Supplementary Material: Examples Showing the Conceptualization of Planets by Scientists, 1600 to 1920

Prepared by:

Philip T. Metzger, University of Central Florida
W. M. Grundy. Lowell Observatory
Mark V. Sykes, Planetary Science Institute
Alan Stern, Southwest Research Institute
James F. Bell III, Arizona State University
Charlene E. Detelich, University of Alaska Anchorage
Kirby Runyon, Johns Hopkins University Applied Physics Laboratory
Michael Summers, George Mason University

Sept. 20, 2021

Table of Contents

Moons Were Classified as Planets

These examples are representative of the conceptualization of planets among scientists during this period.

Examples from the 1600s

Johannes Kepler, 1609

> First, therefore, readers should take it as absolutely settled today among all astronomers that all the planets go round the Sun, with the exception of the moon, which alone has the Earth as its center.
>
> (…)
>
> *How are the planets divided among themselves?*
>
> Into the primary and the secondary. The primary planets are those whose bodies are borne around the sun, as will be shown below; the secondary planets are those whose own circles are arranged not around the sun but around one of the primary planets and who also share in the movement of the primary planet around the sun. Saturn is believed to have two such secondary planets and to draw them around with itself: they come into sight now and then with the help of a telescope. Jupiter has four such planets around itself: D,E,F, H. [refers to the figure] The Earth (b) has one (c) called the moon. It is not yet clear in the case of Mars, Venus, and Mercury whether they too have such a companion or satellite.
>
> *Then how many planets are to be considered in the doctrine on schemata?*
>
> No more than seven: the six so-called primary planets: (1) Saturn, (2) Jupiter, (3) Mars, (4) the Earth--the sun to eyesight, (5) Venus, (6) Mercury, and (7) only one of the secondary planets, the moon, because it alone revolves around our home, the Earth; the other secondary planets do not concern us who inhabit the Earth, and we cannot behold them without excellent telescopes.

Note: Throughout this book, Kepler uses the "primary planet" and "secondary planet" scheme, calling each just "planet" on occasions. He also calls planets "planetary body" and he calls the sun "solar body" on occasion.

> (…)
>
> But the moon, which has a private movement around the Earth during the same common circuit of the Earth, is among the secondary planets, as was said above.

(…)

> For the moon, a secondary and terrestrial planet, made in order to obscure the sun, should have followed the example of the ratios of the sphere of the sun or the Earth.

[Note he is talking about eclipses. His term *terrestrial planet* does not have the modern meaning; it refers to a planet that orbits the Earth in contrast to the *solar planets* that orbit the Sun.]

(…)

> *The determination of what body follows most closely upon the determination of the Earth?*
>
> Of the moon, a secondary planet: (1) because this star* has been assigned to the Earth as its private property, so that the moon might help with the growth of earthly creatures and be observed by the speculative creature on the Earth, and that the observation of the starts might begin with it. (2) Because the reasons for the ratio to be established are practically the same.

[*He called the Moon a star, which was common usage for "star" in that era.]

(…)

> Book IV will call those points the "aphelion" and the "perihelion," in the case of the primary planets; and in the case of the moon, the "apogee" and the "perigee."

Johannes Kepler, *The Harmony of the World*, Transl. by E.J. Aiton, A.M. Duncan, and J.V. Field, American Philosophical Society, 1997. Original by Kepler published 1609.

<u>Galileo Galilei, 1610</u>

> Four Planets revolving around the star of Jupiter…I should disclose and publish to the world the occasion of discovering and observing four PLANETS, never seen from the very beginning of the world up to our own times… These are my observations upon the four Medicean planets…" (all caps in the original)
>
> …for now we have not one planet only [i.e., not just one planet] revolving about another, while both traverse a vast orb about the Sun, but our sense of sight presents to us four stars circling about Jupiter, like the Moon about the Earth…

Galilei, Galileo (1610). *Sidereus Nuncius. A page by page translation Based on the version by Edward Stafford Carlos, Rivingtons, London, 1880. Newly edited and corrected by Peter Barker*. Oklahoma City: Byzantium Press, 2004, pp. cover, 17, 28.

Kepler, 1620

> How are the planets divided among themselves? Into the primary and the secondary. The primary planets are those whose bodies are borne around the sun…; the secondary planets are those whose own circles are arranged not around the sun but around one of the primary planets and who also share in the movement of the primary planet around the sun….Jupiter has four such planets around itself…

Kepler, Johannes (1620). "Epitome astronomiae Copernicanae" Book IV. Transl. by Charles Glenn Wallis. In: Epitome of Copernican Astronomy & Harmonies of the World. Prometheus, 1995.

Galileo. 1632

> …many detailed parallels were drawn between the earth and the moon. More comparisons were made with the moon than with other planets, perhaps from our having more and better sensible evidence about the former by reason of its lesser distance.

Galilei, Galileo (1632). *Dialogue Concerning the Two Chief World System – Ptolemaic & Copernican.* Transl. by Stillman Drake. 2nd ed. Berkeley: University of California Press, 1967, pp. 60-61, 106, 267

Johannes Phocylides Holwarda, 1651

Holwarda, Johannes Phocylides. *Philosophia naturalis, seu Physica vetus-nova ex optimis quibusque autoribus, antiquis paritir et neotericis deducta*. Idzardus Alberti, Acad. Frankerana, 1651.

