f1v. Discontinuity.

Geometric forms of simple organisms

classif: &c [tastes] in
Nat. Sel. the same percentage die in each gen^n in a [static] pop. Those who survive stand an equal chance of continuity [of] their breed

Shrub & tree On the liability to E[rror] in arb[itary] Cla[ssification] [YMCV]
[Math.] ~~Error contingent on an arbitrary classif. of a continuous variable~~

E.4 Botanical Notes on Heritability[7]

F. A. Dixey Md Wadham College Oxford April 9 / 95
Entom: Soc: Trans 1887 pp 310–312
" " Proc: 1887 pp xvii xviii
Transmission of pink tubercles in Saturnia Carpini[8]

F. Merrifield 24 Vernon Terrace Brighton April 7 / 95
[Selenia Illustraria] 4 of a dark bronze colour that breed true[9]

Rev. G. Henslow Charminster Vicarage Dorchester (? permanent address)
April 12 / 95

[7] p. f7.
[8] Emperor Moth.
[9] 'I thought that some data which were needed might be obtained by breeding insects, without too great expenditure of time and money, and it ended in my selecting for the purpose, under the advice of Mr. Merrifield, a particular kind of Moth, the "Selenia illustraria," which breeds twice a year and is hardy', Galton 1908, 307.

Parsnips. The French long ago raised varieties, but Prof Buckman sowing seed of the wild parsnips, raised similar varieties Radishes long a short-rooted.[10] Mr. Carriere[11] sowing seeds of the wild radish raised them by growing them in a loose & in a heavy soil an old fact recorded by Pliny & lately corroborated by the carrot. These varieties became fixed by selection & are quite hereditary by seed.

Parsnip Prof: Buckman neglecting all varieties but one fixed it in 1850 & called it the "student".[12] It is still the best in the trade. Spinescence due to drought—in wet climates the spines are lost Characters have every degree of persistence Question suggested "Are the varieties or specific characters constant under a changed environment? If not, to what extent are they hereditary, or how do they alter?" The wild cabbage, and the wild sea kale, have no varieties when under natural conditions.

I do not understand the following—"Many garden plants show innumerable variations as either two species of the same genus are not in cultivation as the sweet pea, cabbage, Pansy, cineraria; or else the species will not cross with others as the many 'races' which have been established by selection among seedlings of the Chinese primrose."

Instances given of effects of environment—all Alpine plants tend to be dwarf ... desert to be spinescent; acquatic to have finely [...] or ribbon-like submerged leaves.

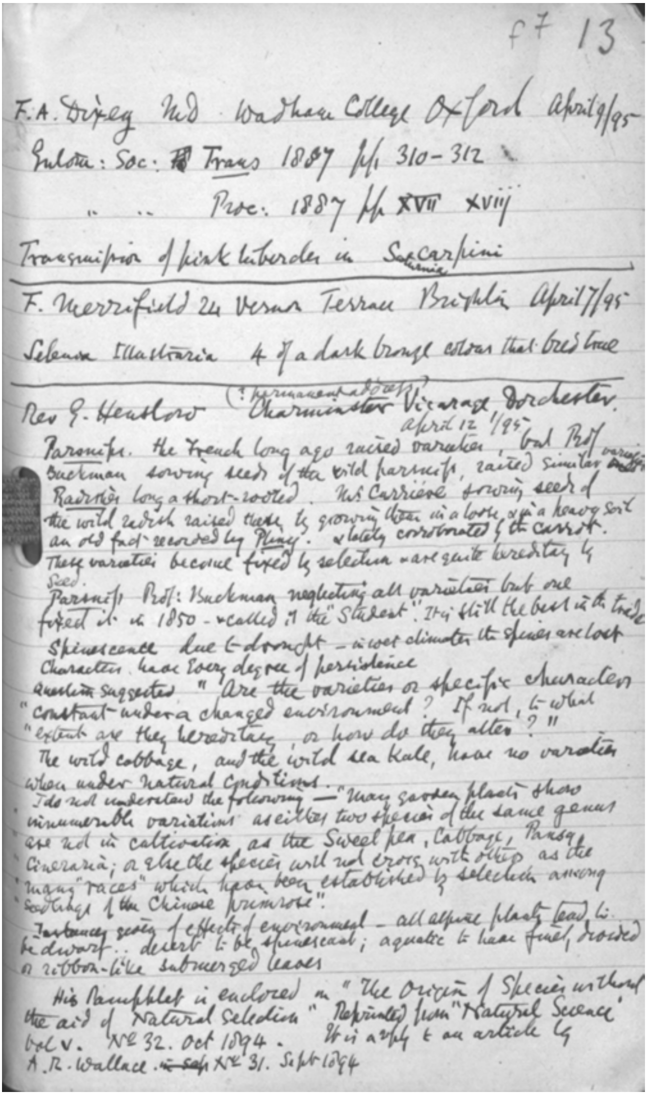
His pamphlet is enclosed on "The Origin of Species without the aid of Natural Selection" reprinted from "Natural Science" vol. V No 32 Oct 1894. It is a reply to an article by A. R.

