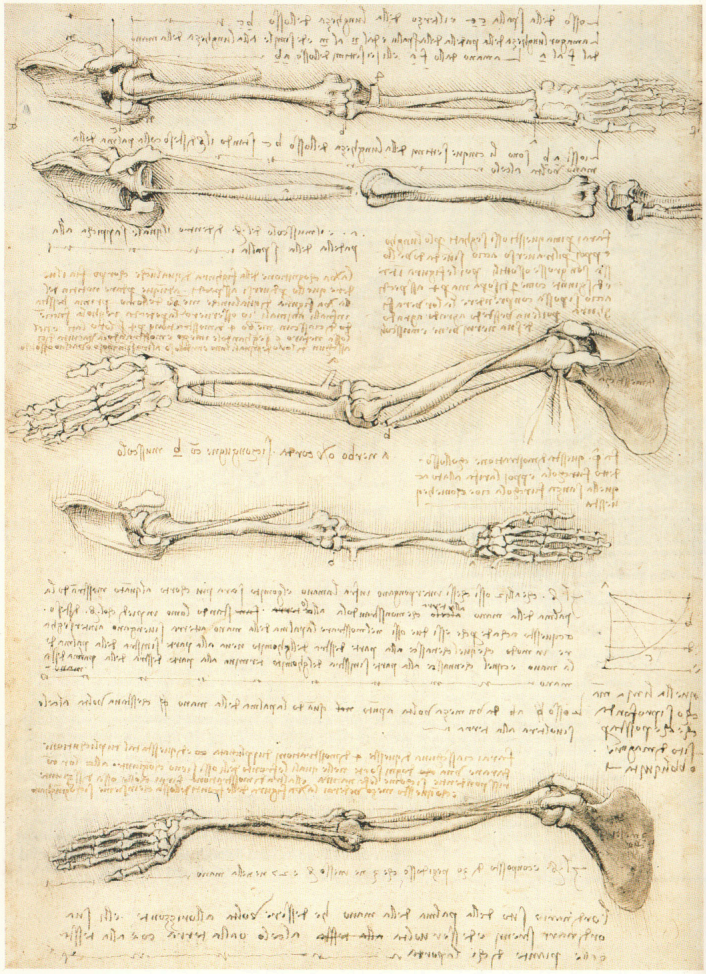


Words, Numbers, Images — Together

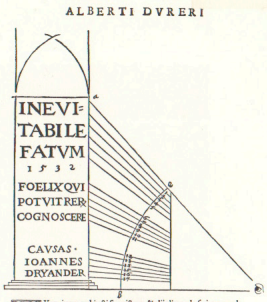
EVIDENCE that bears on questions of any complexity typically involves multiple forms of discourse. In modern scientific research, for example, 25% of published materials are graphs, tables, diagrams, and images; the other 75% are words (in 2,850 articles we randomly sampled from the 10 most-cited scientific journals, 1951–2000). Or, consider a more selective sample from 1610: Galileo's *Starry Messenger* is 30% images and diagrams, all integrated within the text. Or, for a more visual subject, the aesthetic theory and practical geometry of art, architecture, letterforms: Albrecht Dürer's *A Course in the Art of Measurement* (1525) consists of 52% drawings and 48% text, with woodcuts and words combined throughout the book.[1]

Evidence is evidence, whether words, numbers, images, diagrams, still or moving. It is all information after all. For readers and viewers, the intellectual task remains constant regardless of the particular mode of evidence: to understand and to reason about the materials at hand, and to appraise their quality, relevance, and integrity.

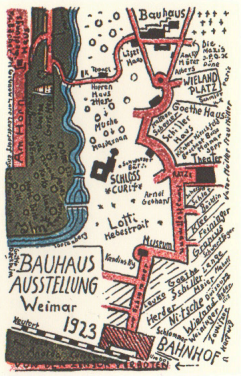
Most techniques for displaying evidence are inherently multimodal, bringing verbal, visual, and quantitative elements together. Statistical graphics and maps are visual-numerical fields labeled with words and framed by numbers. Even an austere image may evoke other images, new or remembered narrative, and perhaps a sense of scale and quantity. Words can simultaneously convey semantic and visual content, as the nouns on a map both name places and locate them in the two-space of latitude and longitude (here at right on a 1923 postcard).

Like Galileo and Dürer, those who reason about evidence often seek to place different forms of information within a common visual field and to treat all forms—verbal or nonverbal—as colleagues in explanation. At left, a manuscript of Leonardo da Vinci reveals intense unification of word and image characteristic of deep evidence-reasoning and evidence-presenting. How could it be otherwise? Leonardo's analysis combines text, beautiful drawings, engineering diagrams, annotation of local detail, and scales of measurement—whatever it takes—to illustrate the anatomy of the arm including such subtleties as the slight contraction in arm length upon turning the hand flat down and crossing the radius and ulna.[2]

YET this bond between verbal and nonverbal evidence has sometimes come undone in the process of *publishing*, as the assorted technologies of reproduction and presentation have segregated information by the accident of its mode of production. What has happened during 1,200 years of presenting text and images on paper and computer screens—and what can be done about it?



[1] Albrecht Dürer, *Institutiones geometricae* (Paris, 1532), 116, Latin edition of *Underweysung der Messung* (Nuremberg, 1525). A woodcut with text explains how to equalize the apparent size of inscriptional lettering on tall monuments as viewed by the eye (lower right of diagram).



Kurt Schmidt, postcard announcing the 1923 Bauhaus show in Weimar.

[2] Leonardo da Vinci, *The Bones and Muscles of the Arm* (1510–1511), pen and ink with wash, 29.3 × 20.1 cm or 11½ × 7⅞ in.

Centaur. Harley ms 647, Aratus, folio 12, ninth century, British Library, London, 20.6 × 21.9 cm, or 8⅛ × 8⅝ in.

CONSIDER the word/image relationships in this remarkable manuscript from the ninth century. In manuscripts, as the word suggests (*manus*, hand + *scriptus*, write), the common source of all marks is a handheld pen, pencil, brush. Thus the hand directly integrates word and image, as in Leonardo's drawings of anatomy, nature, and engineering projects; Galileo's manuscripts on astronomy and physics; ordinary notebooks, today's comics. And especially the centaur at left.

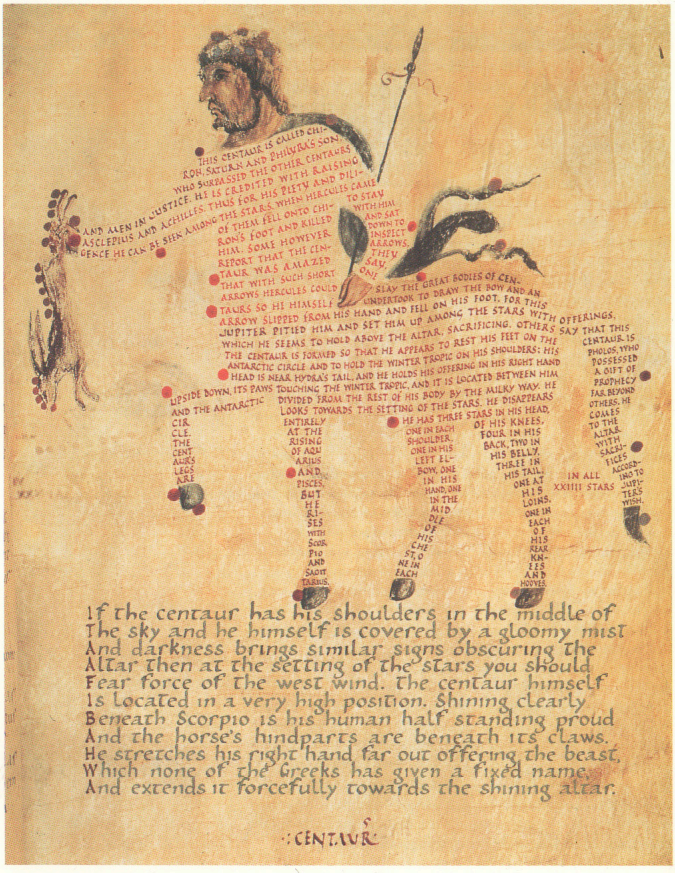
A triumph of multi-functioning signs, and of unification of text and image, this splendid zodiacal word-centaur is from a Carolingian manuscript portraying many constellations as word-pictures. Written in Rustic script, the Latin words "form wavy tracks, and through that curvature they model the form, giving it the fullness and convexity of the flank and rear of a horse."[3] Words begin and end so as to outline the legs and body, and the resulting perimeter links 44 star-dots that more or less form the southern constellation of Centaurus (the text mentions 24 stars). The words of the body are based on *De Astronomia* of Hyginus (2nd century AD); the block of words upon which the centaur stands is from Cicero's Latin translation of a Greek poem, *Phaenomena*, written around 275 BC by Aratus.

[3] Meyer Schapiro, *Words, Script, and Pictures: Semiotics of Visual Language* (New York, 1966), 147.

A variety of centaurs, some facing left and others right, all except this nearly wordless, have wandered through 2,000 years of celestial charts. Same stars, many centaurs. For a long time the amazing reality of the stars has been caught up in a thick mythology-astrology of constellation maps, elaborate stories (at left, 1,320 characters), and ambiguous images imposed upon the starry sky. Along with providing cues for recalling classical mythology, star-myths help us organize and remember the spatial locations of some stars. The centaur-words also describe nearby constellations, linking star stories across the sky.

By outlining *two*-space projections of the stars, constellation maps create an illusory flatland out of what are in fact non-adjacent stars residing in *three*-space. Now that astronomers can accurately measure the distance of many stars from Earth, perhaps it is time to draw three-space celestial maps with new visual-verbal geometries and narratives that will show where stars reside in the depths of space. Of course the Centaur is constructed only from stars visible to the unassisted eye. Galileo's telescope changed all that.

Although the original Latin is incomprehensible to most modern eyes, indeed to most eyes for all time nearly everywhere, today we easily grasp the *visual* meaning of this centaur drawn 1200 years ago: stars, real and imaginary objects, contoured shape reading as three-space, an outline map in two-space, a narrative metaphor grouping the stars into a constellation. For all kinds of images, there is similar continuity of showing and seeing. Chiron the centaur exemplifies the universality of images—and the stupefying locality of languages.



Our previous double-page spread reproduced the original centaur in Latin. Shown at left, Chiron the centaur is translated and reconstructed in English. First Latin, now English, only a few thousand more languages to go. Written in English with the letterforms of the original Rustic script, the poem recalls the harrowing career, noble exploits, and excellent character of the centaur, this fine cartoon animal, half human, half horse. A few words even describe the stars.

Elaine Morse of Graphics Press redrew the centaur; Kenneth Lapatin of Boston University translated the Latin.

Just as in manuscripts, early printing routinely combined text and image. During the first 800 years of printing with moveable reusable type—from the 600s in Korea, Japan, and China and finally in the 1400s in Europe—text and image were printed by the same method: the information to be reproduced was cut in relief in mirror-image reverse on woodblocks by carving away areas to be absent of ink. The information to be printed thus stood proud—like a mountain, in relief—on the woodblock. The wrong-reading raised wood was then inked and pressed onto the paper, leaving a correct-reading copy of the original. Since this method works for any mark, *text and image can be printed simultaneously and integrated on printed sheet without special intervention*. For example, here below is a splendid integration of text and image from the *Diamond Sutra*, printed by woodblock in 868, and according to the British Library catalog, "the world's earliest complete survival of a dated printed book."

Diamond Sutra (AD 868), Dunhuang, China. Ink on paper printed by wooden blocks.

HYPNEROTOMACHIA POLIPHILI,VBI HV
MANA OMNIA NON NISISOMNIVM
ESSE DOCET. ATQVE OBITER
PLVRIMA SCITV SANE
QVAM DIGNA COM
MEMORAT.
* * *
* *
*

Hypnerotomachia Poliphili was probably written by Francesco Colonna, a worldly monk, and was undoubtedly published by the Venetian printer Aldus Manutius in 1499. Although the drawings are often artful, and the typography splendid and influential to this day, *Hypnerotomachia* is a forever beauty because of its harmonious whole combining type and woodcut illustrations.

A long elegy to the reader opens the book. The elegy concludes with confident humanistic exuberance (no humble servant dedicating the work to royalty or religion) and expresses sentiments no doubt felt by other authors since 1499:

Receive what this great cornucopia has offered,
Behold a useful and profitable book. If you think otherwise,
Do not lay the blame on the book, but on yourself.[4]

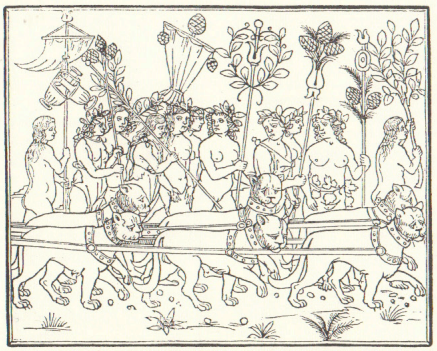
Here at right is a fine page from *Hypnerotomachia*: generous margins, a narrative drawing, a title-summary in capital letters, floriated initial capital letters, and the similar visual texture of all elements. Shown is one of many parade scenes, a rowdy party of nymphs and lions. Some 30 to 40 pages of the book reach this high level of visual eloquence.