Chapter XVI of this Latin text is titled, "*De Planetarum mumero , & divisione in genere*". It is a lengthy discussion of the planets and their taxonomy. It counts 13 planets ("*planetæ*") and divides them into primaries and secondaries ("*Primarios & Secundarios*"), counting 6 primaries ("*Primarios*") and 7 secondary planets ("Planetas secundarios").

Charles Johnson wrote the following commentary on this text in 1895:

> Phocylides' treatise was published at Franeker in 1651, shortly after the death of the author. On the title-page it is described as written "Ab Eximio Viro/Joh. Phocylide Holwarda/ L.A.M. Med. Doct. & Philosophiæ,/dum viveret, Profess. Ordinario." There is also a portrait. (…) Chapter xvi. treats of the number of the planets and their division in kind. Both satellites and planets proper are included in the term "planetæ." After rejecting the sun from his ancient place among the seven planets, and adding to their number the two laterones about Saturn and the four about Jupiter, discovered in the "current century by the aid of new and

> admirable instruments, such as Tubi Optic•, specula, and others of the same sort," he adds the Earth to the twelve hitherto obtained. It is thus certain, he says, that there are at least thirteen planets, since it is not yet known whether Mars, Venus, and Mercury have any laterones revolving about them. "But as to the five other circumjoviales which P. Anon. Mar. de Rheita boasts that he has observed and called Urban Octavianæ, learned men are justly in doubt whether they should he referred to the fixed or to the wandering stars." Nothing further is added at this place, but he proceeds to divide the thirteen planers into primary and secondary. The former (six in number) are on order from Mercury to Saturn, with the Earth in the Sun's former place. The latter are Saturn's two, and Jupiter's four satellites. The seventh is the Moon. Anyone who doubts this, he adds, will be convinced by what is soon to be said, as well as by the considerations contained in the chapter "De Lunæ corpore & motu." After several interesting chapters, including one on Saturn and his laterones, and another on Jupiter and the Medicean stars, we come to chapter xxi…

Johnson, Charles WL. "Pseudo-Satellites of Jupiter in the Seventeenth Century." (1895): 285.

English Astronomer Vincent Wing, 1654

> Twice shall this primary Planet the Earth which we inhabit, be deprived in part of the Sun's illuminating Raies [via eclipses], and twice also shall the Earth's Planet, the Moon, lose part of her Sun-borrowed luster, by the interposition of the Earth between the Sun and her.

Wing, Vincent. O'ΛΥ'ΜΠΙΑΣ ΔΩ'ΜΑΤΑ, or, an Almanac and Prognostication for the year of our Lord, 1654. As quoted in Morrison, 1934.

Zechariah Bridgen, 1659

> Next in order above the Sun, moves the Planet Mercury, and finishes his course in about 88 dayes. To whom succeeds Venus who accomplisheth her period in 225 dayes. After Venus is placed the Earth, which besides her diurnal revolution in 24 houres, hath an Annual periodical motion through the Ecliptique, performed in 365 dayes: about the Earth as its center, the secondary Planet the Moon is carryed, which goes from, and returnes to, the same point in the Zodiaque in the space of 27 dayes, which measures the periodical month. The next primary Planet is Mars, who finisheth his course in 2 yeares. Jupiter takes his place next after Mars and paceth round the Sun in 12 yeares; about whom as in an epicycle move 4 other Planets [Jupiter's moons], not lyable to the eye without the help of the Telescope. The last primary Planet, which is highest in place, and consequently slowest in motion, is Saturn, who runs his circuit in no less than 30 yeares: and as the Earth and Jupiter had their moons or concomitans, so is the body of this Planet environed by two secondary Planets, not visible without the help of the forenamed Instrument. In the outmost surface of this visible world, is seated the Spheare of

> the fixt Stars, which are altogether voyd of motion, but unchangably retayn the places assigned them at their Creation.

Brigden, Zechariah. *New England Almanack of the Coelestial Motions for This Present Year of the Christian Era 1659*, Cambridge, MA: Harvard, 1659.

Giovani Alphonso Borelli, 1666

> Præterea manifestum est, quemlibet sive primarium, sive secudarium planetam aliquem insignem mundi globum quosi veritutis fontem circumdare, qui ita eos stringit, atque conglutinat, ut ab ipso nullo pacto abstrahipossint ; sed ipsum, quacunque contendentem, perpetuis continuisque orbibus congantur consequi : videmus enim Saturnum, Jovem, Martem, Venerem, atque Mercurium Solem ipsum, Medicæa Sidera Jovem, Hugenianumque Sidus Saturnum circumire, non secus, ac cira Telluris Globum Luna ipsa revolvitur.

Translation:

> Moreover, it is evident that any planet, whether primary or secondary, any globe of the world ["world" meaning a center of orbits] is surrounded by a fountain of power, as it were, that binds and attaches them, so that they can by no means be withdrawn from it; but they are united to follow whatever they contend with in perpetual and continuous orbits: for we see that Saturn, Jupiter, Mars, Venus, and Mercury on the Sun, the Medicean stars on Jupiter, and Huygens' star on Saturn, not to mention the Moon itself revolves near the globe of the Earth.