[10] variety

[11] E. A. Carrière.

[12] James Buckman (18141884) was at the Royal Agriculture College in Cirencester, England.

Wallace No. 31, Sept 1894.



f7 13

F. A. Dixey MD Wadham College Oxford April 9/95
Entom: Soc: Trans 1887 pp 310–312
" " Proc: 1887 pp XVII XVIII
Transmission of pink underside in Saccarpini

F. Merrifield 24 Vernon Terrace Brighton April 7/95
Selenia Illustraria 4 of a dark bronze colour that bred true

Rev G. Henslow (? permanent address) Charminster Vicarage, Dorchester. April 12 /95
Parsnips. the French long ago raised varieties, but Prof Buckman sowing seeds of the wild parsnips, raised similar varieties
Radishes long & short-rooted. M. Carrière sowing seeds of the wild radish raised these by growing them in a loose or in a heavy soil an old fact recorded by Pliny. & lately corroborated by the carrot.
These varieties become fixed by selection & are quite hereditary by seed.
Parsnips Prof: Buckman neglecting all varieties but one fixed it in 1850 – & called it the "Student". It is still the best in the trade
Spinescence due to drought – in wet climates the spines are lost
Characters have every degree of persistence
question suggested "Are the varieties or specific characters "constant under a changed environment? If not, to what "extent are they hereditary, or how do they alter?"
The wild cabbage, and the wild sea kale, have no varieties when under natural conditions.
I do not understand the following — "Many garden plants show "innumerable variations as either two species of the same genus "are not in cultivation, as the Sweet pea, Cabbage, Pansy, "Cineraria; or else the species will not cross with others as the "many "races" which have been established by selection among "seedlings of the Chinese primrose".
Instances given of effects of environment – all alpine plants tend to be dwarf.. desert to be spinescent; aquatic to have finely divided or ribbon-like submerged leaves

His Pamphlet is enclosed on "The Origin of Species without the aid of Natural Selection" Reprinted from "Natural Science" vol V. No 32. Oct 1894. It is a reply to an article by A. R. Wallace. ~~in Sept~~ No 31. Sept 1894

Figure E.3: Page f7. Heritability.

E.5 Botanical Notes on Heritability (2)[13]

Haycraft Darwinism &c Swan & Sonnenschein / 95[14]
p 40 Among plants it really appears as if by adjusting the soil & the climate you may produce stunted varieties whose seed produce small plants. A classical case mentioned by Lemaire (D'Orbigny's dictionary[15]) is that of the [herass] when removed from Piedmont to France become a smaller variety only 1/2 its former height, in 2 or 3 generations

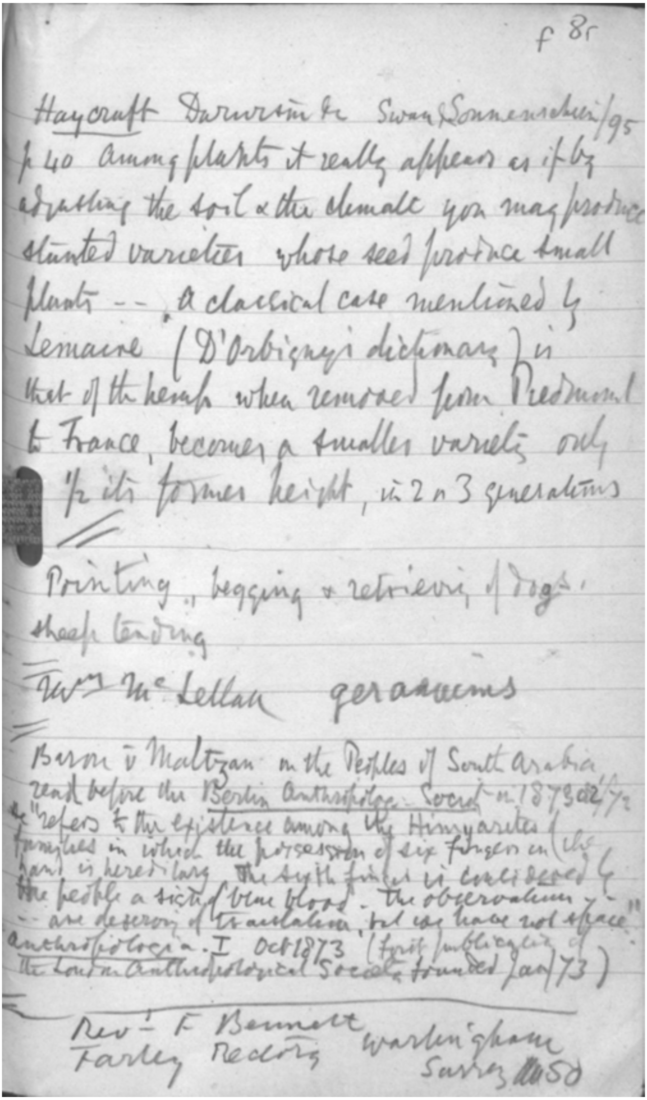
Pointing, begging & retrieving of dogs.
sheep tending.