Hypnerotomachia has been studied for centuries by design students as an aesthetic exemplar of printing, layout, and typography—and *only* that, since few could read the original words, a unique confected Italian-Latin-Greek hybrid language. Unreadable classics teach that some books are beautiful simply as pure amazing art objects. Unfortunately they also teach *content indifference*: in text/image relations, designers need only consider aesthetic effects. Of course such effects are central to decorative and commercial art. But for serious work in reasoning about evidence, *the essential test of text/image relations is how well they assist understanding of the content*, not how perfectly stylish the pages look. To make this test, one must know *what the words mean in their relation to the images, and what the images mean in relation to the words*. Recall Eric Gill's point:

If you look after truth and goodness,
Beauty looks after herself.

Francesco Colonna, *Hypnerotomachia Poliphili* (Venice, 1499), at left, title; at right, l5.

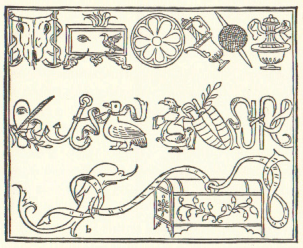
[4] *Hypnerotomachia Poliphili: The Strife of Love in a Dream* (New York, 1999), translated by Joscelyn Godwin, 5.



LA MVLTITVDINE DEGLI AMANTI GIOVENI, ET DILLE DIVE AMOROSE PVELLE LA NYMPHA APOLI PHILO FACVNDAMENTE DECHIARA, CHIFVRO- NOET COMEDAGLI DII AMATE. ET GLI CHORI DE GLIDIVI VATICANTANTI VIDE.

SCVNOMAIDITANTOINDEFESSOELO quio aptamente ſe accommodarebbe,che gli diuini ar chani diſertando copioſo & pienamente poteſſe euade re & uſcire. Et expreſſamente narrare,& cum quanto di ua pompa,indeſinenti Triumphi, perennegloria, feſti ua lætitia,& fœlice tripudio,circa a queſte quatro iuiſi tateſeiuge de memorando ſpectamine cum parole ſufficientemente ex- primere ualeſſe. Oltragli inclyti adoleſcentuli & ſtipanteagmine di ínu- mere & periucunde Nymphe,piu che la tenerecia degli anni ſui elle pru- dente & graue & aſtutule cum gli acceptiſſimi amanti de pubeſcente & depile gene. Ad alcuni la primula lanugine ſplendeſcéte le male in- ferpiua delitioſe alacremente feſtigiauano. Molte hauendo le facoleſue accenſe & ardente. Alcune uidi Paſtophore. . Altre cum drite haſte adornate de priſcheſpolie. Ettali di uarii Trophæi optimaméte ordinate

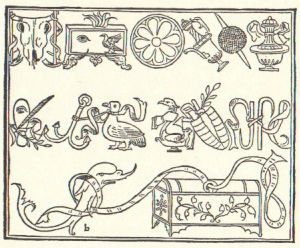
retico baſamento in circuito inſcalpto digniſſimamẽte tali hieraglyphi. Primo uno capitale oſſo cornato di boue,cum dui inſtrumenti agricultorii,alle corne innodati,& una Ara fundata ſopra dui pedi hircini,cum una ardente fiammula,Nella facia dellaquale era uno ochio,& uno uulture. Dapoſcia uno Malluuio,& uno uaſo Gutturnio,ſequẽdo uno Glomo di filo,ifixo i uno Pyrono,& uno Antiquario uaſo cu lorificio obturato.. Vna Solea cum uno ochio,cum due fronde intranfuerſate,luna di oliua & laltra di palma politamẽte lorate. Vna ancora,& uno anfere. Vna Antiquaria lucerna,cum una mano tenente. Vno Temone antico,cum uno ramo di fructigera Olea circunfaſciato-poſcia dui Harpagul. Vno Delphino-& ultimo una Area recluſa-Erano queſti hieraglyphi optima Scalptura in queſti graphiamenti-



Lequale uetuſtiſſime & facreſcripture penſiculante,cuſi io le interpretai.

EX LABORE DEO NATVRAE SACRIFICA LIBER A LITER, PAVLATIM REDVCES ANIMVM DEO SVBIECTVM. FIRMAM CVSTODIAM VITAE TVAE MISERI CORDITER GVBERNANDO TENEBIT, INCOLVMEM QVESER VABIT.

the piazza, I saw the following hieroglyphs engraved in suitable style around the porphyry base. First, the horned skull of a bull with two agricultural tools tied to the horns; then an altar resting on two goat's feet, with a burning flame and, on its face, an eye and a vulture. Next, a washing basin and a ewer; then a ball of string transfixed by a spindle, and an antique vase with its mouth stopped. There was a sole with an eye, crossed by two branches, one of laurel and the other of palm, neatly tied; an anchor, and a goose; an antique lantern, with a hand holding it; an ancient rudder, bound up together with a fruited olive-branch; then two hooks, a dolphin, and lastly a closed coffer. These hieroglyphs were well carved in the following graphic form:



After thinking over these ancient and sacred writings, I interpreted them thus:

FROM YOUR LABOUR TO THE GOD OF NATURE SACRIFICE FREELY. GRADUALLY YOU WILL MAKE YOUR SOUL SUBJECT TO GOD. HE WILL HOLD THE FIRM GUIDANCE OF YOUR LIFE, MERCIFULLY GOVERNING YOU, AND WILL PRESERVE YOU UNHARMED.

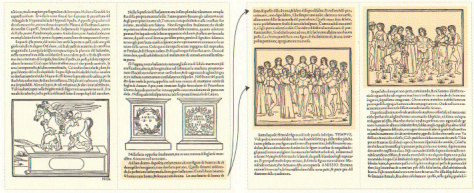
In 1999, Joscelyn Godwin published the first complete English translation of *Hypnerotomachia*, which revealed an intense language of superabundant imagery, a text as visual as a text can be. Above, we see the same page from the 1499 original and the 1999 English translation, as words track detailed little images in a rebus. Surely these words were written with a sketch at hand. The rebus woodcut, a verbal/visual confection, itself becomes a sentence element, as the text introduces the rebus image with the phrase "in the following graphic form." Continuing interplay-multiplicity of text/image/text/image carries on to the end of the page.

To see the cognitive (as well as optical) relationships between words and images in *Hypnerotomachia*, I have read the English text surrounding each of 170 woodcuts in the book and then collated the English against the original book of 1499. Nearly always, the words closely follow the images—and the images closely follow the words—as in the rebus page. Here are the details of all the content-links between words and images.

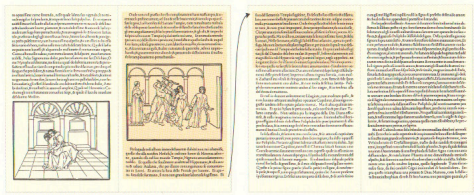
Left, Francisco Colonna, *Hypnerotomachia Poliphili* (Venice, 1499), c1; and, at right, *Hypnerotomachia Poliphili: The Strife of Love in a Dream* (New York, 1999), translated by Joscelyn Godwin, 41.

Of the 170 woodcuts in *Hypnerotomachia*, fully 73% have *all* their relevant words within the common visual field of the same double-page spread of the open book. At right, for example, a double-page spread shows all the words (highlighted) belonging to an image (highlighted). Indeed, for this example, text and image are unified not merely on the spread but on *each page*. On the left page, the text applies fully to the image below; on the right page, the relevant text surrounds its image.

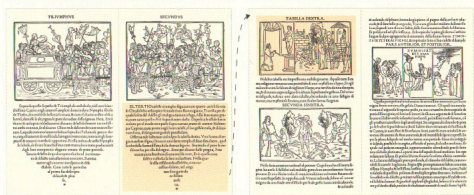
Sometimes the appropriate words and images are not fully within our eyespan all at once, as the words narrating the image-scene begin on the page *prior* to the spread containing the image. In this sequential pair of double-page spreads at right, the relevant words begin on the second page of the first spread (4 highlighted lines at the bottom) and then flow on over to the next spread where the image resides. Found in 21% of the 170 images, this arrangement usually maintains a reasonable unity of narrative.



Then, for 4% of the woodcuts, the words spill over *after* the relevant image, as we see now at right. The relevant (highlighted) words and image begin together, but then the relevant words continue on over to the next double-page spread. In this event, it might be helpful at times to repeat the same image near the spilled-over text.



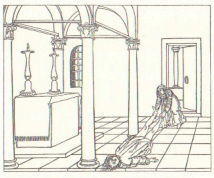
Only 2.4% of all the woodcuts (4 of 170) are not directly adjacent to any of their words. At right, for example, the relevant text ends on the first double-page spread, then the relevant image appears on the next. At least this is a *local* non-adjacency, for the image is not distantly appended somewhere at the back of the book.



Overall, the design of *Hypnerotomachia* tightly integrates the relevant text with the relevant image, a *cognitive integration* along with the celebrated optical integration. Again it is likely that Aldus Manutius and his colleagues were guided by image-sketches placed within the original manuscript itself.

The pages reproduced from *Hypnerotomachia*, 1499 (with corresponding pages in Godwin, 1999) are: *top*: l3'- l4 (174-175); *row* 2: b4'- b6 (32-35); *row* 3: c5'- c7 (422-425); and *bottom*: k7'- l1 (166-169).

Poliphili briefly dies.

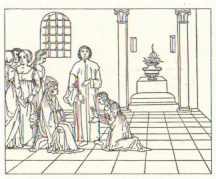


Polia drags Poliphili out by his feet.

At the temple, Polia revives Poliphili.

P & P amorously embrace, but then . . .

P & P are chased away by the High Priestess.

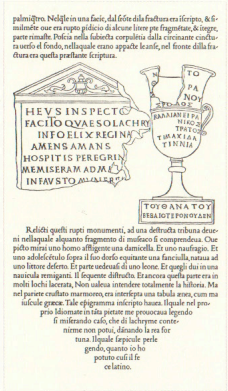


Later, back at the temple, all is well.

Hypnerotomachia, 1499, a8r, b1, c5, c5r, c6, d1.

Along with placing the right words next to the right images, the book unifies the verbal-visual story by linked temporal images that thread through long textual passages. This narrative sequence above illustrates the 40-page love story of Polia and Poliphili. Brought together, these woodcuts provide a crisp visual summary of a distinctly wordy account, a *storyboard* (a powerful analytical and narrative display method) that sets and links scenes, locates and animates characters. The *Hypnerotomachia* sequence resembles a modern movie storyboard; for example, the scary cornfield sequence in Alfred Hitchcock's *North by Northwest* (1959):

Compared with Leonardo's anatomical drawings of 1510 and movie storyboards of 1959, the *Hypnerotomachia* woodcuts are flat, medieval. And unintentionally humorous, as Polia drags out a temporarily deceased Poliphili by his feet, greatly elongating him in the process.

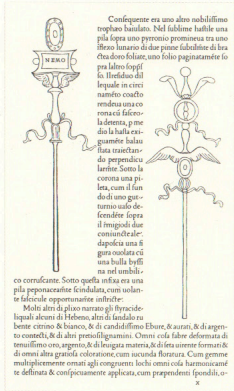


palmigtro. Nelqle in una facie, dal fróte dila fractura era iícripto, & fi-nalmẽte oue era rupto pidicio di alcune litere pte frammẽtate, & integre, parte rimaste. Poícia nella fubiecta corpulẽta dalla circinante cinctura oueio el fondo, nellaquale erano appacte le anfe, nel fronte dilla fractura era quella praefante fcriptura.

HEVS INSPECT
FACTIO QVAE SOLACHRY
INFOELIX REGINA
AMENS AMANS
HOSPITIS PEREGRIN
MEMISERAM ADAM
INFAVSTO

TOY ΘΑΝΑΤΟΥ
ΕΒΒΑΙΟΤΕΡΟΝΟΥΔΕΝ

Reliqui queíti rupti monumenti, ad una deftracta tribuna deueni nellaquale alquanto fragmento di muíaico fi comprendeua. Oue pócho mirai uno homo affligente una damicella. Et uno naufragio. Et uno adolefcẽtulo fopra il luo dorío equitante una fanciulla, natata ad uno littore deferto. Et parte uedeuale di uno leone. Et quegli dui in una nauicula remiganti. Il fequente diftructo. Et ancora quella parte era in molti lochi lacerata, Non ualeua intendere totalmente la hiftoria. Ma nel parlete crufiato marmoreo, era interfepta una tabula aurea, cum ma iuícule greece. Tale epigramma inícripto haura. Iliquale nel proprio Idiomate in tãta pietate me prouocaua legendo fi miferando cafo, che di lachryme contenieme non potui, dãando la rea for tuna Iliquale fepiculo perle gendo, quanto io ho potuto cufi il fe ce latino.



NERO

Cõfequente era uno altro nobiliffimo trophaeo baiulato. Nel fublime haftile una pila fopra uno pyramio promineua tra uno ftrato lunario di due pinne fubuliníe di bra cchia dorio foliate, uno folio paginatamẽte fo pra latro fopíf fo. Ilrefiduo dil lequale in circi naméto coacto rendeua una co ronacii fafcero la detenta, p me dio la halla exiguamẽte balau ftata traiectan do perpendicu larẽte Sotto la corona una pi leta, cum il fun do di uno gut turnio uafo de fcendẽte fopra il mugiodi due coniunẽte ale dapoícia una fi gura ouolata cũ una bulla byfi na nel umbili co corrifcante. Sotto quefta infixa era una pila peponacearíte fcindulata, cum uolante faleicule opportunarẽte inffrẽte.