Joa. Alph. Borelli, *Theor. Medic. Planetar. Ex causis Physicis deduct*, lib. 1. Cap. 2. P. 5. Florent. 1666. 4th. Quoted in: Pringle, John. *A Discourse on the Attraction of Mountains, Delivered at the Anniversary Meeting of the Royal Society, November 30, 1775. By Sir John Pringle, Baronet, President. Published by Their Order*. Vol. 4. Royal Society, 1775.

Christiaan Huygens, 1659

> For it appeared that the two neighbouring appendages clinging to Saturn were by no means two planets, but rather something different [i.e., the rings], while, distinct from these there was a single planet [Titan], at a greater distance from Saturn and revolving round him in sixteen days.

Huygens, Christiaan, 1659. *Systema Saturnium.* Transl. by John H. Walden, 1928. Quoted in: Fitzgerald, A. P. "Saturn: Ringed Wonder of the Universe." *Irish Astronomical Journal* 3 (1954): 14.

John Wallis, 1666

> And accordingly, that the Secondary Planets about Jupiter and Saturn, are not (like their Principals) turned about their own Axis. (…) And accordingly, the Line of the Annual motion, (whether Circular or Elliptical) of which I am not here to dispute,) will be described, not by the Center of the Earth (as we commonly estimate it, making the Earth a Primary and the Moon a Secondary Planet,) nor by the Center of the Moon, (as they would do, who make the Moon the Primary and the Earth a Secondary Planet, against which we were before disputing:) But by the *Common Center of Gravity of the Bodies, Earth and Moon*, as one Aggregate.

Wallis, John. "An essay of Dr. John Wallis, exhibiting his hypothesis about the flux and reflux of the sea, taken from the consideration of the common center of gravity of the Earth and Moon." *Philosophical Transactions of the Royal Society of London* 1, no. 16: 263-281. (1666)

Giovanni Cassini, 1673

> A Discovery of 10 small Fixt Stars, and of one New Planet, first.
>
> This Passage of Saturn gave us occasion to discover in the same place,…Eleven other smaller Stars, one of which, by its particular motion, shew'd it self to be a true Planet [Iapetus]: which we found by comparing it not only to Saturn and his Ordinary Satellit, discovered 1655 by Mr. *Hugens*, but also to other Fix't Stars, and particularly to three, marked *a, b, d,* in the First *Table,* where, to avoid a long explication of our first Observations, we have described the way of Saturn, and that of the New Planet…. These Observations shew a motion of this new Planet that is very manifest in respect of the Fix't Stars, but less sensible in respect of Saturn….Whence it was consequent, *that,* if this Planet were a Satellit of Saturn, he must be unto the end of *September* in the inferior part of his Circle, and from the beginning of *November* in the superior part…The greatest digression [distance from Saturn] of this Planet of *treble* to that of the *ordinary* Satellit [Titan], and this enabled us to judge the Time of his revolution to be *quintuple*, applying to the Satellits that proportion, which *Kepler* hath noted in the Principle Planets, between the periodical Times and their Distances. But there was one circumstance, which made us doubt, whether it was a *Satellit* or a *Principle Planet*, which was, That in the last observations we took notice, that he had a *little* Southern latitude in respect to the Line of the wings of Saturn,...;yet it might well be, that the Circle of this Planet [Iapteus] might have some declination from the Circle of the other Satellit [Titan], as it comes to pass in the Principal planets, the Circles of which are inclined to one another…A Discovery of another New Planet [Rhea]…Our application to observe the Planet nearest to Saturn [Rhea], in the small time we had at evenings, by reason of his proximity to the Sun-beams, had diverted us from the other more remote Planet [Iapteus].

Cassini, G. D. (1673). "A Discovery of two New Planets about Saturn, made in the Royal Parisian Observatory by Signor Cassini, Fellow of both the Royal Societys, of England and France; English't out of French". *Philosophical Transactions*. 8: 5178–5185.

Bernard Le Bovier de Fontenelle, 1686

[Much of the book is useful as it reveals the concepts held by a prominent scientist in the late 1600s, but only a few selections are given below. The entire book should be read. This book is also extremely useful for seeing the differences of meaning between “world” and “planet”.]