Mrs. McLennan geraniums

Baron v. Maltzan on the People of South Arabia, read before the Berlin Anthropological Society in 1873 or / 72 He "refers to the existence among the Himyarites of families in which the possession of six fingers on the hand is hereditary. The sixth finger is considered by the people a sign of blue blood. The observations ... are deserving of translation, but we have not space." Anthropologica I Oct 1873 (first publication of the London Anthropological Society founded Jan / 73)[16]

Revd F. Bennett
Farley Rectory Warlingham Surrey 50

[13] p. f8r.
[14] John Berry Haycraft (1859–1922) *Darwinism and Race Progress* (London: Swan and Sonnenschein, 1895).
[15] Charles D'Orbigny (1802-1857) *Dictionnaire Universel d'Histoire Naturelle* (1849).
[16] *Anthropologica* Vol. I, October 1873, p. 115.


f 8r

Haycraft Darwinism &c Swan Sonnenschein /95
p 40 among plants it really appears as if by adjusting the soil & the climate you may produce stunted varieties whose seed produce small plants -- a classical case mentioned by Lemaire (D'Orbigny's dictionary) is that of the hemp when removed from Piedmont to France, becomes a smaller variety only ½ its former height, in 2 or 3 generations

//

Pointing, begging & retrieving of dogs. sheep tending

Mrs McLellan geraniums

Baron v Maltzan on the Peoples of South Arabia read before the Berlin Anthropolog. Society in 1873 [illegible] "refers to the existence among the Himyarites of families in which the possession of six fingers on the hand is hereditary. The sixth finger is considered by the people a sign of blue blood. The observations -- are deserving of translation, but we have not space" Anthropologia. I Oct 1873 (first publication of the London Anthropological Society founded Jan/73)

Rev. F Bennett Farley Rectory Warlingham Surrey [illegible]

Figure E.4: Page f8r. Heritability.

E.6 Botanical Notes on Heritability (3)[17]

Hubert Airy Proc. R. Soc
(1) Feb 27 / 1873 p 176 Leaf arrangement

[17] p. f10.

(2) March 23 / 1874 p. 298 " "
(3) May 8 / 1876 p 158 Cranberry

Shows that the *maxima* of stability are at the terms of the $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$ &c [series] The particular term depending on the distance of the ball from the india rubber band

A variability per saltum in no. of vertical [ranks] is a reasonable hypothesis 1874 p 304

"... it does not seem possible that one could be produced from another by accumulative 'modification' see Summary p 307

Compare however with 1876 p 160 where one series in the cranberry is frequently turned into another by unequal condensation resulting in spiral dislocation

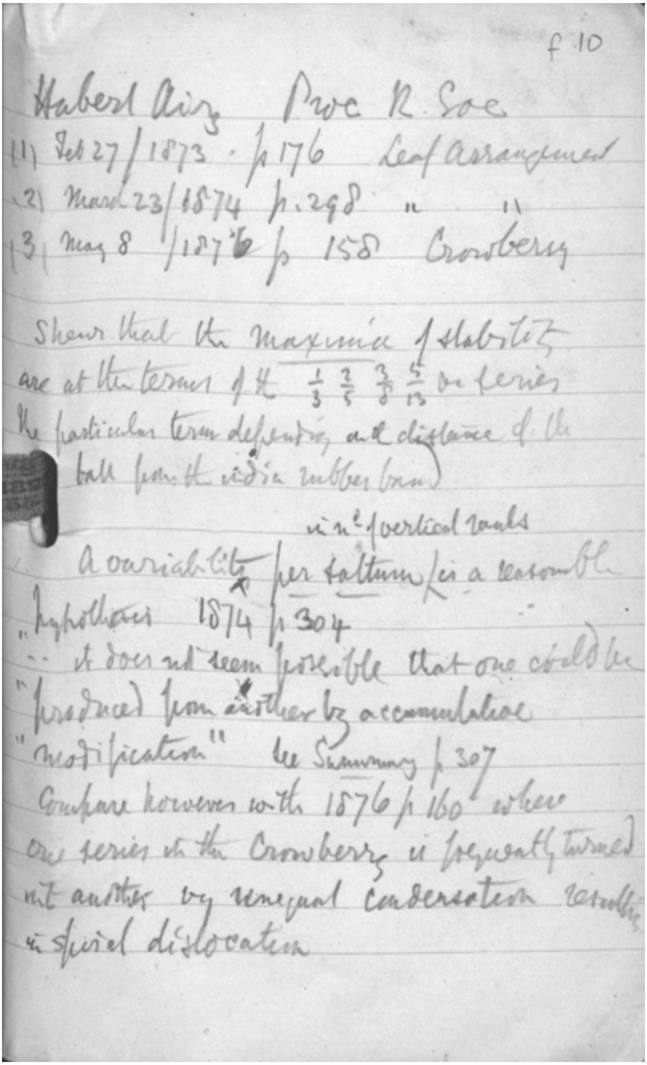
E.7 Fingerprint Data[18]