Molti altri di pixo narrato gli fyracide liquali alcuni di Hebeno, altri di fandalo ru bente citrino & bianco, & di candidiffimo Ebure, & aurati, & di argento conteẽti, & di altri pretiofiffimi mi. Omni cofa fabre deformata di tenuiffimo oro, argento, & di leugata materia, & di feta uirente formati & di omni altra gratiofa coloratione, cum iucunda ftoratura. Cum gemme multiplicemente ornati agli congruenti lochi omni cofa harmonicamẽte deftinata & confpicuamente applicata, cum præpendenti fpondili, o-

x

ftatua fupra ftante di tutto, quale laltra, Senõche era regina, Laquale fubleuato il dextro bracio cum lindice fignaua la parte retro le fue fpalle, & cum laltro teniua una tabella ritinuta cum il coperto & cum la mano fua indiuifa. Nella ifle etiam iícripto era tale epigramma in tri idiomi.

ΟΣΤΙΣ ΕΙ. ΑΑΒΕ ΕΚ ΤΟΥΔΕ
ΤΟΥΘΗΣΑΥΡΟΥ, ΟΣΟΝ ΑΝ Α
ΡΕΣΚΟΙΤΑΡΑΙΝΟΔΕΞΕ ΑΑ-
ΒΗΣ ΤΗΝ ΚΕΦΑΛΗΝ. ΜΗ Α
ΠΤΟΥ ΣΩΜΑΤΟΣ.

QVISQVIS ES, QVANTVN
CVNQVE LIBVERIT HV-
IVS THESAVRI SVME AT-
MONEO . AVFER CAPVT.
CORPVS NE TANGITO.

Di tanta nouitate digna di relato mirabondo, & degli arnigmati pretele gendoli fapicule, dil tutto io refiai ignaro, & dilla interpretatione & fophifmo fignificato molto ambiguo. Non era aufo percio alcuna cofa perten tare. Ma quafi iníuffo darimore in quello loco retro & illumine, quantunque gli fuffe il lucernale lume. Nientedi manco il folicito defiderio di contemplare la triumphante porta ftimulante, piu legitima cauía fue che quiui non dimoraffe, che altro. Dopoe fencia altro fare, cum penfiero & propofito per omni modo dapo la contemplatione di effa porta mi rabile, unalira fiata quiui ritornare. Et pia tranquillamente fpecularetale magnificentia de inuento dagli humani ingegni, cittiffimo allapertura peruenì. Et defendando ufciui fora dil exuilcerato monfito. Inuentione inexcogitabile, & fencia exiftimatione, exceíío di faticha, & temerario aufo humano, quale. Trepano trembrare tanta durezia & contumacia di petra, & euasuarentanta duritudine di materia, ouero altre fabrile machine ponnoo? Concordemente consumendo il cauato intorno cum la for ma exteriore. Finalmẽte fopra la piacia ritornato, udi un queílo porphyretico

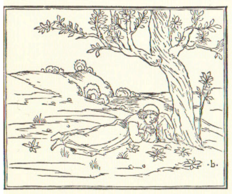
Hypnerotomachia, 1499, q5, x1, b8r.

Words decorate many of the illustrations. Some 57 concocted Latin and Greek inscriptions (2,300 words in English translation) show up on pots, boxes, tablets, architecture, and in a garden with letterforms constructed from marjoram plants. At left, an inscribed pot sits on a pedestal of shaped type. In the center image above, the text flows around the objects described, a nearly too-clever layout perhaps disconcerting to those actually reading the text. At right, a woman standing on a tomb holds a tablet with Hebrew, Greek, and Latin words—real show-off typography for 1499.

The typography of *Hypnerotomachia* is imaginative, confident, and self-conscious. Words run around images, words generate shaped patterns. Now done easily on the computer, such practices have recently produced a lot of annoying designer typography and unread words, as well some beautiful poetic designs, especially for books with modest verbal content.

Hypnerotomachia is lusciously visual, and its 468 pages conjure up ancient architecture, stupendously elaborate gardens, an operatic love story, and 4 parades. Love, landscape, and architecture are described in a lush sensual language of dreamy impossibility. Although 94% of the book consists of text (the remaining 6% images), the words themselves are intensely visual, a thesaurus of fantasized obsessive detail.

All those visual words enrich reading of the woodcuts. Viewed without the adjacent text, the drawings evoke mixed evaluations: heavy-handed, naive, charming, thin, cartoonish. Certainly not Dürer woodcuts or fine art. It is the drawings *together* with the words that make a beautiful book.



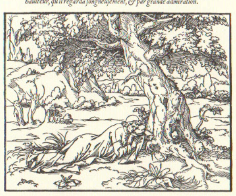
POLIPHILO QVIVI NARRA, CHE GLI PARVE ANCORA DI DORMIRE, ET ALTRONDE IN SOMNO RITROVARSE IN VNA CONVALLE, LAQVALE NEL FINE ERA SERATA DE VNA MIRABILE CLAVSVRA CVM VNA PORTENTOSA PYRAMIDE, DE ADMIRATIONE DIGNA, ET VNO EXCELSO OBELISCO DE SOPRA. LAQVALE CVM DILIGENTIA ET PIACERE SVBTILMENTE LA CONSIDEROE.

LA SPAVENTEVOLE SILVA, ET CONSTIpato Nemore euaſo, & gli primi altri lochi per el dolce ſomno che ſe hauea per le feſſe & proſternate mēbre diffuſo relicti, me ritrouai di nouo in uno piu delectabile ſito aſſai piu che el præcedente. El quale non era de monti horridi, & crepidinoſe rupe intorniato, ne falcato di ſtrumoſi iugi. Ma compoſitamente de grate montagniole di non tropo altecia. Siluoſe di giouani quercioli, di roburi, fraxini & Carpini, & di frondoſi Eſculi, & Ilice, & di teneri Coryli, & di Alni, & di Tilie, & di Opio, & de infructuoſi Oleaſtri, diſpoſiti ſecondo laſpecto de gli arboriferi Colli. Et giu al piano erano grate ſiluule di altri ſiluatici

Hypnerotomachia Poliphili (Venice, 1499), a6'.

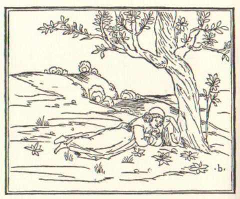
LIVRE PREMIER DE

Poliphile racompte comme il luy fut aduis en ſonge qu'il dormoit, & en dormant ſe trouuoit en une uallee fermée d'une grand cloſture en forme de pyramide, ſur laquelle eſtoit aſſis un obeliſque de merueilleuſe haulteur, qu'il regarda ſongneuſement, & par grande admiration.



LA foreſt eſpouentable aiant eſté par moy paſſée, & apres auoir delaiſſe ceſte premiere region par le doulx ſommeil qui m'auoit lors eſpris, ie me trouuay tout de nouueau en vn lieu beaucoup plus delectable que ie premier, car il eſtoit bordé & enuironné de plaiſans cotaulx verdoians, & peuplez de diuerſes manieres d'arbres, comme cheſnes, faux, planes, ormes, fraiſnes, charmes, tilleulz, & autres, plantez ſelon l'aſpect du lieu. & abas atrauers la plaine, y auoit de petitz buyſſons d'arbriſſeaux ſauluaiges, cōme geneſtz, geneuriers, bruyeres, & tamarins, chargez de fleurs. parmy les prez croiſſoient les herbes medicinales, a ſcauoir les trois conſolides, enule, cheurefeuil, branque vrſine, liueſche, perſil de macedoine, piuoyne, guymauues, plantain, betoyne, & autres ſimples de toutes ſortes & eſpeces, pluſieurs deſquelles m'eſtoient incōgneues. Vn peu plus auant que le mylieu de ceſte plaine, y auoit vne ſablonniere meſlée de petites mottes verdes, & pleine d'herbe menuette, & vn petit boys de palmiers, eſquelz les Egyptiēs cueillent pain, vin, huille, veſtement, & meſrain pour baſtir. leurs fueilles ſembloient lames d'eſpees, & eſtoiēt chargées de fruict. il y en auoit de grandes, moiennes, & petites, & leur ont les anciens donnéce

Hypnerotomachie, ov Discours du songe de Poliphile (Paris, 1546), a3'.



POLIPHILO TELLS THAT HE SEEMED TO SLEEP AGAIN, AND TO FIND HIMSELF SOMEWHERE ELSE IN A DREAM. HE WAS IN A VALLEY, BLOCKED AT THE END BY A MARVELLOUS ENCLOSURE, WITH A MIGHTY AND ADMIRABLE PYRAMID AND A TALL OBELISK ABOVE IT. HE STUDIED THIS CAREFULLY, WITH DILIGENCE AND ENJOYMENT.

LEAVING BEHIND THE TERRIBLE FOREST, the dense woodland and the other previous places, thanks to the sweet sleep that had bathed my tired and prostrate members, I now found myself in a much more agreeable region. It was not hemmed in by dread mountains and cloven rocks, nor encircled by craggy peaks, but by pleasant hills of no great height. These were wooded with young oaks, roburs, ash and hornbeam; with leafy winter-oaks, holm-oaks and tender hazels; with alders, limes, maples and wild olives, disposed according to the aspect of the forested slopes. Even on the plain there were pleasant copses of other wild shrubs and flowering brooms, and

20

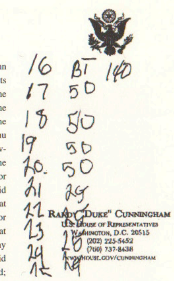
Hypnerotomachia Poliphili: The Strife of Love in a Dream (New York, 1999), 20.

FOR 500 years, the integration of words and images in *Hypnerotomachia* has persisted in most editions. The original edition of 1499 illustrates the beginning of Poliphilo's book-long dream. The elegant French edition of 1546 redid the illustrations and typography (large initial capitals 10 lines deep; chapter summaries placed above the images and set in italics rather than capital letters). At right, in the complete English edition published in 1999, *Hypnerotomachia Poliphili: The Strife of Love in a Dream*, the page layouts and illustrations closely follow the 1499 original. How could words and images not be unified in such a book?

LIKE *Hypnerotomachia*, the legal document excerpted at right integrates text and image in a farcical narrative and thesaurus of grotesque luxury. Government prosecutors, by means of images of incriminating documents and color pictures of the loot (cash, boats, antiques, a "Dream Home"), enumerate the bribes received by a corrupt and acquisitive politician, Randy "Duke" Cunningham. In American courts, the standard format for legal documents yields thin information densities (is productivity measured by the page?) induced by excessively leaded-out type. Here, however, the adroit use of visual evidence intensifies the prosecutorial advocacy, reveals the scope of corruption, and mocks the attempts at evidence fabrication, making the Duke's criminality appear ludicrous and, 507 years later, nearly as fantastical as *Hypnerotomachia Poliphili*.

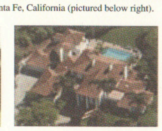
Carol C. Lam, Sanjay B. Bhandari, Jason A. Forge, Phillip L. B. Halpern, "Government Sentencing Memorandum," *United States of America v. Randall Harold Cunningham, aka Randy "Duke" Cunningham*, United States District Court, Southern District of California, March 3, 2006. Redrawn.

In this "bribe menu," the left column represented the millions in government contracts that could be "ordered" from Cunningham. The right column was the amount of the bribes that the Congressman was demanding in exchange for the contracts. For example, Cunningham's menu offered $16 million to Coconspirator No. 2 in government contracts in exchange for the contractor giving up his title to a boat ("BT") for which Coconspirator No. 2 had initially paid $140,000 ("140"). The next four rows indicate that an additional million dollars in funding was "for sale" in exchange for every additional $50,000 that Coconspirator No. 2 was willing to pay Cunningham. Once Coconspirator No. 2 had paid Cunningham $340,000 in bribes, the rates dropped; and, as the final five rows reflect, Cunningham would charge only $25,000 for each additional million dollars that was awarded in additional government contracts.



Between September 2000 and April 2001, this co-conspirator paid $11,116.50 for Cunningham's yacht mortgage. Despite this "purported sale," the yacht remained with Cunningham throughout this entire time period.

Towards the end of July or the beginning of August, Cunningham mentioned to the realtor that because he had a million dollars to spend, perhaps he would simply sell his home at 13832 Mercado Drive in Del Mar for $1.5 million and use the million dollars netted from that sale to purchase a bigger house for himself. Cunningham said that his partner (whom he had identified as Coconspirator No. 2) could simply have an office in Cunningham's bigger home. The next day, the realtor asked Cunningham if she could handle the listing for his Del Mar home. Cunningham replied that he already had a buyer for it. Thereafter, the realtor and Cunningham began looking at a number of homes that Cunningham picked out of a magazine featuring "Dream Homes" in the San Diego area. Cunningham's plan turned out to be to use the profits from the sale of his Del Mar home (pictured below left) to purchase a Spanish style mansion located at 7094 Via Del Charro in Rancho Santa Fe, California (pictured below right).



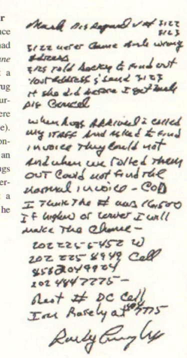
On or about October 28, 2003, Cunningham instructed the realtor to submit an offer on the 7094 Via Del Charro house. Eventually, the Cunninghams and the sellers agreed on a purchase price of $2,550,000.