> I see that in general that planet [the Moon] and the earth have very different degrees of light... [p. 41]
>
> [*The Marchioness speaking to de Fontenelle*:] I am very happy to have inhabitants restored to the moon ; I am glad also that you give them a surrounding atmosphere, for it seems to me that a planet would be too naked without one. [p. 64]
>
> [*The Author speaking*:] These two different airs, said I, one belonging to the earth, the other to the moon, tend to prevent communication between the two planets...Were the two planets nearer together... [p. 64]
>
> ...so in these two planets [Earth and Moon]… [p. 71]
>
> ...let us make this tour to the planets... [The tour begins with the Moon] [p. 72]
>
> But what a beautiful object is Jupiter, surrounded by his four little moons, or satellites! These moons are four little planets which, whilst Jupiter revolves in twelve years round the sun, constantly go round him as the moon does round the earth. But, interrupted the Marchioness, how is it that there are planets which go round other planets, no better than themselves? It seems to me that there would be much more regularity and uniformity in assigning to all the planets but one sort of orbit in which they should move round the sun. [p. 92]
>
> If a smaller planet comes within the vortex of a larger one [N.B., this is the vortex theory of Descartes before gravity was understood], it is irresistibly carried round the larger one, and altogether the large, and the small planet, and the vortex that encloses them, perform their revolution round the sun. Thus at the commencement of creation we obliged the moon to follow us because she came within the influence of our vortex, and was by that means subjugated to our will. Jupiter, the planet we were speaking of, was more fortunate, or more powerful than the earth. Four little planets were in the neighborhood, and he became master of them all ; and we, who are a planet of some importance, would probably have felt his power if we had been near him. He is a thousand times larger than the earth ; and would easily have drawn us into his cortex, and made us one of his

> moons ; instead of this we have a planet attend on us : so true is it that the situation into which we are thrown decides the fate of our lives. [pp. 94-5]

There follows a discussion of why planets stay in their "ranks" instead of disturbing and capturing each other. This was an early recognition of planets dominating their own orbits, but the physics was incorrect. Note that despite recognizing that some planets dominate their orbits, the secondary planets were still planets; dominating orbits was not considered the basis for planethood.

> You will not fail, I suppose, said the Marchioness, to people these four moons [i.e., to claim they are inhabited], though they are only little subaltern planets, intended to give light to another during the night. Undoubtedly not, I replied. These little planets are not unworthy of inhabitants because they are unfortunate enough to be subjected to a larger planet. [p. 96]
>
> To the planets nearest to him [i.e., to the secondary planets nearest to Jupiter] he appears sixteen hundred times larger than our moon appears to us." [A footnote in the later edition sought to correct this number.]
>
> However, the inhabitants [of Jupiter] can see Mars, their own four satellites, and Saturn with all his moons. Surely then they have planets enough to perplex their astronomers..." [p. 102]
>
> This great vortex [surrounding the sun] contains 16 planets... [This count included the 10 known moons.] [p. 103]
>
> For ought we know one vortex [stellar system] may have more planets revolving round its sun, another fewer. In one there are subaltern planets [moons], turning round the principle planets, in another they may all be alike... [p. 116]
>
> [Regarding the variable brightness of Iapetus] Though this moon is a planet, and therefore cannot exactly guide our opinion with respect to suns, yet we may suppose that a sun can be partially covered with spots. [p. 125]

de Fontenelle, M. (1686). *Conversations on the Plurality of Worlds*. Engl. transl. unknown. Thomas Carlson (London, 1767).

Isaac Newton, 1687

On Apr. 6, 1687, Newton presented the 3rd book of Principia to the Royal Society. The entry in the Journal of the Royal Society describes the event:

> It contained the whole system of celestial motions, as well of the secondary as primary planets, with the theory of comets, which is illustrated by the example of the great comet of 1660-1…

Quoted in: Newton, Isaac. *Correspondence of Sir Isaac Newton and Professor Cotes: Including Letters of Other Eminent Men, Now First Published from the Originals in the Library of Trinity College, Cambridge; Together with an Appendix, Containing Other Unpublished Letters and Papers by Newton*. JW Parker, 1850

Isaac Newton, 1692/3

> …the several Distances of the primary Planets from the Sun, and of the secondary ones from Saturn, Jupiter, and the Earth; and the Velocities with which these Planets could revolve about those Quantities of Matter in the central Bodies…
>
> …The same power, whether natural or supernatural, which placed the sun in the center of the six primary Planets, placed Saturn in the center of the orbs of his five secondary planets, and Jupiter in the center of his family of secondary Planets, and the Earth in the Center of the Moon's Orb…

Newton, Isaac (1692/3). Letters of Isaac Newton to Richard Bentley, Dec. 10, 1692 to Feb. 25, 1693. Quoted in Newton, Isaac. *Four letters from Sir Isaac Newton to Doctor Bentley: containing some arguments in proof of a deity*. London: R. and J. Dodsley, 1756.

Christiaan Huygens, 1698

This work, *Cosmotheoros*, was written in 1695 but published posthumously according to his direction in 1698. Below we cite from the 1722 English translation, *The Celestial Worlds discover'd: or, Conjectures concerning the inhabitants, plants, and productions of the worlds in the planets*.

The title of the English translation demonstrates that "worlds" were considered to be the civilizations that can exist on the planets, not the geological bodies (planets), themselves.

Selections from this work:

> A Man that is of Copernicus's opinion, that this earth of ours is a planet, carry'd round and enlighten'd by the sun, like the rest of them, cannot but sometimes have a fancy, that it is not improbable that the rest of the plenats have their dress and furniture, nay and their inhabitants too as well as this earth of ours: especially if he considers the later discoveries made since Copernicus's time of the attendants of Jupiter and Saturn, and the champaign and hilly countries in the moon, which are an argument of a relation and kin between our earth and them, as well as a proof of the truth of that system.