[Editor: Brief fingerprint data for Dorothy and Muriel Brooke]

E.8 Botanical Notes on Heritability (4)[19]

J Buckman Report in Experimental plots at the Agricult: coll: Cirencester Journ Brit: Assocn 200
p. 202 Agrostis—the three forms Agr. vulgaris, alba & stolonifera seem referable to a simple species.[20] The seed of one, though for the most part coming true will still send up exceptional examples of each of the others. A. vulgaris is common in upland meadows, A. alba in ditches & damp places. A stolonifera in

[18] p. f11.
[19] p. f16b.
[20] Bent grass.


f 10

Habert Airy Proc R Soc
(1) Feb 27/1873 · p 176 Leaf Arrangement
(2) March 23/1874 p. 298 " "
(3) May 8 /1876 p 158 Crowberry

Shews that the maxima of stability
are at the terms of the 1/3 2/5 3/8 5/13 &c series
the particular term depending on distance of the
ball from the india rubber band

in n° of vertical ranks
a variability per saltum is a reasonable
"hypothesis 1874 p 304
"... it does not seem possible that one could be
"produced from another by accumulative
"modification" see Summary p 307
Compare however with 1876 p 160 where
one series in the Crowberry is frequently turned
into another by unequal condensation resulting
in spiral dislocation

Figure E.5: Page f10. Heritability.

strong bushes &c.

Festuca loliacea, pratensis, and elatior[21] are similarly shown by experiment to be all referable to a single species. (1) grows true in meadows by the sides of rivers (2) in rich meadow flats. (3) on alluvial sandy clay banks by the seaside or poor siliceous clays instead Journ. Brit Assoc 1860 p. 35 These experiments with Festuca repeated successfully

p. 39 Pastinaca Sativa Parsnip—the Student Parsnip (only alluded to)[22] Brassica Oleracea, Wild Cabbage. Its seeds produced plants showing tendency to run into many of the cabbage varieties long petioles—Kale, greens, &c, both with broad, more or less undivided leaves, and with a tendency to deep lobes and divisions.

The paper in 1859 does not help me

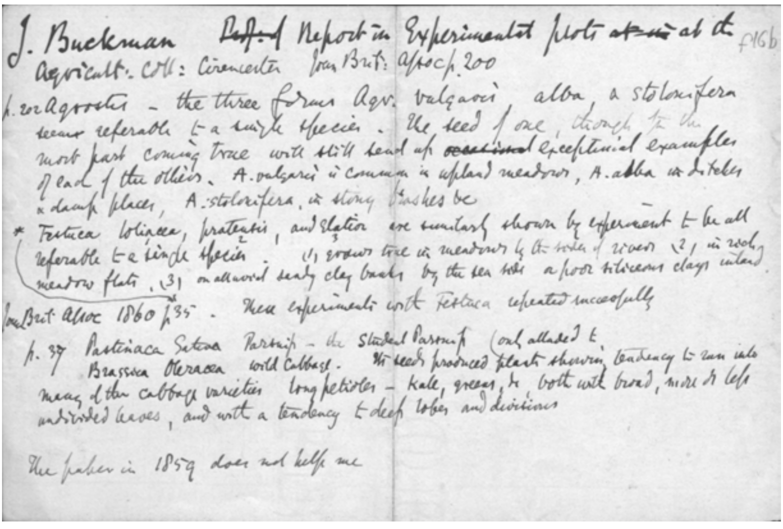

J. Buckman ~~Ref~~ Report on Experimental plots ~~at~~ at the f16b
Agricult. Coll: Cirencester Journ Brit: Assoc p. 200
p. on Agrostis – the three forms Agr. vulgaris, alba, & stolonifera seem referable to a single species. The seed of one, though for the most part coming true will still send up ~~occasional~~ exceptional examples of each of the others. A. vulgaris is common in upland meadows, A. alba in ditches & damp places, A. stolonifera in stony brashes &c
* Festuca loliacea, pratensis, and elatior are similarly shown by experiment to be all referable to a single species. (1) grows true in meadows by the sides of rivers (2) in rich meadow flats. (3) on alluvial sandy clay banks by the sea side or poor siliceous clays inland.
Journ Brit. Assoc 1860 p 35. These experiments with Festuca repeated successfully
p. 37 Pastinaca Sativa Parsnip – the Student Parsnip (only alluded to)
Brassica Oleracea wild Cabbage. Its seeds produced plants showing tendency to run into many of the cabbage varieties long petioles – Kale, greens, &c both with broad, more or less undivided leaves, and with a tendency to deep lobes and divisions
The paper in 1859 does not help me

Figure E.6: Page f16b. Heritability.

[21]Meadow grass.
[22]Wild parsnip.