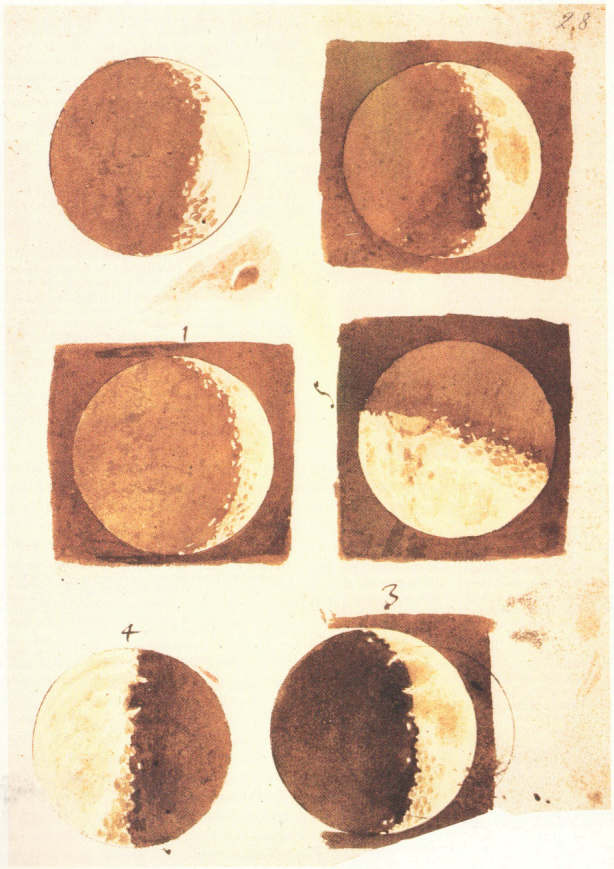
When Cunningham eventually sold the Arlington, Virginia condominium (in August 2004), it was literally stuffed with furniture, including the many antiques and rugs given to Cunningham as bribes. Cunningham shipped all of these items (some of which are pictured below) to his Rancho Santa Fe mansion. Among other things, the shipping manifest that Cunningham signed included: (1) two Bejar Rugs valued at $40,000 a piece; (2) a corner lead glass armoire valued at $5,200; (3) a large lead glass armoire valued at $4,500; (4) a small lead glass armoire valued at $2,700; (5) a china hutch circa 1890 valued at $24,000; (6) two candelabras valued at $1,400; (7)

two smoking tables valued at $2,000; (8) a French lamp shade valued at $3,500; (9) three smoking tables valued at $2,000; (10) cobalt blue lamps valued at $300 a piece; (11) a cut glass floor piece valued at $1,200; (12) a Tiffany statue valued at $2,000; (13) an Erte statue valued at $12,000; (14) four crystal lamps valued at $2,800; (15) a cut glass lamp valued at $2,400; (16) an eagle ceramic valued at $500; (17) three cut glass doors valued at $5,000; (18) glass armoire valued at $5,400; (19) a French bedroom armoire valued at $5,200; (20) three marble top French dressers valued at $12,600; (21) a marble top mirrored vanity valued at $2,200; (22) an antique mirror valued at $1,200; (23) a living room armoire valued at $5,200; (24) a marble top / marble fold shelf valued at $4,200; (25) a hall tree valued at $3,700; (26) small bedroom armoire valued at $2,700; (27) an armoire valued at $3,200; (28) an antique secretary valued at $4,200; (29) two German antique bars valued at $6,400; and (30) two silver candle sticks valued at $5,600.

Fabrication of Evidence – Rug Dealer

Cunningham's attempts to tamper with evidence were not limited to individuals with whom he had a personal relationship. After the *Union-Tribune* story broke in June 2005, Cunningham sent a handwritten note and a $16,500 check to the rug dealer from whom Coconspirator No. 2 had purchased the $15,200 worth of rugs that were shipped to Cunningham in May 2005 (see above). In the note, reproduced at right, Cunningham concocted a story about having looked in vain for an invoice or address to send payment when the rugs arrived at his Escondido office. He then preposterously suggested that he had previously sent a check for the rugs that had been returned because he had the wrong address.





Galileo's Evidence: "The Wonder of the Spectacle and the Accuracy of the Expression"

WHAT *Hypnerotomachia* (1499) is to the design of word-image narrative in fiction, Galileo's *Sidereus Nuncius* [*The Starry Messenger*] (1610) is to nonfiction. Both books describe wonderful new objects and narrate complex events; both weave words and images together in elegant and vivid arrangements. Of course the substance differs: *Hypnerotomachia* is limited because the stuff must be made up; *The Starry Messenger* adds several orders of magnitude to understanding Nature's amazing reality.

In late 1609, Galileo constructed a telescope and soon "made more discoveries that changed the world than anyone has ever made before or since."[5] *The Starry Messenger*, published in March 1610, announced discovery of craters on the moon, a multitude of stars beyond those few seen by unaided eyes, and the 4 satellites of Jupiter. More importantly, the book "told the learned community that a new age had begun and that the universe and the way in which it was studied would never be the same."[6] From then on, theories about the universe had to be tested against the visual evidence of empirical observation. This is the forever idea in Galileo's book. And so armchair speculation, parsing Aristotle and religious doctrine, and philosophizing were no longer good enough. Evidence became decisive in understanding Nature.

Sidereus Nuncius presents its evidence in 78 images and drawings, all tightly integrated within their explanatory text, that cover 30% of the printed area in the book's 60 pages. Galileo observed lunar mountains, plains, craters, earthshine—in a delicate play of light and shadow near the terminator between the illuminated and unilluminated parts of the moon. Galileo made these beautiful ink and watercolor drawings of his observations.[7] Peaks of mountains appear as bright spots on the dark edge of the terminator (see drawing 3, where the lighted mountain peaks extend deep into the dark side). As on Earth, a rising sun catches the tops of higher peaks; and on the bright side of the terminator, shadow and sunlight fill the crater basins.

To depict this level of detail, Galileo personally financed the copper engravings for his images of the moon that appeared in *Sidereus Nuncius*.[8] Engravings were considerably more expensive and difficult to print than woodcuts; also, to combine word and image on the same page, the paper had to pass through two different presses, one to print the type (relief) and another to print the high-resolution engravings (intaglio). These complexities yielded some copies of Galileo's *Starry Messenger* that omit the engravings, causing auction houses 395 years later to note dutifully that their copy at auction is the "issue without the 5 text engravings BUT these supplied in facsimile printed directly on the original leaves . . . an extraordinary hybrid copy."[9]

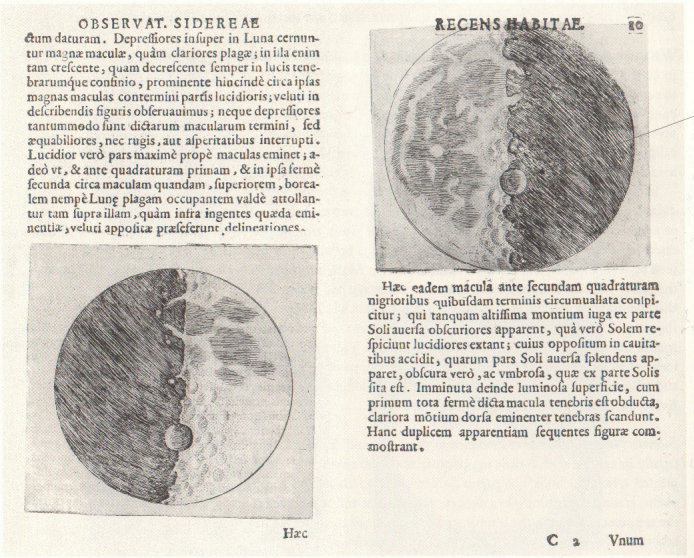
[5] Noel W. Swerdlow, "Galileo's discoveries with the telescope and their evidence for the Copernican theory," in *The Cambridge Companion to Galileo*, ed. Peter Machamer (Cambridge, 1998), 245.

[6] Albert Van Helden, "Preface," *Sidereus Nuncius*, translated by Albert Van Helden (Chicago, 1989), vii.

[7] Source: Biblioteca Nazionale Centrale, Florence. All 6 drawings show bright spots on the terminator's dark edge, as the sun catches the tops of higher peaks. These bright spots can be seen today with >15× stabilized binoculars or telescope.

[8] Detailed accounts of Galileo's 2 books on astronomy are Owen Gingerich and Albert Van Helden, "From *Occhiale* to Printed Page: The Making of Galileo's *Sidereus Nuncius*," *Journal for the History of Astronomy*, 24 (2003), 251-267; and Albert Van Helden and Mary G. Winkler, "Representing the Heavens: Galileo and Visual Astronomy," *Isis*, 83 (1992), 195-217.

[9] Sotheby's New York, *Fine books and Manuscripts*, November 30, 2005, item 44.



OBSERVAT. SIDEREAE

ćum daturam. Depreſſiores inſuper in Luna cernuntur magnæ maculæ, quàm clariores plagæ; in illa enim tam creſcente, quam decreſcente ſemper in lucis tenebrarumque confinio, prominente hinc indè circa ipſas magnas maculas contermini partis lucidioris; veluti in deſcribendis figuris obſeruauimus; neque depreſſiores tantummodo ſunt dictarum macularum termini, ſed æquabiliores, nec rugis, aut aſperitatibus interrupti. Lucidior verò pars maximè propè maculas eminet; adeò vt, & ante quadraturam primam, & in ipſa fermè ſecunda circa maculam quandam, ſuperiorem, borealem nempè Lunæ plagam occupantem valdè attollantur tam ſupra illam, quàm infra ingentes quædā eminentiæ, veluti appoſitæ præſeferunt delineationes.

Hæc

RECENS HABITAE. 10

Hæc eadem macula ante ſecundam quadraturam nigrioribus quibuſdam terminis circumuallata conſpicitur; qui tanquam altiſſima montium iuga ex parte Soli auerſa obſcuriores apparent, quà verò Solem reſpiciunt lucidiores extant; cuius oppoſitum in cauitatibus accidit, quarum pars Soli auerſa ſplendens apparet, obſcura verò, ac vmbroſa, quæ ex parte Solis ſita eſt. Imminuta deinde luminoſa ſuperficie, cum primum tota fermè dicta macula tenebris eſt obducta, clariora mōtium dorſa eminenter tenebras ſcandunt. Hanc duplicem apparentiam ſequentes figuræ commoſtrant.

C 2 Vnum

Sidereus Nuncius presents 5 engraved images of the moon (4 unique and 1 repeat), the first astronomical pictures ever printed. A major scientific finding is that the moon

> [is] not smooth, even, and perfectly spherical, as the great crowd of philosophers have believed about this and other heavenly bodies, but, on the contrary, [is] uneven, rough, and crowded with depressions and bulges. And it is like the face of the Earth itself, which is marked here and there with chains of mountains and depths of valleys.[10]

In 1610 the discovery of such surface irregularities was significant because Aristotle had claimed that all celestial bodies were perfect, smooth, and without blemish (unlike the wretched Earth). This evidence-free fancy had become religious doctrine before being demolished by 10 pages of visual observations reported in *Sidereus Nuncius*. Galileo later questioned why religious faith need depend on the presence or absence of craters on the moon or, indeed, other astronomical observations.

Galileo Galilei, *Sidereus Nuncius* (Venice, 1610), 9V–10R.

[10] *Sidereus Nuncius*, translated by Albert Van Helden (Chicago, 1989), 40.

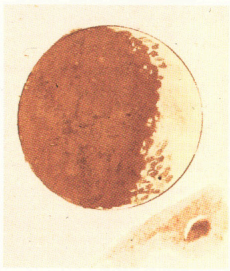
Scholars have compared Galileo's images with modern photographs.[11] The 1610 engravings *qualitatively* picture the actual moon, except the big crater is way too big, a deliberate local enlargement designed to portray operative details of light and shadow. At this huge size in the original pages at left, the crater would have been visible to unaided eyes on the Earth, deterring the smooth-moon doctrine forever. The gigantic generic crater contradicts the rest of the image, a realistic representation of the moon's surface. For presenting evidence about light and shadow, it is far better to show the generic crater in a *separate* image as Galileo did in his original watercolor (here at right), similar to an artist showing an enlarged detail in a sketchbook. Unlike the book engravings, the watercolor images do not place the big generic crater on the moon itself, since the separate callout shows details of light and shadow.

Accompanying the astronomical pictures of *Sidereus Nuncius* is an intensely visual language describing the surface of the moon. Nearly half of that text describes *visual variation over time*, systematic changes in the appearance of the surface resulting from changes in the sun's elevation:

> Not only are the boundaries between light and dark on the Moon perceived to be uneven and sinuous, but, what causes even greater wonder, is that very many bright points appear within the dark part of the Moon, entirely separated and removed from the illuminated region and located no small distance from it. Gradually, after a small period of time, these are increased in size and brightness. Indeed, after 2 or 3 hours they are joined with the rest of the bright part, which has now become larger. In the meantime, more and more bright points light up, as if they are sprouting, in the dark part, grow, and are connected at length with that bright surface as it extends farther in this direction. . . . . [When] the bright surface has decreased in size, as soon as almost this entire spot is covered in darkness, brighter ridges of mountains rise loftily out of the darkness . . . . [Change] of shapes [is] caused by the changing illumination of the Sun's rays as it regards the Moon from different positions . . .[12]

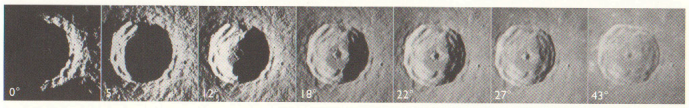
Although Galileo's words describe change, the images are frozen in time. The pictures of *Sidereus Nuncius* present *spatial comparisons* of various craters under the same sunlight, rather than *temporal comparisons* of varying sunlight on the same crater. Below, modern photographs now show the changing appearance of a single crater, as the sun's angle of elevation gradually moves from 0° to 43°. In this fine sequence of 7 images, direct temporal comparisons now make the visual evidence, formerly static, as dynamic as Galileo's eloquent text. Shifting crescents of light play in and out of a crater over time in a narrative of surface and shadow. The lack of a light-scattering atmosphere produces intensely dark Moon shadows.