At one point he calls the other planets, or the civilizations on those other planets, "earths":

> But geometry stands in no need of being proved after this manner. Nor doth it want assistance from other arts which depend upon it, but we may have a nearer and shorter assurance of their not being without it in those earths. [p. 113]

In the next quote he refers only to the primary planets using the term "planet", showing the polysemic usage:

> As Jupiter can see no planet but Saturn, so Saturn knows of no planet but Jupiter; which appears to him much as Venus does to us, never removing about 37 degrees from the sun.
>
> This then shall be what I have to say to the primary planets. [new para] We are now come a little lower, to make an enquiry into the attendants of these planets, especially our own." [p. 173]
>
> …I can scarce find anything to say about it [the Moon], because I have not a planet of the same nature before my eyes, as in all the primary ones I have. [p. 174]
>
> …so they turn always the same face to their primary planets. [p. 180]
>
> Having thus explain'd the primary and secondary planets round the sun, we should next… [p. 187]
>
> And in our age Alphonsus Bellorus, who was of the same opinion in other planets as well as the moon, makes the gravitation of the primary planets to be toward the sun, as that of the secondary is towards the planets round which they move. [p. 215]
>
> 'Tis certain moreover, that the moon has no air or atmosphere surrounding it as we have…this is that notable difference between that planet and us that hinders all probable conjectures about it.

Huygens also uses "world" to mean the entire cosmos:

> But Kepler had a private design in making the sun thus superior to all the other stars, and planting it in the middle of the world, attended with the planets: a favour that he did not desire to grant the rest.

Huygens, "*The Celestial Worlds discover'd: or, Conjectures concerning the inhabitants, plants, and productions of the worlds in the planets.*" (1722). Translation of *Cosmotheoros* (1698).

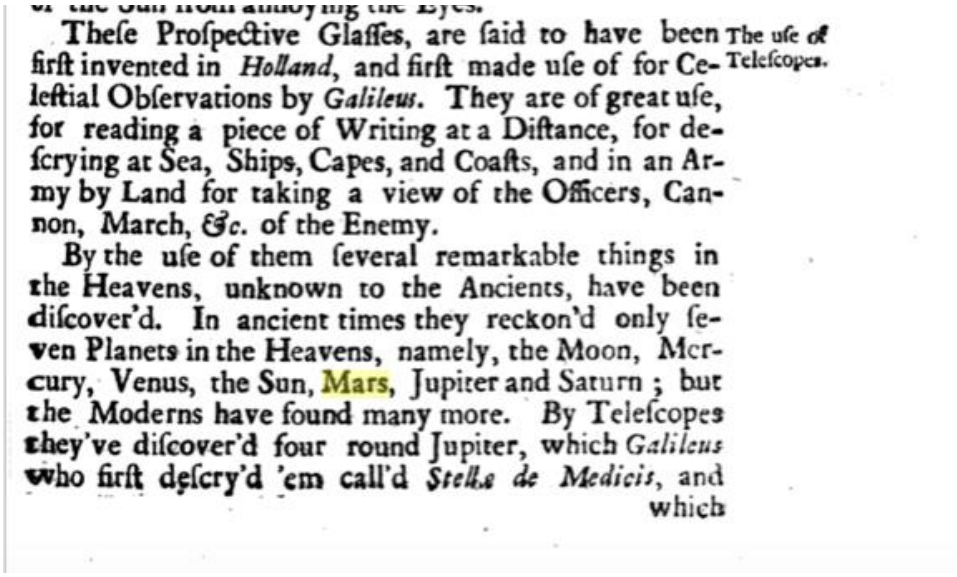
Examples from the 1700s

Joshua Oldfield, 1707

> *Saturn*, the highest of the Planets, is observed by the Telescope to be *girt* or encompassed about at some distance with a bright Arch or Circle, and to have five smaller Planets, call'd his Satellites, or *Guards* (which are conceiv'd to be as Moons) attending him…

Oldfield, Joshua. *An essay towards the improvement of reason: in the pursuit of learning and conduct of life.* T. Parkhurst, 1707