E.9 Balfour's Foundations of Belief[23]

Foundations of belief. A. J. Balfour
Longmans 1895.[24]

5. Kant requires to be rethought by Enlightenment & reproduced in a form the Englishmen will assimilate. Chap I Naturalising Ethics

11. The substance of the moral law is accepted by all but the grounds on which they accept it differ. (? as to this—Code of honour & duelling in a Xtn[25] society—war Effort of western nations as against quietude—celibacy/ Claims of family & of state ...)

13. No moral code can be effective which does not inspire reverence (1) (? reverence is a compound of love & fear. A moral code may be based on either separately. Love—The children carrying out the mere fancies of a deceased parent; loyalty, self-sacrifice of a lover Mother's teachings. Fear of the world's opinion, of the law of an autocrat. Discipline.)

13. The capacity of a code to excite reverence &c cannot be wholly (2) independent of its accepted origin. (His estimate of naturalism seems to me a gross exaggeration of what necessarily follows from his description of it p. 7 Emotional capacity, aesthetic &c must potentially exist in the material out of which we are made. They may be almost infinitesimal in each particle but the battery of a vast multitude of organised particles gives finite effects.)

[23] p. f57a.

[24] Arthur James Balfour (1848–1930) was Prime Minister, 1902–1905. *The foundations of belief; being notes introductory to the study of theology, by the Right Hon. Arthur James Balfour* went through many editions. Balfour contested the idea that Darwinism undermined religion.

[25] Christian.

14 &c. He concludes from (2) that the naturalistic creed cannot excite reverence.

18 Kant composes the moral law to the starry heavens. The naturalist might compose it to the protective blotches on on a beetle's back.[26]

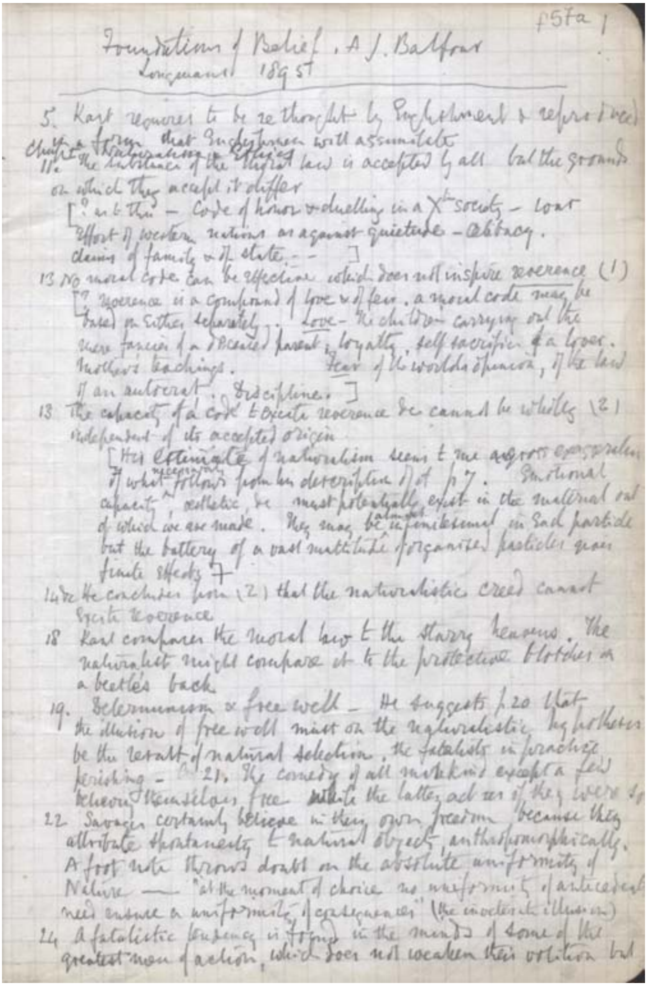
Determinism & free will. He suggests p. 20 that the dilution of free will must on the naturalistic hypothesis be the result of natural selection, the fatalists in practice perishing.

21. The comedy of all mankind except a few believing themselves free while the latter act as if they were so.

22 Savages certainly believe in their own freedom because they attribute spontaneity to natural objects, anthropomorphically. A foot note throws doubt on the absolute uniformity of Nature—"at the moment of choice no uniformity of antecedents need ensure a uniformity of consequences" (the inveterate illusion)

24 A fatalistic tendency is found in the minds of some of the greatest men of action, which does not weaken their volition but

[26]'Kant, as we all know, compared the Moral Law to the starry heavens, and found them both sublime. It would, on the naturalistic hypothesis, be more appropriate to compare it to the protective blotches on the beetle's back, and to find them both ingenious'.