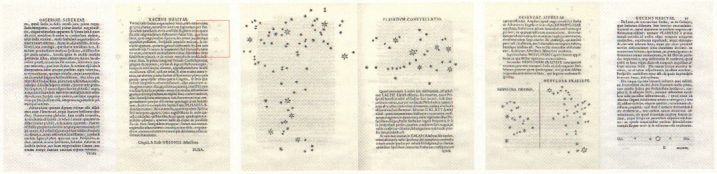
[11] See Ewan A. Whitaker, "Galileo's Lunar Observations and the Dating of the Composition of *Sidereus Nuncius*," *Journal for the History of Astronomy*, 9 (October 1978), 155–179.



[12] *Sidereus Nuncius*, translated by Albert Van Helden (Chicago, 1989), 42, 45, 47.

John E. Westfall, *Atlas of the Lunar Terminator* (Cambridge, 2000), 32; images from the Apollo-15 Mapping Camera.





page 16v *page 1 of insert* *page 2* *(double-page spread of insert)* *page 3* *page 4 of insert* *page 17r*

Galileo Galilei, *Sidereus Nuncius* (Venice, 1610), p. 16v at far left, 17r at far right. In the center, the unpaginated 4-page insert.

A few days before *Sidereus Nuncius* was published in March 1610, Galileo added 4 new unnumbered pages (above in yellow), inserted between pages 16v and 17r. Half text and half image, these pages report the astounding discovery of vast numbers of stars far beyond those seen by unaided eyes. Preparing readers for the images to come, the insert's first page uses words and numbers to announce the findings:

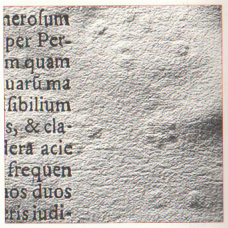
> But in order that you may see one or two illustrations of the almost inconceivable crowd of [stars], and from their example form a judgment about the rest of [the stars], I decided to reproduce two star groups. In the first I had decided to depict the entire constellation of Orion . . . . there are more than five hundred new stars around the old ones, spread over a space of 1 or 2 degrees. . . .[To] the three in Orion's belt and the six in his sword that were observed long ago, I have added eighty others seen recently, and I have retained their separations as accurately as possible. . . . In the second example we have depicted the six stars of the Bull called the Pleiades. . . . Near these lie more than forty other invisible stars, none of which is farther removed from the aforementioned six than scarcely half a degree. We have marked down only thirty-six of these, preserving their mutual distances, sizes, and the distinction between old and new ones, as in the case of Orion.[13]

Then a glorious double-page layout *shows* the evidence. Reproduced above in the context of surrounding material and on our righthand page at medium size (and at original size to follow), this triumph of scientific discovery *and* of information design depicts the visible stars of brighter magnitude ✲ seen by unaided eyes for centuries, as well as innumerable "invisible stars" now seen by the telescope ⁎ ⁎ ✲. Symbolizing the cosmic vastness, printed stars flow into the margins and then off the pages into an unbounded void, breaking out of the book's typographic grid (for Nature is nowhere rectangular) and breaking the limits of past knowledge.

A ghostly word-impression lurks in the background of these 2 starry pages, as the rectangular typographic grids of words show through from opposite sides of the not entirely opaque paper. Show-through goes both ways: on the insert's first page, the stars printed on its backside push the paper up, making little braille-like bumps that anticipate the sky map about to appear. These star bumps, a byproduct of letterpress printing of isolated elements (such as page numbers or stars) that tend to punch through, are shown at near right.[14] The raking light and consequent shadows are similar to, say, the play of sunlight on lunar mountains.

[13] *Sidereus Nuncius*, translated by Albert Van Helden (Chicago, 1989), 59–62.

[14] On the first page of the insert (above left), a red box locates the enlarged detail below:

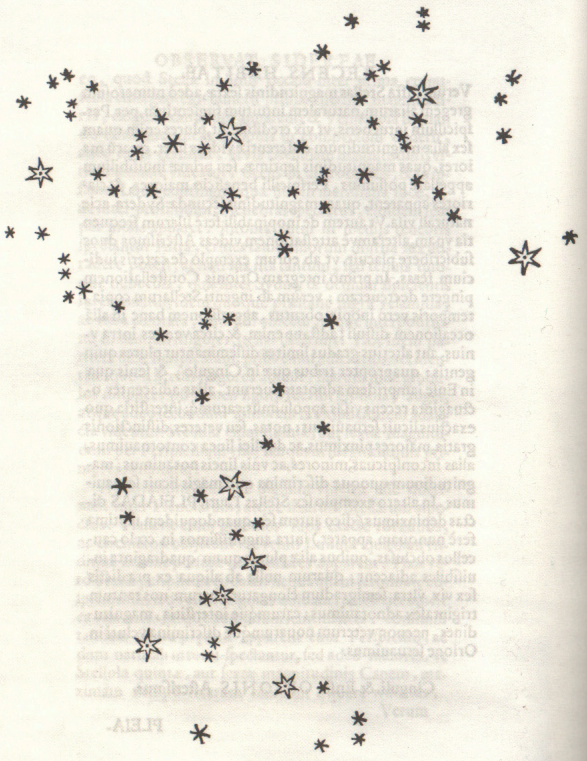


Galileo Galilei, *Sidereus Nuncius* (Venice, 1610), middle 2 pages of the unpaginated 4-page insert between pages 16v and 17r. Color added.

Describing the innumerable stars, Galileo distinguishes between word and image in reasoning about celestial objects. Before 1610 astronomy had largely been verbal gymnastics, speculation, philosophizing, disputation. In contrast, these new telescopic images are the direct, visible, decisive testimony of Nature herself. In the Latin text accompanying the stars scattered across the pages, Galileo makes the key link between empirical observation and credibility with the phrase "visible certainty," oculata certitudine. And that is the grand, forever consequence of *Sidereus Nuncius*: from then on, all science, to be credible, had to be based on publicly displayed evidence of seeing and reasoning, and not merely on wordy arguments. Galileo wrote:

> What was observed by us in the third place is the nature or matter of the Milky Way itself, which, with the aid of the spyglass, may be observed so well that all the disputes that for so many generations have vexed philosophers are destroyed by visible certainty, and we are liberated from wordy arguments. For the Galaxy is nothing else than a congeries of innumerable stars distributed in clusters. To whatever region you direct your spyglass, an immense number of stars immediately offer themselves to view, of which very many appear rather large and very conspicuous but the multitude of small ones is truly unfathomable.
>
> And since that milky luster, like whitish clouds, is seen not only in the Milky Way, but dispersed through the ether, many similarly colored patches shine weakly; if you direct a glass to any of them, you will meet with a dense crowd of stars.[15]

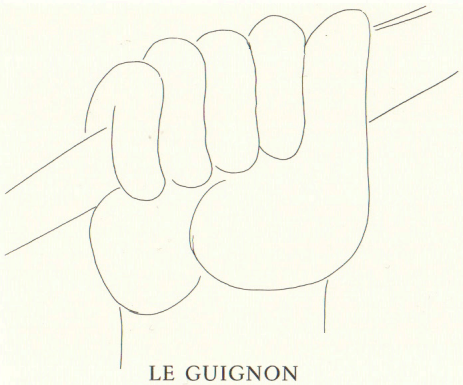
[15] *Sidereus Nuncius*, translated by Albert Van Helden (Chicago, 1989), 62.



PLEIADVM CONSTELLATIO.

Quòd tertio loco à nobis fuit obſeruatum, eſt ipſiuſmet LACTEI Circuli eſſentia, ſeu materies, quam Perſpicilli beneficio adeò ad ſenſum licet intueri, vt & altercationes omnes, quæ per tot ſæcula Philoſophos excruciarunt ab oculata certitudine dirimantur, nosque à verboſis diſputationibus liberemur. Eſt enim GALAXYA nihil aliud, quam innumerarum Stellarum coaceruatim conſitarum congeries; in quamcunq; enim regionem illius Perſpicillum dirigas, ſtatim Stellarum ingens frequentia ſe ſe in conſpectum profert, quarum complures ſatis magnæ, ac valde conſpicuæ videntur; ſed exiguarum multitudo prorſus inexplorabilis eſt.

At cum non tantum in GALAXYA lacteus ille candor, veluti albicantis nubis ſpectetur, ſed complures conſimilis coloris areolæ ſparſim per æthera ſubfulgeant, ſi in illarum quamlibet Specillum conuertas Stellarum conſtipatarum cętum



LE GUIGNON

Au-dessus du bêtail ahuri des humains
Bondissaient en clartés les sauvages crinières
Des mendieurs d'azur le pied dans nos chemins.

Un noir vent sur leur marche ployé pour bannières
La flagellait de froid tel jusque dans la chair,
Qu'il y creusait aussi d'irritables ornières.

This double-page spread is from Henri Matisse's *Poésies*, one of the finest artists' books of the 20th-century. Like Galileo's page layout in *The Starry Messenger* showing the innumerable stars, the Matisse drawings break out of the typographic grid. As Matisse wrote: "The design fills the unmargined page, for the design is not, as usual, massed toward the center, but radiating over the whole sheet. The problem was then to balance the two pages—one white, that of the etching, and one relatively black, that of the typography. I obtained my result by modifying my arabesque so that the attention of the spectator would be drawn again to the white page as much as to the promise of reading the text." This parallelism of Galileo and Matisse reflects the one deep communality of science and art: to show the results of intense seeing.

After describing the innumerable stars, *Sidereus Nuncius* then reports the discovery of Jupiter's 4 satellites. Published data begin January 7 and conclude March 2, 1610, just 10 days before the book came off the press. Early March was a busy time for Galileo and the woodcut artist, copper engraver, typesetter, and printer—as they quickly produced 550 copies of their book, which immediately sold out.

A visual/verbal narrative presents the evidence: sequential images of Jupiter (the capital letter ○) and the moons (∗ ∗ ∗ ∗) accompanied by words that record the time and date of observation, estimated distances of the moons from Jupiter, and Galileo's reasoning. An original page in Latin from *Sidereus Nuncius* is shown below at left, with a translation at right. This narrative sequence, a detective story of discovery, resembles a handwritten notebook that completely integrates words, drawings, data. Enormous detail is provided in 24 pages showing 65 annotated little drawings of Jupiter and its satellites; every image is introduced by text

Illustration, previous page: Henri Matisse, etchings for "Le Gaugnon" in Stéphane Mallarmé, *Poésies* (Lausanne, 1932), 8–9. Henri Matisse, "Comment j'ai fait mes livres," in Albert Skira, *Anthologie du livre illustré par les peintres et sculpteurs de l'école de Paris* (Geneva, 1946), in Philip Hofer and Eleanor M. Garvey, *The Artist and the Book 1860-1960* (Boston, 1961), 138.

At left, Galileo Galilei, *Sidereus Nuncius* (Venice, 1610), 18v; at right, *Sidereus Nuncius*, translated by Albert Van Helden (Chicago, 1989), 67–68.

OBSERVAT. SIDEREAE

Ori. ∗ ∗○ ∗ Occ.

Stella occidentaliori maior, ambæ tamen valdè conſpicuæ, ac ſplendidæ: vtra quæ diſtabat à Ioue ſcrupulis primis duobus; tertia quoque Stellula apparere cepit hora tertia prius minimè conſpecta, quæ ex parte orientali Iouem ferè tangebat, eratque admodum exigua. Omnes fuerunt in eadem recta, & ſecundum Ecliptícæ longitudinem coordinatæ.

Die decimatertia primum à me quatuor conſpectæ fuerunt Stellulæ in hac ad Iouem conſtitutione. Erant tres occidentales, & vna orientalis; lineam proximè

Ori. ∗ ○∗∗ Occ.

rectam conſtituebant; media enim occidétalium paululum à recta Septentrionem verſus deflectebat. Aberat orientalior à Ioue minuta duo: reliquarum, & Iouis intercapedines erant ſingulæ vnius tantum minuti. Stellæ omnes eandem præ ſe ferebant magnitudinem; ac licet exiguam, luciditſſimæ tamen erant, ac fixis eiuſdem magnitudinis longe ſplendidiores.

Die decimaquarta nubiloſa fuit tempeſtas.

Die decimaquinta, hora noctis tertia in proximè depicta fuerunt habitudine quatuor Stellæ ad Iouem;

Ori. ○ · ∗ ∗ ∗ Occ.

occidentales omnes: ac in eadem proxim recta linea diſpoſitæ; quæ enim tertia à Ioue numerabatur paululum

Thus, on the twelfth, at the first hour of the following night, I saw the stars arranged in this manner. The more

East ∗ ∗○ ∗ West

eastern star was larger than the western one, but both were very conspicuous and bright. Both were two minutes distant from Jupiter. In the third hour a third little star, not at all seen earlier, also began to appear. This almost touched Jupiter on the eastern side and was very small. All were in the same straight line and aligned along the ecliptic.

On the thirteenth, for the first time four little stars were seen by me in this formation with respect to Jupiter. Three were on the west and one on the east. They formed a very nearly straight line, but the middle star of the

East ∗ ○∗∗ West

western ones was displaced a little to the north from the straight line. The more eastern one was 2 minutes distant from Jupiter; the intervals between the remaining ones and Jupiter were only 1 minute. All these stars displayed the same size, and although small they were nevertheless very brilliant and much brighter than fixed stars of the same size.