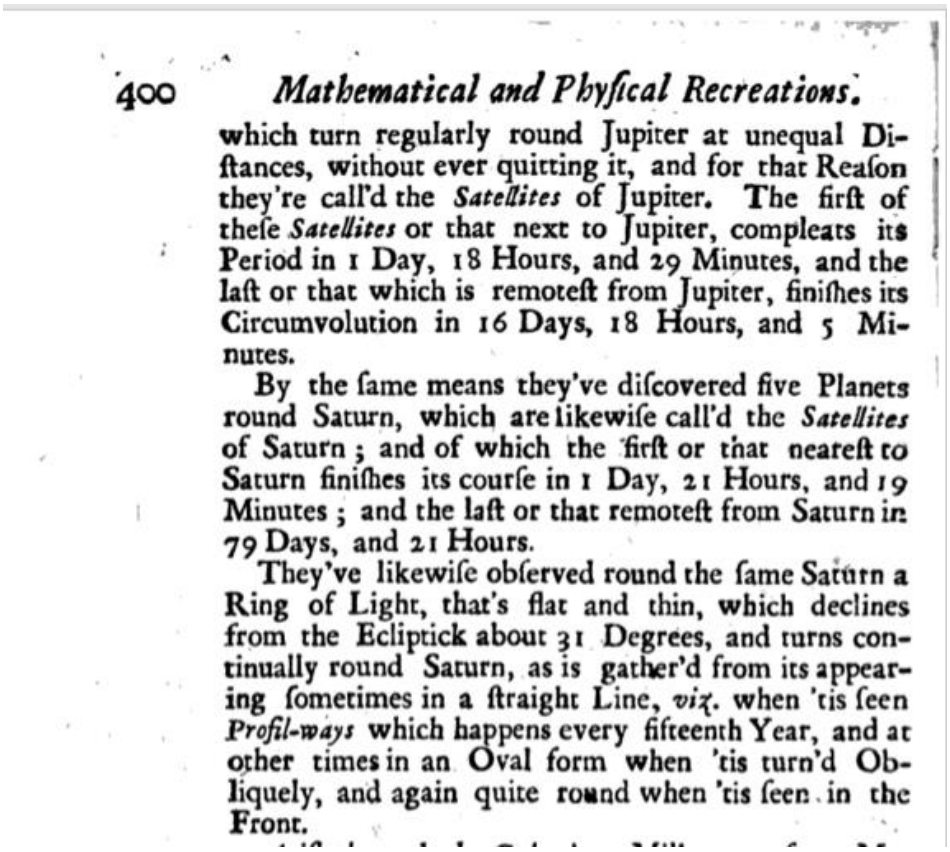
Jacques Ozanam, 1708



of the Sun from annoying the Eyes.

Theſe Proſpective Glaſſes, are ſaid to have been first invented in *Holland*, and firſt made uſe of for Celeſtial Obſervations by *Galileus*. They are of great uſe, for reading a piece of Writing at a Diſtance, for deſcrying at Sea, Ships, Capes, and Coaſts, and in an Army by Land for taking a view of the Officers, Cannon, March, *&c.* of the Enemy. The uſe of Teleſcopes.

By the uſe of them ſeveral remarkable things in the Heavens, unknown to the Ancients, have been diſcover'd. In ancient times they reckon'd only ſeven Planets in the Heavens, namely, the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn; but the Moderns have found many more. By Teleſcopes they've diſcover'd four round Jupiter, which *Galileus* who firſt deſcry'd 'em call'd *Stellæ de Medicis*, and which



400 *Mathematical and Phyſical Recreations.*

which turn regularly round Jupiter at unequal Diſtances, without ever quitting it, and for that Reaſon they're call'd the *Satellites* of Jupiter. The firſt of theſe *Satellites* or that next to Jupiter, compleats its Period in 1 Day, 18 Hours, and 29 Minutes, and the laſt or that which is remoteſt from Jupiter, finiſhes its Circumvolution in 16 Days, 18 Hours, and 5 Minutes.

By the ſame means they've diſcovered five Planets round Saturn, which are likewiſe call'd the *Satellites* of Saturn; and of which the firſt or that neareſt to Saturn finiſhes its courſe in 1 Day, 21 Hours, and 19 Minutes; and the laſt or that remoteſt from Saturn in 79 Days, and 21 Hours.

They've likewiſe obſerved round the ſame Saturn a Ring of Light, that's flat and thin, which declines from the Ecliptick about 31 Degrees, and turns continually round Saturn, as is gather'd from its appearing ſometimes in a ſtraight Line, *viz.* when 'tis ſeen *Profil-ways* which happens every fifteenth Year, and at other times in an Oval form when 'tis turn'd Obliquely, and again quite round when 'tis ſeen in the Front.

Ozanam, Jacques. *Recreations Mathematical and Physical: Laying Down, and Solving Many Profitable and Delightful Problems of Arithmetick, Geometry, Opticks, Gnomonicks, Consmography, Mechanicks, Physicks, and Pyrotechny*. R. Bonwick, 1708, pp. 399-400.

Roger Cotes, 1712/3

> Now it is confess'd by all Astronomers that the Primary Planets about ye Sun and the Secondary about their respective primary doe describe areas proportional to the times…Therefore the centripetal forces of the Primary Planets revolving about the Sun & of the Secondary Planets revolving about their Primary ones, are in duplicate proportion &c.

Cotes, Roger (1712/13), letter to Sir Isaac Newton, Feb. 18, 1712/13. In: Edelston, J. , ed. *Correspondence of Sir Isaac Newton and Professor Cotes*. London: John W. Parker, 1850, pp. 151-2.

David Gregory and Edmond Halley, 1715

> Proposition I. To give a general account of the Order, and Periods of the Primary Planets revolving about the Sun, and their Distances from it; as also what we are to think of the Comets and Fixt Stars.

[Note it doesn't need to add "primary" every time. The next occurrence omits it:]

> The Sun is to be look'd upon as immovable, and placed in the midst of that immense Space, in which the Planets perform their Revolutions.