f57a

Foundations of Belief. A J. Balfour
Longmans 1895

5. Kant requires to be re thought by Englishmen & reproduced in a form that Englishmen will assimilate
11. The substance of the highest law is accepted by all but the grounds on which they accept it differ
[? but this – Code of honor & duelling in a X^tn society – [illegible] effort of western nations as against quietude – celibacy. claims of family & of state. –]
13 No moral code can be effective which does not inspire reverence (1)
[? reverence is a compound of love & of fear. a moral code may be based on either separately. Love – the children carrying out the mere fancies of a deceased parent, loyalty, self sacrifice of a lover. mother's teachings. Fear of the world's opinion, of the law of an autocrat, discipline.]
13 The capacity of a code to excite reverence &c cannot be wholly (2) independent of its accepted origin
[His estimate of naturalism seems to me a gross [illegible] of what necessarily follows from his description of it p7. Emotional capacity, aesthetic &c must potentially exist in the material out of which we are made. They may be almost infinitesimal in each particle but the battery of a vast multitude of organized particles gives finite effects]
14 &c He concludes from (2) that the naturalistic creed cannot excite reverence
18 Kant compares the moral law to the starry heavens. The naturalist might compare it to the protective blotches on a beetle's back
19. Determinism & free will – He suggests p20 that the illusion of free will must on the naturalistic hypothesis be the result of natural selection, the fatalists in practice perishing – 21. The comedy of all mankind except a few believing themselves free while the latter act as if they were so
22 Savages certainly believe in their own freedom because they attribute spontaneity to natural objects anthropomorphically. A foot note throws doubt on the absolute uniformity of Nature — "at the moment of choice no uniformity of antecedents need ensure a uniformity of consequences" (the [illegible] illusion)
24 A fatalistic tendency is found in the minds of some of the greatest men of action, which does not weaken their volition but

Figure E.7: Page f57a. Balfour.

E.10 Balfour's Foundations of Belief (continued)[27]

adds a finer temper to their courage. Still in general belief in determinism does really conflict with the sense of personal

[27] p. f57b.

responsibility.

25 The admiration accorded to a virtuous man would become like that we now accord to a well made machine.

26 (1) Are the ends prescribed by morality adequate? (on the naturalistic hypothesis) conflict between egoism & altruism, unequal distribution of happiness with
27 no future state to set matters right.

28 Emotional adequacy—felicity of the sentient creation—but man's action
29 is so unimportant, moreover he is (naturalistically) a mere accident (fine passage about the blunderings & vileness of man)

32 Our practical ideal is beggared by these thoughts

Chap II Naturalism & Aesthetic

33. Aesthetics useless for preservation must be by-products Take music as free from objections to the rest (architecture & utility &c) A preexisting taste is needed to cause the favourable variation.

38 Spencer's muscular [contraction] "of the abdomen &c" and the noises there deduced have association &c absurdity of it. The sounds that 41 have associations give no delight & those that give delight have no assoc.

Discordant views of beauty—critical traditions.

The outfit of a critic is as much intellectual as emotional.
50 fashion in dress

The general tendency to agreement—sets & coteries

59 The arts progress but the pleasure given by them to each successive generation does not seem to increase.

Chap III Naturalism & Reason

67 The non-rational origin of reason (Is this fair?)

69 It is most improbable that our senses are even approximately adequate

73 Reason creates habits by wh: it is itself supplanted

75 Spencer's trust that man will become so perfectly adapted to his surroundings that goodness will be automatic—but so will reason & all that time we shall be idiotic. Sensibly poorer by this deposition of reason from its ancient position to that of an expedient for maintaining organic life.

Chap IV Summary of Part I[28]

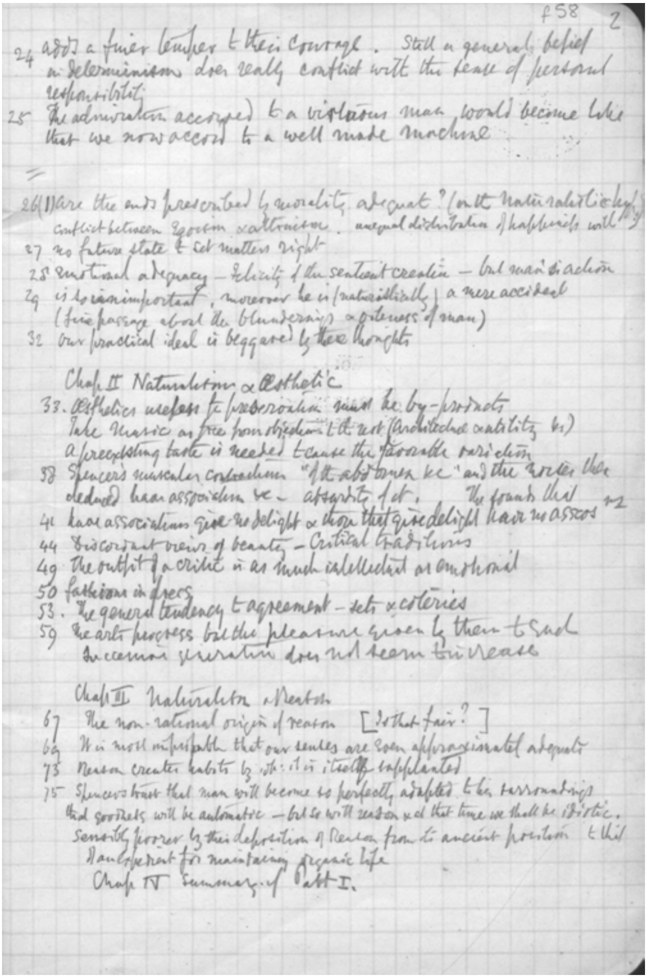
E.11 Encoding[29]

[Editor: first page with numerical encoding in terms of dots and dashes]

E.12 Encoding Rhumbs and Decimals[30]

Another trial Jul 29 / 96
with 24 rhumbs and decimals.