On the fourteenth, the weather was cloudy.

On the fifteenth, in the third hour of the night, the four stars were positioned with respect to Jupiter as shown

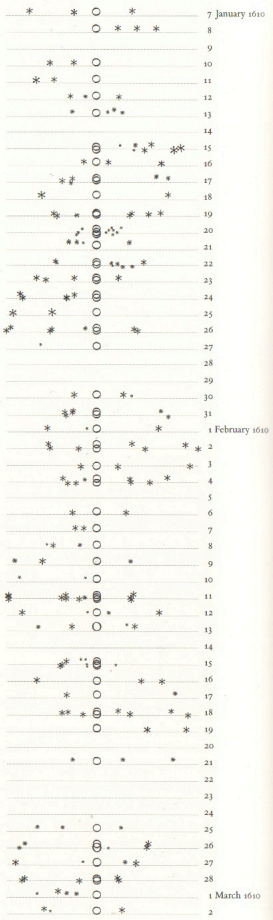
East ○ · ∗ ∗ ∗ West

in the next figure. They were all to the west and arranged very nearly in a straight line, except that the third one from Jupiter was raised a little bit to the north.

Galileo Galilei, *Sidereus Nuncius* (Venice, 1610), 17R–28R.

describing how the satellites changed position over the hours and days. Shown in full above, this lengthy, detailed, enthusiastic narrative adds up—on and on and on—to a convincing, overwhelming scientific presentation.

Nonetheless 24 consecutive pages of 65 annotated observations break the visual evidence up into stupefying fragments. Although an excellent design for a diary of discovery, this sequential text/image arrangement is not good for Jupiter. Barricades of words disrupt the visual continuity of the evidence. How might the evidence of *Sidereus Nuncius* be redesigned to show the swift and elegant motion of the Galilean satellites?



At right, this redesign brings together all 65 of Galileo's published observations of Jupiter and its satellites that we saw earlier. When the intervening text is omitted, the visual evidence becomes adjacent, linked, sequential, moving. No longer a choppy series of 65 little anecdotes spread over 24 pages, the observations flow more or less continuously. This graph provides the first evidence of the "corkscrew" structure that lay behind the nightly movements of the points of light of Jupiter's moons observed by Galileo.

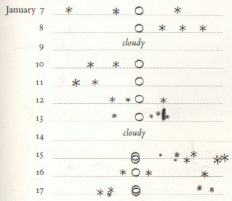
The nightly images are properly located relative to one another, placed on a vertical time-scale showing the date and hour of observation. The capital letter ○ representing Jupiter is now scaled down to its correct relative size (to the diameter of the orbit of the outer satellite) from the over-large original in *Sidereus Nuncius*. Some nights have no data; the gap near the top of the chart, for example, indicates that it was a cloudy evening in Padua on January 9, 1610. Overlapping Jupiters ⦵ show multiple viewings made by Galileo during a single night; the changing positions of the moons can be detected hour by hour.

Jupiter and its satellites reside in 4 dimensions: 3-space and the 4th dimension of time. Yet in the graph at right, as in nearly all displays of the motion of Jupiter's satellites, the 3 spatial dimensions are compressed into one-dimensional lineland. Then these linelands are stacked in time, which flows downward instead of the customary left-to-right. This curious and imaginative design is the direct consequence of the special arrangement of Jupiter and its satellites, all of which revolve in nearly the *same* orbital plane as Earth and the other planets. Thus we see the orbits approximately on edge, parallel to the ecliptic, as the points of light of Jupiter's satellites appear to move back and forth along a straight line. This stack of linelands is an unconventional design; usually in plotting data with strong periodicities, time flows horizontally from left to right. The arrangement here, however, elegantly reflects the nightly views seen through the telescope and recorded sequentially in a scientific notebook.

These 2 different presentations—the original verbal/visual diary of discovery *and* this new graphic of stacked observations at right—tell the story of Jupiter's satellites. *Both arrangements are necessary to analyze the evidence*; each independently contributes to understanding the satellites.

Assorted views of the same underlying data are often helpful. Multiple portrayals may reveal multiple stories, or demonstrate that inferences are coherent, or that findings survive various looks at the evidence in a kind of internal replication. Both Galileo's diary of discovery and the stacked lineland sequence here use the same 65 images—a repetition of data, but not design, which yields new knowledge and enhances the credibility of both images. Graphical displays used in scientific reports and exploratory data analysis should not be afraid to repeat themselves, and to play some visual variations around the main evidence.

Still another redesign serves to combine Galileo's verbal narrative of discovery and the 65 little images by replacing the original *serial* arrangement of text/image/text/image/text . . . with *parallel* sequences of words and images now moving together night after night. Below, in this parallel design, words from Galileo's diary (compressed and paraphrased) annotate each observation during the first 11 days of observation:



With my new telescope, I saw 3 stars around Jupiter in a straight line parallel to the ecliptic.
Provoked by curiosity, tonight I viewed Jupiter again; now 3 stars were all west of Jupiter.
Unfortunately tonight the sky was covered everywhere with clouds.
Only 2 stars, to the east! Is a third hiding behind Jupiter? Jupiter can't move that fast; thus the stars must move.
It appears that 3 stars wander around Jupiter, like Venus and Mercury around the Sun.
As I watched, a third star appeared nearest to Jupiter. All 3 little stars were straight on the ecliptic.
For the first time I saw 4 separate stars near Jupiter. The eastern star was 2 minutes from Jupiter, and the 3 other stars apart at about 1 minute intervals. But now, on the 14th, the weather was cloudy.
About 3 hours after sunset, 4 stars appeared; at 7 hours after, only 3 were in the same straight line.
Then 2 stars appeared within a distance of 40 seconds of Jupiter with 1 star 8 minutes from J in the west.
Again 2 stars; 4 hours later another emerged, which, I suspect, had been united with the first one.

For the *Starry Messenger*, with its tone and velocity of a news report, the pages were quickly produced by following the layout of Galileo's hand-written scientific journals. In his journals and letters, and thus in his book, Galileo makes no distinction among words, diagrams, images. Evidence is evidence. The similar treatment of text, diagrams, and images suggests to readers that images are as relevant and credible as words and diagrams. A book design that treats all modes of information alike reinforces the point. Galileo's images of course earned specific credibility for substantive reasons: their precise detail and sheer number, their depiction of Jupiter's moons in systematic motion, their narrative of discovery of an intriguing reality beyond imagination. This evidence was contested by a critic who proposed an alternative explanation: the images might simply be optical illusions induced by the telescope rather than actual satellites moving. In response, a characteristically sharp and sardonic Galileo offered a large reward to anyone who could construct a telescope that would create illusory satellites around one planet but not others![16]

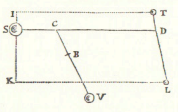
[16] *Le Opere di Galileo Galilei*, edited by Antonio Favaro (Florence, 1890–1909, 1964–1966), volume XI, 107, as cited by Stillman Drake, *Galileo At Work: His Scientific Biography* (Chicago, 1978), 166.

After Galileo, Newton. In 1687 Isaac Newton published the *Principia*, or the *Mathematical Principles of Natural Philosophy*. At the beginning of the book, Edmund Halley wrote a celebratory ode on this "Mathematico-Physical Treatise," which included this Galilean echo:

The things that so often vexed the minds of the ancient philosophers
And fruitlessly disturb the schools with noisy debate
We see right before our eyes, since mathematics drives away the cloud.

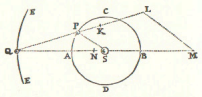
tum D ob proportionales CS, CD describet Ellipsin confimilem, e regione. Corpora autem T & L viribus motricibus $SD \times T$ & $SD \times L$, (prius priore, posterius posteriore) æqualiter & secundum lineas parallelas TI & LK (ut dictum est) attracta, pergent (per Legum Corollarium quintum & sextum) circa centrum mobile D Ellipses suas describendo, ut prius. Q. E. I.

Addatur jam corpus quartum V, & simili argumento concludetur hoc & punctum C Ellipses circa omnium commune centrum gravitatis B describere; manentibus motibus priorum corporum T, L & S circa centra D & C, sed paulo acceleratis. Et eadem methodo corpora plura adjungere licebit. Q. E. I.



Hæc ita se habent ubi corpora T & L trahunt se mutuo viribus acceleratricibus majoribus vel minoribus quam trahunt corpotur: sitq; major semper ubi trium commune illud centrum, minuendo motum corporis S, moveri incipit & magis deinceps magisq; agitatur.

Corol. Et hinc si corpora plura minora revolvantur circa maximum, colligere licet quod Orbitæ descriptæ propius accedent ad Ellipticas, & arearum descriptiones fient magis æquabiles, si corpora omnia viribus acceleratricibus, quæ sunt ut eorum vires absolutæ directe & quadrata distantiarum inverse, se mutuo trahent agitentq;, & Orbitæ cujusq; umbilicus collocetur in communi centro gravitatis corporum omnium interiorum (nimirum umbilicus Orbitæ primæ & intimæ in centro gravitatis corporis maximi & intimi; ille Orbitæ secundæ, in communi centro gravitatis corporum duorum intimorum; iste



Isaac Newton, *Principia* (London, 1687), illustrations at 170, 189.

NEWTON'S *Principia* (1687) integrates hundreds of physics diagrams so as to fall properly in the text. This serves the convenience and understanding of readers, who can view a diagram and its relevant text together. The first edition helpfully repeats the *same* diagram (above right) in position on 4 double-page layouts and, in the third edition, on 7 consecutive layouts. This technique of relevant repetition was also used (with 11 repeats) in the first edition of Descartes' *Principia* (1644).

This fine integration of text and image in Newton's *Principia* resulted because (1) the book was printed in relief, so words and woodcut images printed simultaneously in one pass through the press; (2) the excellent Edmund Halley, an intensely visual scientist and cartographer, financed the publication and watched over the process of book production along with Newton. In this collaboration of two very bright, content-oriented book designers, Halley wrote to Newton on June 29, 1686:

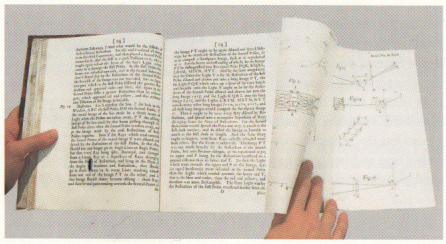
> Now you approve of the Character and Paper, I will push on the Edition Vigorously. I have sometimes had thoughts of having the Cutts neatly done in Wood, so as to stand in the page, with the demonstrations, it will be more convenient, and not much more charge, if it please you to have it so, I will trie how well it can be done . . .

Newton replied on July 14, 1686:

> I have considered your proposal about wooden cuts & beleive it will be much convenienter for ye Reader & may be sufficiently handsome.[17]

[17] *The Correspondence of Isaac Newton*, 7 volumes edited by H. W. Turbull, J. F. Scott, A. Rupert Hall, Laura Tilling (Cambridge, 1959-1977), letters 289 and 290, quotations at pages 443, 444.

NEITHER Halley nor woodcuts, however, were deployed in publication of Newton's *Optics* (1704), a book reporting fundamental discoveries: interference effects, the color composition of sunlight, Newton's rings, and design of the Newtonian reflector telescope still used to this day. All, indeed, rather visual topics; one-third of Newton's text directly addresses 55 diagrams that show light in action. Troubles began when *the diagrams were printed as free-standing engravings, completely separate from the text.*

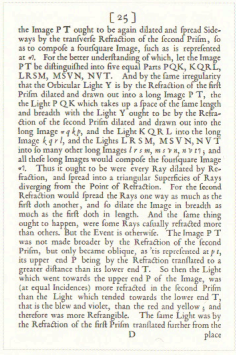


Isaac Newton, *Opticks: or, A Treatise of the Reflections, Refractions, Inflections, and Colours of Light* (London, 1704), at left pages 24-25 with the flaps "Book I. Plate I. Part I., Fig. 2., Fig. 3., Fig. 5., Fig. 7."and "Book I. Plate III. Part I., Fig. 13., Fig. 14., Fig. 15., Fig. 16." Below, page 25.

Newton's 55 original drawings were sent to an engraver, who ganged and printed them on 12 pages of flaps bound into 4 clusters variously inserted into the book. Each cluster opens out sideways and dangles from the book, as shown above. All this printing and binding yields an ingenious but contraptionary collation of *Opticks*:

> 80 pages of pure text, followed by 5 dangling flaps with 29 ganged figures
> 84 pages of pure text, followed by 4 dangling flaps with 16 ganged figures
> 48 pages of pure text, followed by 2 dangling flaps with 7 ganged figures
> 90 pages of pure text, followed by 1 dangling flap with 3 ganged figures.

To link some text to some distant flap diagram requires 5 hierarchical levels of flap label codes. For example, the phrase "Prism DEGdeg" in the text is illustrated elsewhere on the flap page with the address "Book I. Part II. Plate IV. Fig. 16," where the visual version of "Prism DEGdeg" unhappily resides. The first 80 text pages of *Opticks* contain 6,300 letter-codes (at right, a grim sample) that refer to illustrations stashed away after page 80. To read the book requires an enormous back and forth between the text and the enflapped diagrams, between a book of words and 4 parallel booklets of illustrations. This is a competent design for comparing or admiring diagrams, or handwaving over a famous book by Newton, but a poor design for learning about light and optics.