[Another example how they don't use "primary" every time:]

> Wherefore (by *Prop.* xi.) the Forces by which they are kept in their Orbits, do not tend to it. Besides, the Primary Planets, *viz.* Mercury, Venus, Mars, Jupiter and Saturn, in respect of the Earth, do sometimes go forwards from the West towards the East, sometimes backwards from the East towards the West, and sometimes stand still: But the time in which these Motions are perform'd, always flow uniformly; and therefore the Areas describ'd by a Radius drawn to the Earth from any Planet, are not proportional to the Times of description. Consequently, by the foregoing Proposition, each Planet is urged and retained in its own Orbit, by a Force that does not tend toward the Earth.

[continuing examples:]

> S E C T I O N III. Of the Order, Distances, and Periods of the Secondary Planets revolving about their Primary ones, and their Phænomena ; together with the Direction of the Forces, whereby they are kept in their Orbits.
>
> Proposition XV. TO describe the Order, and Periods of the Secondary Planets, or Satellites, about their Primary Ones, and Distances from them. Of the Six Primary Planets, that revolve about the Sun, there are but three, as we are sure of by Observation, that have Satellites, or others revolving about them, hence called, Secondary Planets. The Earth has one, viz,, the Moon, compleating its Revolution in 27 ½ Days, and distant about 60 Semidiameters of the Earth from it.
>
> Jupiter has four;…
>
> Saturn has five;… The Planes of the Orbits of the Satellites of the same primary Planet, do not coincide, but are variously inclin'd to one another, and to the Plane of the Orbit of the Primary one.
>
> The Moon, being a secondary planet,…[the page is not scanned correctly so not entirely legible] [p. 27]
>
> The same Phænomena will appear in Jupiter and Saturn : For their Satellites or Moons, will be eclipsed, by being immers'd in the shadow of their primary Planet ; and those Eclipses of them are observed by us, just as the Eclipses of our Moon may be observed from them. In like manner, every Satelles coming between the Sun and its Primary, casts a shadow upon the Primary, which seems to move along the Disk of the Primary from East to West like a Sp[ot?]. But the Duration,

> Phases, Periods, &c. of these Phænomena are various, and differing from th[e?] like seen by us, and arising from our Moon according to the diversity of the Shadows, Motions and Magnitudes, both of the Primary and Secondary Planet. [p. 40]
>
> Proposition XX. *Each of the Secondary Planets mention'd in Prop. XV. is urged by a Force compounded of a Centripetal Force, tending the center of the Primary, about which it revolves, and of all the Accelerating Force with which the Primary is urged. And therefore the Forces whereby the Satellites are retain'd in their Orbits about the Primary ones, tend towards the center of the Primary ones respectively.* [In the remainder of this section, the primary planets are always called "Primary Planet" or "Primary" – never just "Planet" -- whereas the satellites are called either "Secondary", "Secondary Planets", "Satelles", or "Satellites" as synonyms.]
>
> Section IV. Of the Periods of the Primary Planets about the Sun, and the Secondary about their respective Primary, compar'd together,… [p. 42]

[This type of usage continues consistently throughout…]

> Among the Secondary Planets, the Moon, the Earth's attendant, besides its monthly Motion about the Earth, and annual about the Sun, (by which alone each line in it would be always parallel to its self,) it likewise revolves about itself in the same space of a Month, so as to turn always the same Face to the Earth.
>
> We are not certain yet of the other Planets, both Primary and Secondary, from Observations. [p. 60]

Gregory, David, and Edmond Halley. *The elements of astronomy, physical and geometrical.* Vol. 1. J. Nicholson and sold, 1715.

William Whiston, 1717

> All the Planets and Comets gravitate to the Sun in a duplicate reciprocal Proportion of their Distances from it, and are thereby retained in their several Orbits. Their Periodical Times are in a sesquiplicate or sesquialteral proportion to their Distances; that is, the Triplicate or Cubes of the Distances, are as the Duplicate or Squares of the periodical Times; and that to the greatest Exactness possible; which equally obtains in the secondary Planets, with regard to their primary Ones also and is the fundamental Law of the entire System.
>
> No secondary Planets have yet been observed about it [Mercury], nor any Diurnal Rotation.

No secondary Planets have yet been discovered about it [Venus] yet has it a Diurnal Revolution on its own Axis in 23 Hours.

The Earth is the next Planet to Venus, and has the Moon for its secondary Planet ; the common Center of whole Gravity describes an Ellipsis about the Sun in one Year, or 365 Days and a Quarter, nearly;…

This Annual Motion is perform'd in the Ecliptick, and is directed, as is that of all the Planets, primary and secondary, from West to East, or according to the Order of the Signs, and therefore causes the Sun to have an apparent Annual Motion the same way, and in the same Plain; but as still in the opposite Point of the Ecliptick.

…it [Mars] has no secondary Planet that can be seen,…

Jupiter, the largest of all the Planets, is much higher in the System, and has four Satelites or Moons revolving about it; and all by this common Center of Gravity describe a very great Ellipsis about the Sun.

Saturn, the highest and most remote of all the known Planets, has five Satellites or Moons, and a vast but thin Ring encompassing his Body, as an Horizon does a Globe; all which, or rather the common Center of their Gravity, describes an Ellipsis about the Sun.