[28]There are no more sections in the notebook on Balfour.
[29]p. f59.
[30]p. f67r.



f58 2

24 adds a finer temper to their courage. Still a general belief in determinism does really conflict with the sense of personal responsibility

25 The admiration accorded to a virtuous man would become like that we now accord to a well made machine

=

26 (1) Are the ends prescribed by morality adequate? (on the naturalistic hyp.) conflict between egoism & altruism. unequal distribution of happiness with [illegible]

27 no future state to set matters right

28 Emotional adequacy — felicity of the sentient creation — but man's action

29 is too unimportant, moreover he is (naturalistically) a mere accident (fine passage about the blunderings & [illegible] of man)

32 Our practical ideal is beggared by these thoughts

Chap II Naturalism & Aesthetic

33. Aesthetics useless to preservation must be by-products

Take music as free from objections to the rest (architecture & utility [illegible])

a preexisting taste is needed to cause the favorable variation

38 Spencer's muscular contractions "of the abdomen &c" and the [illegible] theory deduced from association &c — absurdity of it. He founds that

41 base associations give no delight & those that give delight have no assocs

44 Discordant views of beauty — Critical traditions

49 The outfit of a critic is as much intellectual as emotional

50 fashions in dress

53. The general tendency to agreement — sets & coteries

59 The arts progress but the pleasure given by them to each successive generation does not seem to increase

Chap III Naturalism & Reason

67 The non-rational origin of reason [Is that fair?]

69 It is most improbable that our senses are even approximately adequate

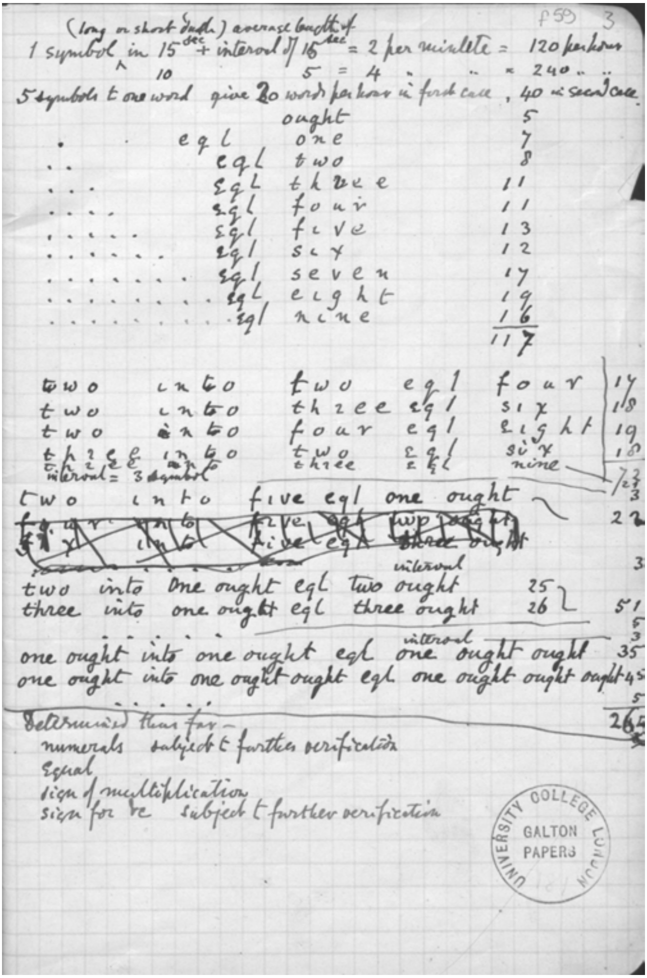
73 Reason creates habits by which it is itself supplanted

75 Spencer's trust that man will become so perfectly adapted to his surroundings that goodness will be automatic — but so will reason & at that time we shall be [illegible]. Sensibly poorer by this deposition of Reason from its ancient position to this [illegible] for maintaining organic life

Chap IV Summary of Part I.

Figure E.8: Page f57b. Balfour.

[...]


(long or short dash) average length of
1 symbol in 15 sec + interval of 15 sec = 2 per minute = 120 per hour
10 5 = 4 " " = 240 " "
5 symbols to one word give 20 words per hour in first case, 40 in second case

ought 5
. eql one 7
. . eql two 8
. . . eql three 11
. . . . eql four 11
. . . . . eql five 13
. . . . . . eql six 12
. . . . eql seven 17
. . . . eql eight 19
. . . . eql nine 16
117

two into two eql four 17
two into three eql six 18
two into four eql eight 19
three into two eql six 18
three into three eql nine
interval = 3 symbol

two into five eql one ought 22

interval
two into one ought eql two ought 25
three into one ought eql three ought 26 51

interval
one ought into one ought eql one ought ought 35
one ought into one ought ought eql one ought ought ought 45

Determined thus far—
numerals subject to further verification
Equal
sign of multiplication
sign for ve subject to further verification

Figure E.9: Page f59. Encoding.