[25]

the Image P T ought to be again dilated and ſpread Sideways by the tranſverſe Refraction of the ſecond Prism, ſo as to compoſe a fourſquare Image, ſuch as is repreſented at *vt*. For the better underſtanding of which, let the Image P T be diſtinguiſhed into five equal Parts PQK, KQRL, LRSM, MSVN, NVT. And by the ſame irregularity that the Orbicular Light Y is by the Refraction of the firſt Priſm dilated and drawn out into a long Image P T, the the Light P Q K which takes up a ſpace of the ſame length and breadth with the Light Y ought to be by the Refraction of the ſecond Priſm dilated and drawn out into the long Image *v q k p*, and the Light K Q R L into the long Image *k q r l*, and the Lights L R S M, M S V N, N V T into ſo many other long Images *l r s m*, *m s v n*, *n v t s*; and all theſe long Images would compoſe the fourſquare Image *vt*. Thus it ought to be were every Ray dilated by Refraction, and ſpread into a triangular Superficies of Rays diverging from the Point of Refraction. For the ſecond Refraction would ſpread the Rays one way as much as the firſt doth another, and ſo dilate the Image in breadth as much as the firſt doth in length. And the ſame thing ought to happen, were ſome Rays caſually refracted more than others. But the Event is otherwiſe. The Image P T was not made broader by the Refraction of the ſecond Priſm, but only became oblique, as 'tis repreſented at *p t*, its upper end P being by the Refraction tranſlated to a greater diſtance than its lower end T. So then the Light which went towards the upper end P of the Image, was (at equal Incidences) more refracted in the ſecond Priſm than the Light which tended towards the lower end T, that is the blew and violet, than the red and yellow; and therefore was more Refrangible. The ſame Light was by the Refraction of the firſt Priſm tranſlated further from the

D place

Ganged and segregated engravings have proved convenient to certain nonreaders. A common fate of separate pages of engravings in old books has been for some dealers in antiquarian prints to slice the engravings out of the original book, frame them, and sell them off—in the ultimate segregation of image and text. It is fine to appreciate physics drawings as art objects. It is even finer to know what they mean and who thought them up, and to keep the relevant images with the relevant words forever.

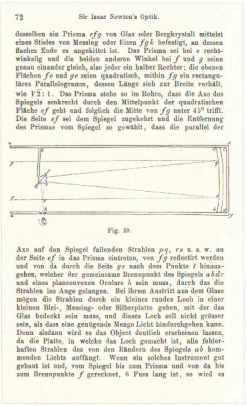
For Newton's *Opticks*, bureaucracies of presentation and mechanical reproduction corrupted the understanding of the content. You're lucky if they don't.

THIS big table reports the dreary history of text/image segregation for the 23 editions in 5 languages of Newton's *Opticks* published since 1704. Several of these books are elegant examples of fine printing, others are heavy-handed. Nearly all are quite difficult to read, since only 2 of the 23 editions completely integrate Newton's images with his words! To top it off, a 1964 volume stuffed the 55 images into a little pocket attached to the inside back cover. Nearly all the 23 published editions of *Opticks* can only be admired, for they can hardly be understood.

With 19th-century lithography allowing text and image to be simultaneously printed on the same page, publishers finally produced integrated editions of *Opticks* in 1898, 1931, and 1952. At right, Newton's words and images are together for the first time, 194 years late, on a page reporting the invention of the Newtonian telescope. But, as our table shows, the ghost of the original segregation haunts the 5 most recent versions, including an elegant digital reproduction that first replicates and then multiplies all the problems of the original Opticks.

Few editors, translators, and publishers of *Opticks* overcame the segregation of word and image that started in 1704; nearly all appear unaware of the inherently visual and explanatory quality of the content. The initial book design tends to persist, whether good (*Hypnerotomachia*) or bad (*Opticks*). It is worthwhile to get the original right.

If Newton's great work can be disrupted and rendered substantially incoherent by the technologies of reproduction for some 300 years, then no work with visual elements is safe.



72 Sir Isaac Newton's Optik.

desselben ein Prisma *efg* von Glas oder Bergkrystall mittelst eines Stieles von Messing oder Eisen *fgk* befestigt, an dessen flachen Ende es angekittet ist. Das Prisma sei bei *e* rechtwinklig und die beiden anderen Winkel bei *f* und *g* seien genau einander gleich, also jeder ein halber Rechter; die obenen Flächen *fe* und *ge* seien quadratisch, mithin *fg* ein rechangeläres Parallelogramm, dessen Länge sich zur Breite verhält, wie 17:1. Das Prisma stehe so im Rohre, dass die Axe des Spiegels senkrecht durch den Mittelpunkt der quadratischen Fläche *ef* geht und folglich die Mitte von *fg* unter 45° trifft. Die Seite *ef* sei dem Spiegel zugekehrt und die Entfernung des Prismas vom Spiegel so gewählt, dass die parallel der

Fig. 29.

Axe auf den Spiegel fallenden Strahlen *pq*, *rs* u. s. w. an der Seite *ef* in das Prisma eintreten, von *fg* reflectirt werden und von da durch die Seite *ge* nach dem Punkte *t* hinausgehen, welcher der gemeinsame Brennpunkt des Spiegels *abd* und eines planconvexen Oculars *h* sein muss, durch das die Strahlen ins Auge gelangen. Bei ihrem Austritt aus dem Glase mögen die Strahlen durch ein kleines rundes Loch in einer kleinen Blei-, Messing- oder Silberplatte gehen, mit der das Glas bedeckt sein muss, und dieses Loch soll nicht grösser sein, als dass eine genügende Menge Licht hindurchgehen kann. Denn alsdann wird es das Object deutlich erscheinen lassen, da die Platte, in welche das Loch gemacht ist, alle fehlerhaften Strahlen des von den Rändern des Spiegels *ab* kommenden Lichts auffängt. Wenn ein solches Instrument gut gebaut ist und, vom Spiegel bis zum Prisma und von da bis zum Brennpunkte *f* gerechnet, 6 Fuss lang ist, so wird es

Sir Isaac Newton's Optik, oder Abhandlung über Spiegelungen, Brechungen, Beugungen und Farben des Lichts, translated by William Abendroth (Leipzig, 1898), 72.

A dismal history: Text and image in the 23 published editions, from 1704 to 1998,
Isaac Newton, *Opticks: or, A Treatise of the Reflections, Refractions, Inflections, and Colours of Light*

EDITIONS	TEXT AND IMAGE: INTEGRATED OR SEGREGATED?
First English edition (London, 1704)	**Segregated.** 12 fold-out flaps show 55 figures. These flaps are grouped in 4 clusters, and each flap-cluster is bound into the book at the end of each of the 4 sections of *Opticks*. This format was used in most editions of *Opticks* for the next 300 years.
First Latin edition (London, 1706)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures.
Second English edition (London, 1717)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures.
Second Latin edition (London, 1719)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures.
First French edition (Amsterdam, 1720)	**Segregated in a new way, even more.** All figures placed at *back* of book, where 12 fold-out flaps show 55 figures. Now the illustrations are even further from their text.
Third English edition (London, 1721)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures.
Second French edition (Paris, 1722)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures. Each of the 4 sections begins with a new, identical engraving of one of Newton's experiments. This the most beautifully designed and printed of all editions of *Opticks*, but just as disorganized.

Text and image in Newton's *Opticks* (dismal table continued)

EDITIONS	TEXT AND IMAGE: INTEGRATED OR SEGREGATED?
Fourth ("deathbed") English edition (London, 1730)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures. Newton made changes in this edition shortly before his death.
Third Latin edition (Lausanne, 1740)	**Segregated even more.** All figures at *back* of book, 12 fold-out flaps show 55 figures.
Latin edition (Graz, 1747) Latin edition (Padua, 1749) Latin edition (Padua, 1773)	**Segregated in a different way.** For all 3 of these Latin editions, 40 plates are at the end of the book. The first 28 plates are from earlier works on optics by Newton bound in the same volume; the last 12 plates show the usual 55 figures for *Opticks*.
Collected works, *Isaaci Newtoni opera quae exstant omnia*, ed. S. Horsley (London, 1779–1785), 5 volumes	**Segregated in still another way.** All figures placed at end of text of *Opticks*, where 12 pages show 55 figures. These drawings are no longer on fold-out flaps, so it is nearly impossible to view the figures and text simultaneously. These are *the collected works*, volumes that should celebrate rather than dismantle Newton's thought.
Third French edition (Paris, 1787)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures.
First German edition (Leipzig, 1898), 2 volumes	**Completely integrated!** All figures are correctly placed with their accompanying text throughout the 2 volumes of the German translation. Text often fitted around figures. This is the first edition in any language to combine Newton's words and images, 194 years after *Opticks* was first published. Sample page shown at far upper left.
Reprint of fourth English edition of 1730 (London, 1931); this in turn reprinted in paperback (New York: Dover, 1952, in print as of 2006)	**Partly integrated.** 28 figures are placed with their accompanying text; the remaining 27 figures are alas turned sideways (for rotating readers) and placed on separate pages within 1 to 5 pages of their textual reference. Sometimes awkward and inconvenient, but the only in-print edition for reading Newton. Introduction by Albert Einstein.
Reprint of second English edition 1717 (Chicago, 1952)	**Completely integrated!** At last, in English, all of Newton's words and images brought together. All figures are appropriately placed with their accompanying text. Published as volume 34, *The Great Books of the Western World*, of all places. It took 248 years to combine word and image in the original English.
Reprint of second French edition (Paris, 1955)	**Segregated.** Grouped in 4 clusters, 12 fold-out flaps show 55 figures.
Reprint edition of Newton's collected works, edited by S. Horsley, 1779–1785 (Stuttgart-Bad Cannstatt, 1964), 5 volumes	**Segregated in another way.** Newton's 55 illustrations are reproduced on 12 separate folded sheets stuffed into a pocket affixed to the inside back cover. A jumble, making for extremely awkward, inconvenient reading.
Reprint of first English edition of 1704 (Brussels, 1966)	**Segregated in a new way.** The 12 plates, usually folded and placed in clusters at end of the 4 sections of *Opticks* have now been redistributed throughout the book, placing some figures closer to the accompanying text; many figures, however, are 5 to 10 pages arbitrarily distant from their text. In this edition, the plates are no longer mounted on fold-out flaps, making it impossible to view the figures and text simultaneously.
First Romanian edition (Bucharest, 1970)	**Segregated.** All figures placed at end.
Digital reproduction for computer, high-resolution photographs of first edition of 1704 (Oakland, California: Octavo, 1998)	**Segregated in the newest way.** As usual, words and images are separated, but now we're on the computer: 4 clusters of 12 plates show 55 figures. Integrating words and images on the screen demands complex efforts by computer users; it is perhaps easier to read through nearly any printed edition, even those segregating text and image. In an inexpensive format, this superb digital reproduction does provide a good sense of the character of the very rare first edition of Newton's *Opticks*.

RECENTLY some book publishers have required authors to place their images but not their text on the internet. Segregation of text and image requires text/image linkage codes of the sort that we saw in *Opticks*—"Book I. Part II. Plate IV. Fig. 16. Prism DEGdeg."[18] Modern graphic designers, buttressed by semiotics mumbo-jumbo and compromised by commercial expediency, have styled new linkage systems that have proved as inconvenient and annoying as those of the 1704 *Opticks*. Here is a sandwich collation for a modern designer field guide to the weather:

176 pages of black-only type and a few diagrams printed on bible paper
96 pages of color pictures each with a few words printed on glossy paper
212 pages of black-only type and a few diagrams printed on bible paper

Icon-symbol thumbtabs then link up the segregated words and images. All this stuff turns into a Book Operating System, which requires 570 words of preposterous documentation. A sample:

20 How to Use This Guide

Example 2
A small funnel forming at the base of a cloud

You are visiting friends in Kansas who live just a few miles from your house, and you have heard on the radio that a tornado watch has been issued. You scan the sky and notice that a small funnel has formed at the base of a thick thunderstorm cloud overhead.

1. Turn to the Thumb Tab Guide. There you find a vortex-shaped silhouette, standing for the group Tornadoes and Other Whirls. The symbol refers you to the color plates 207–230.
2. You look at the color plates and quickly surmise that the funnel shape in the sky overhead may be the beginning stage of a tornado. The captions refer you to the text on pages 511–522.
3. Reading the text, you become convinced that there is a tornado forming. You and your friends immediately seek the storm shelter and wait for the threat to pass.

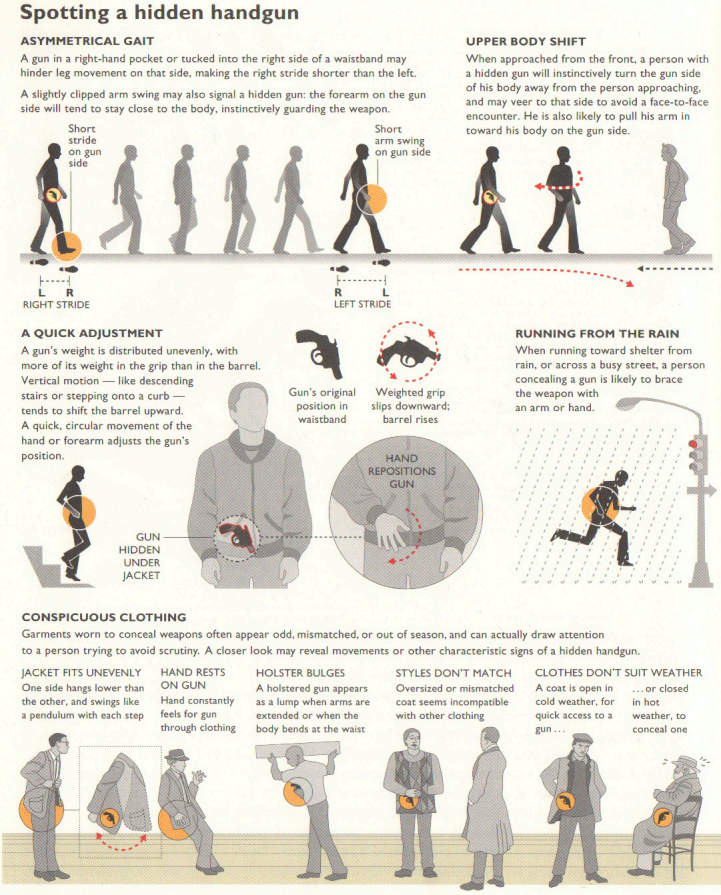
Following an Icon Learning Experience, readers must search for 3 links in 3 separate clusters of 6, 24, and 12 pages. The computer-interface metaphor extends to the presentation style, which emulates an inept technical manual: the second person that soon becomes cloying from overuse (11 uses of *you* and *your* in 9 sentences); the lame humor (tornado, Kansas); the tone that suggests the reader is an idiot; the clunky typography (double spaces after a period, and the narrow columns and failure to hyphenate that produce wildly varying line lengths and a hyper-active right rag with the lonely letter "a" floating off the end of 3 lines). Like a technical manual, the book's actual subject—the weather—is not mentioned until the last word of a 9 word insecure bureaucracy of a book title.

[18] In the Case of the Disappearing Diagrams of Descartes, the beautifully integrated text and image of the first edition was promptly dismantled by the bureaucracies of secondary production: "In the first Latin edition of the *Principia philosophiae* of 1644, illustrations are incorporated into the main body of the text… These illustrations are appended to the end of the text in the French edition of 1647 prepared by Abbé Picot, Charles Adam and Paul Tannery—the editors of the canonical edition of Descartes's works—followed the practice of Picot, which in turn means that they were compelled to add a number of awkward footnotes that link the pictures to the appropriate bits of text. Though the editors of the recent English edition—Miller and Miller (1983)—maintain that their edition is based on the original Latin text, this edition adopts Picot's practice of placing the pictures at the end of the text. Numerous annotations of phrases and passages are added in footnotes that are often helpful with the text, *but not one reference to the illustrations is offered that is not to be found in Descartes's original text. It is as though these illustrations do not exist.*" Brian Baigrie, "Descartes's Scientific Illustrations and *la grande mécanique de la nature*," in *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science* (Toronto, 1996), 87 (italics added).

National Audubon Society Field Guide to North American Weather (New York, 1991, 1998), 20.

SOMETIMES metaphors or analogies, at least other than basing field guides on computer interfaces, assist reasoning about analytical design. *But usually the metaphors for analytical design should be the content and the reasoning associated with the content.* For example, the purpose of a field guide is to combine visual recognition of physical objects with new verbal, geographic, and graphical information. And so for the birds above, we are provided with their images, shape comparisons for 7 birds in profile at the top, location maps, song scores, description, and identifying keys. Location maps are particularly helpful in avoiding ridiculous identifications, such as apparently observing a bird in Montreal that in fact resides exclusively in Acapulco. In this classic Golden Field Guide, there is a sense of craft, detail, and credibility that comes from gathering and displaying good evidence all together.

Chandler S. Robbins, Bertel Bruun, and Herbert S. Zim, illustrated by Arthur Singer, *Birds of North America: A Guide to Field Identification* (New York, 1966), 208–209.

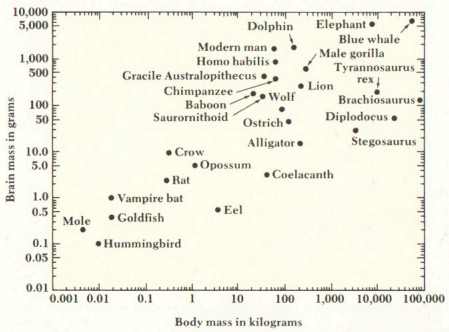


Parts of this graphic appeared in *The New York Times*, May 26, 1992. The graphic here is greatly expanded and redrawn for this book. Research and artwork for both graphics are based on interviews with Robert T. Gallagher of the New York City Police Department, and were done by Megan Jaegerman, who worked at the *Times* news graphics department from 1990 to 1998. Her email of March 2005, reproduced in the text, describes the interviews with Detective Gallagher.

THIS excellent report describes clues to detect hidden handguns carried on the street and also for meeting the standards of evidence necessary to obtain a conviction. Somewhat like the 18th-century dance annotation we saw earlier, the various scenes here choreograph movement in 3-space by means of sequences, call-outs, parallelism, motion arrows, mappings, multiple viewpoints (silhouette, 3-dimensional, flatland footprints), and particularly words and images working together to describe an extended causal sequence. To create this display, Megan Jaegerman did *both* the research and the design, breaking their common alienation. This design amplifies the content, because the designer created the content. Her backup documentation, at a level demanded by editors at high-quality newspapers, indicates the care and craft of the work:

> I confirmed his ID as Detective Robert T. Gallagher of the NYC Police Dept. at criminaljustice.state.ny.us/ops/staff/index.htm. Also lists his award (see below).
>
> From my notes: He was a New York City policeman for 18 years, who for much [unknown] of that time worked as a plain-clothes undercover detective [anti-robbery tactical unit, confiscating illegal firearms], in Bronx & Manhattan, 6pm to 2am shift. He got very good at picking out people carrying weapons. So good that he received [not sure of exact terminology] 1984 Governor's Police Officer of the Year Award. The great achievement was not just making gun arrests (1,200 of them), but making them stick. The letter nominating him said he had "an almost flawless conviction rate." I believe he put it at "99.99."
>
> That's the whole point of his observation—not just to get a gun off the street, and then maybe have the arrest thrown out, which apparently happens too often—but to get from arrest to conviction and jail time. It's all about probable cause, he explained. First identify suspicious demeanor, appearance, behavior (which don't qualify as grounds for arrest), and then wait for probable cause, or legal grounds for frisking and/or arresting someone. He pretty much had to watch for enough clues to justify suspicion, which would allow him to stop a suspect. Then he'd identify himself as a policeman, and THEN he'd watch for the hand reaching toward the waistband, or the guy instinctively turning away, and pulling his arm in to his side. That would combine to give probable cause for a frisk. And when there's a frisk and a weapon, there's an arrest, and apparently with Gallagher, very often a conviction. The sequence is necessary, in the context of suspects' rights and legal requirements for arrest—evidence must exist that rises above suspicion to probable cause.
>
> The tell-tale signs are those in the graphic—slight asymmetries in gait, odd clothing combinations or styles or misfits, instinctive evasive moves when confronted, constant hand-to-gun, holding gun while running, visible bulges or irregularities in the way clothing fits or hangs . . . etc. Source for gun art is a photo from Gallagher of three kinds of revolvers, all looking about the same.
>
> He did act out the motions for me, with guns hidden in all the usual places, and demonstrations of grabbing and frisking and all of that. And he let me do some of the gun handling and role playing. So I'm confident in the graphic.

When and how should data points in statistical graphics be labeled with words? In a classic book, *The Elements of Graphing Data*, William Cleveland suggests that word-labels on data may well "interfere with our assessment of the overall pattern of quantitative data."[19] Several examples then show interfering labels within data fields, including this



Graph from Carl Sagan, *The Dragons of Eden: Speculations on the Evolution of Human Intelligence* (New York, 1977), 39, based on Harry J. Jerison, *Evolution of the Brain and Intelligence* (New York, 1973), 42–45.

noisy, cluttered scatterplot of the empirical relationship between body mass and brain mass for 26 animals. Cleveland's analysis suggests these imperatives for putting words on data points:

> Do not allow data labels in the data region to interfere with the quantitative data or to clutter the graphs. Avoid putting notes, keys, and markers in the data region. Put keys and markers just outside the data region and put notes in the legend or in the text.[20]

Conflicting with the idea of integrating evidence regardless of its mode, these guidelines provoke several issues:

First, labels *are* data, even intriguing data. For example, among the really big animals, relatively smaller brains are found in the prehistoric tyrannosaurus rex, brachiosaurus, diplodocus, stegosaurus—a result that emerges from seeing data dots linked to their names. Or, why is the hummingbird shown as heavier than the mole, the wolf than humans? Such plotting errors can be more easily detected when data points are named. And where would the gnat, mosquito, cat, hammerhead shark, or centaur appear on the graph? Just like numbers, nouns are evidence.

Second, when labels abandon the data points, then a code is often needed to relink names to numbers. Such codes, keys, and legends are impediments to learning, causing the reader's brow to furrow.

[19] William S. Cleveland, *The Elements of Graphing Data* (Monterey, California, 1985), 46.

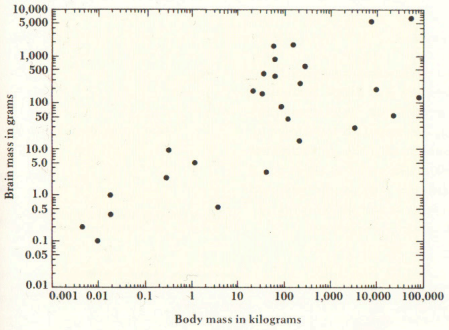
[20] Cleveland, *The Elements of Graphing Data*, 44–47.

Third, segregating nouns from data-dots breaks up evidence on the basis of mode (verbal vs. nonverbal), a distinction lacking substantive relevance. Such separation is uncartographic; contradicting the methods of map design often causes trouble for any type of graphical display.

Fourth, design strategies that reduce data-resolution take evidence displays in the wrong direction.

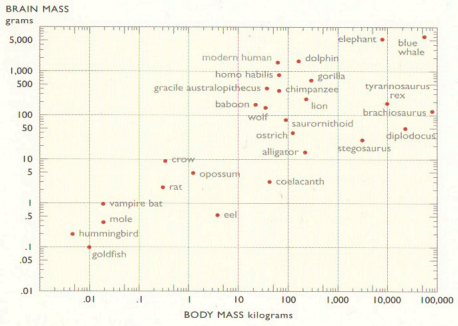
Fifth, what clutter? Even this supposedly cluttered graph clearly shows the main ideas: brain and body mass are roughly linear in logarithms, and as both variables increase, this linearity becomes less tight.

But verbal arguments do not resolve design questions. Visual evidence decides visual issues. And it turns out that Cleveland has a strong point. The 26 labels do in fact clutter up the graph, obscuring relations among the data. Perhaps something will show up if all the words disappear:



Without the dark typography of the labels, we see very differently: the big blob of words in the top half of the original graph inflates the visual variability of body mass for heavier animals. Thus one possible solution for label-clutter, particularly in exploratory data analysis, is to examine *both* scatterplots, with and without labels.

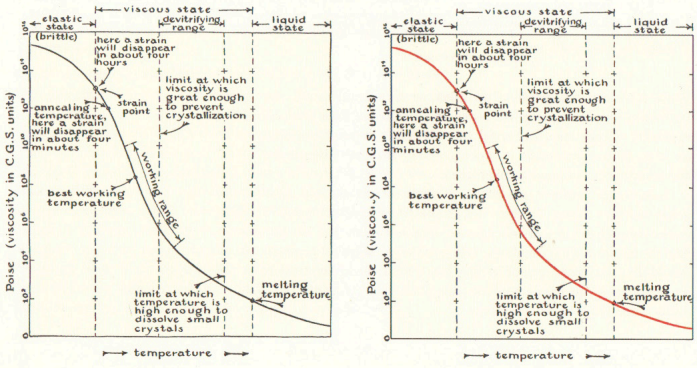
Good design, however, can dispose of clutter *and* show all the data points and their names. To repair this graphic, the data-dots need to gather themselves together on a *different visual level* from their labels. And the labels need to calm down. Like good maps, statistical graphics should have a layered depth of reading. Not a hierarchy of importance for verbal versus quantitative information, but rather a pluralism of distinctions. This suggests a redesign.

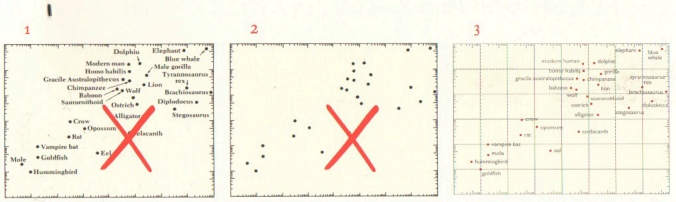


In this revised graph, *red* helps to cluster 26 data-dots now placed in a quiet field of grayed-down words. *Label clutter has vanished, but the labels are still there.* Clutter calls for a design solution, not a content reduction.

At lower left, this chart on the varying viscosity of glass in relation to temperature has an overall sameness of texture and color. Administrative elements (frames, grids, pointer lines, tick marks) are as visually active as the evidence curve itself. At right, the red color pulls out the curve from the graphic debris, while maintaining a unity of text and linework by means of the cartographic strategy of layering and separation.

Roger Hayward in John Strong, *Procedures in Experimental Physics* (New York, 1938), 6.





The redesign sequence reflects these fundamental principles: 1. Clutter is a failure of design, not an attribute of information. 2. Visual problems should not be fixed by reducing content-resolution (such as, for example, discarding words that label data). 3. Instead, fix the design.

Words and data-dots are abstracted representations of actual animals and body/brain masses. In a spirit of seeking visual solutions for visual problems, let each animal represent *itself* at its two-space location in the scatterplot below. Image sizes are proportional only to space available—except for the big brachiosaurus and tiny humans, shown together here at right, whose amazing relative sizes are approximately correct. Other details below repay study.