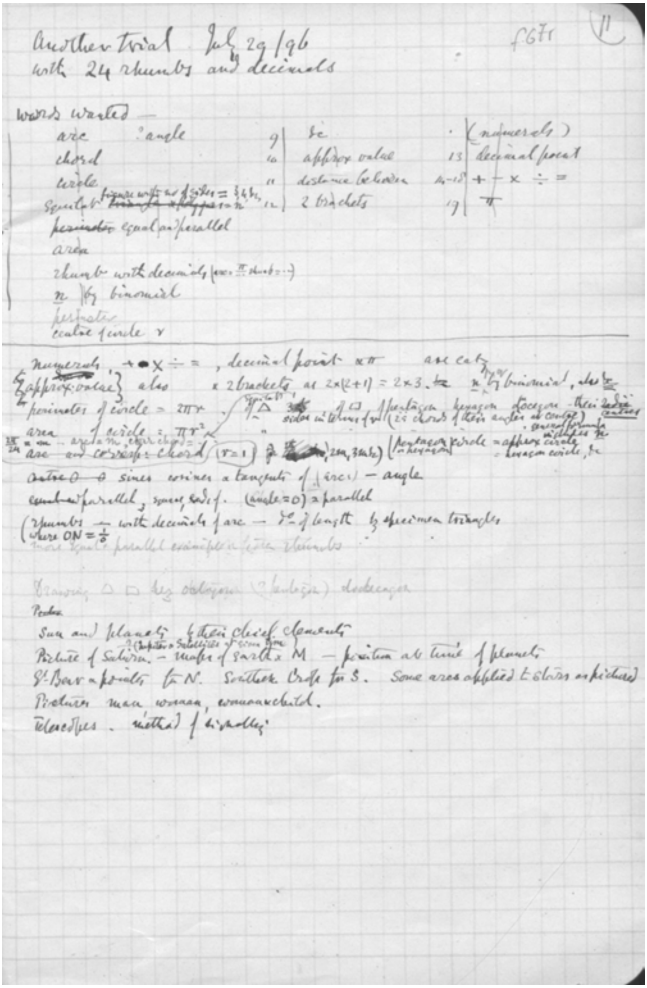


Figure E.10: Page f67r. Encoding.

Bibliography

Forrest, Derek William (1974). *Francis Galton. The Life and Work of a Victorian Genius*. London: Paul Elek, 1974.

Galton, Francis (1855). *The Art of Travel; or, Shifts and Contrivances Available in Wild Countries*. First. `http://galton.org/books/art-of-travel/index.html`. London: John Murray, 1855.

— (1856a). "Signals Available to Men who are Adrift on Wrecks at Sea". In: *Times* (Apr. 4, 1856), 10e.

— (1856b). *The Art of Travel; or, Shifts and Contrivances Available in Wild Countries*. Second. `http://galton.org/books/art-of-travel/index.html`. London: John Murray, 1856.

— (1858). "A description of a hand heliostat". In: *Report of the British Association for the Advancement of Science* (1858), pp. 211–212.

— (1860). *The Art of Travel; or, Shifts and Contrivances Available in Wild Countries*. Third. `http://galton.org/books/art-of-travel/index.html`. London: John Murray, 1860.

— ed. (1861). *Vacation tourists and Notes of Travel in 1860*. London: Macmillan, 1861.

— (1866). "Meteor". In: *Times* (June 21, 1866), 7f.

— (1867). *The Art of Travel; or, Shifts and Contrivances Available in Wild Countries*. Fourth. `http://galton.org/books/art-of-travel/index.html`. London: John Murray, 1867.

Galton, Francis (1872). *The Art of Travel; or, Shifts and Contrivances Available in Wild Countries*. Fifth. http://galton.org/books/art-of-travel/index.html. London: John Murray, 1872.

— (1879). "Observations on the eclipse of 1860". In: *Memoirs of the Royal Astronomical Society* XLI (1879), pp. 563–564.

— (1892). "Sun Signals to Mars". In: *Times* (Aug. 6, 1892), 7f.

— (1893). "The just-perceptible difference". In: *Proceedings of the Royal Institution* 14 (Jan. 27, 1893), pp. 13–26.

— (1896a). "Intelligible signals between neighbouring stars". In: *Fortnightly Review* 60 (Nov. 1, 1896), pp. 657–64.

— (1896b). "Signalling from Mars". In: *London Evening Standard* (Oct. 29, 1896), p. 2.

— (1908). *Memories of My Life*. http://galton.org/books/memories/index.html. London: Methuen, 1908.

Tredoux, Gavan (2018). *Francis Galton's Crisis. 1840–1868*. galton.org, 2018.