Of the *Satellites*, or *secondary Planets*; the most eminent as to us is the *Moon*.

Jupiter's four Satellites, or secondary Planets, are visible with an ordinary Telescope, and sometimes pass like Spots on the Face of Jupiter, and sometimes enter into his Shadow ; which to an Eye in Jupiter would cause Appearances just like our Solar and Lunar Eclipses…The Cubes of their Distances are also as the Squares of their periodical Times; and so they are kept in their Curvilinear Orbits by their Gravity towards *Jupiter*'s Center, in a duplicate reciprocal Proportion from it ; as is the Case of all the Planets, both Primary and Secondary about the Sun.

Saturn has *five Satellites* or secondary Planets. The Fourth in order from Saturn is the largest, and was discovered by the celebrated *Hugenius* ; the Third and Fifth are visible in the next Degree; but the Knowledge of the two Innermost are wholly owing to *Cassini*'s extraordinary Glasses, and Diligence.

N. B. The other Secondary Planets, I mean those about *Jupiter* and *Saturn*, are too small and too remote from us, to afford us such Indications of their State, as we have of the State of our Secondary Planet, the Moon. Nor indeed do the primary ones themselves afford us enow of them to determine in particular their own State, as to many such Matters. Only *Jupiter* affords us the Appearance of Belts, or movable Girdles, and besides them, his Satellits afford us that famous

> Phænomenon of the Velocity of the Rays of Light: And Saturn, besides his Five Planets, affords us such a Ring encompassing his Body, as seems to be the most singular and curious Spectacle in the whole System. Of these Three Phænomena therefore I shall give some farther Account, before I proceed to the Comets and fixed Stars.

Whiston, William. *Astronomical principles of religion, natural and reveal'd.* Vol. 2. J. Senex, and W. Taylor, 1717.

Johann Friedrich Treiber, 1719

> However, the number of planets has grown from 7 to 19 today. Hence the planets have been divided into *Primarios* or Main-Planets [Ger., *Haupt-Planeten*] / so run alone around the sun from evening to morning; and in *Planetas secondarios*, or Minor-Planets [Ger., *Neben-Planeten*, lit. "Next Planets"] / which are moved around a Main Planet at the same time, or around the same / around the sun. The main planets are six / as *Saturnus*, *Jupiter*, *Mars*, *Tellus* (The Earth) *Venus* and *Mercurius*. The Minor Planets, however, thirteen / namely the Moon around our Earth / four small planets or moons around *Jovem*, five of them around *Saturnum*, and finally three around *Martem* [sic]. [The original text used Roman font for Latin words, which are left untranslated here, and Blackletter font for German.]

Treiber, Johann Friedrich. *Astronom- und Chronologische Seltenheiten*. Funcke, 1719.

Charles Leadbetter, 1727

> SATELLITE. The Word signifies a Sergeant, or Yeoman of the Guard ; but it is us'd for distinguishing of *Saturn*'s Five, and *Jupiter*'s Four Attendants. The Moon is a Satellite to our Earth. [p. 10]
>
> VENUS…is the most splendid of all the Primary Planets… [p. 43]
>
> MERCURY…is the seldomest seen of all the Primary Planets. [p. 62]
>
> To know when any of the Five Primary Planets are in Aphelion, or Perihelion…[p. 67]
>
> The Moon is a Secondary Planet… This Planet (different from all the rest) respects our Earth for her Center… [p. 74]
>
> The Secondary Planets, both *Jupiter* and *Saturn*, do fall so short of their Principals in respect of Magnitude…The Moons as well of *Jupiter* and *Saturn*…These small Planets in general are continually changing their Apparent Distances from their Principals, and wander from them several ways….nor are these little Planets subject to any considerable Variation in this respect.

> If we would speak accurately, I say, the Primary Planet doth as well revolve about the Secondary, as the Secondary about the Primary ; they both indeed only revolving about the common Center of Gravity of both. So that if the Secondary one, so call'd, were equal in Magnitude to the Primary one, they might either of them be called the Primary, and either Secondary, with equal Right. However, seeing that besides the common Name of Secondary ones given to these Moons, according to the common Use of Speech ; those which thus revolve, are all of them small ones ; and whether taken separately or conjunctly, are nothing in respect of Magnitude, when compared with each other ; therefore we may with good Reason appropriate the Name of *Secondary* to them, reserving to the other the Appellation of *Primary*.
>
> This is a Thing which holds good in the Motion of the Planets in general, whether Primary or Secondary, without any Exception ; namely, that the Planet,…

A great many other examples exist in this text that have not been included, here.

Leadbetter, Charles. *Astronomy; or, the True system of the planets demonstrated, etc.[With plates.]*. J. Wilcox; T. Heath, 1727.

Henry Pemberton, 1728

> This system is disposed in the following manner. In the middle is placed the sun. About him six globes continually roll. These are the primary planets…Besides these there are discovered in this system ten other bodies, which move about some of these primary planets in the same manner, as they move round the sun. These are called secondary planets…Those which move about Jupiter and Saturn, are usually called satellites… The secondary planets move round their respective primary, much in the same manner as the primary do round the sun.

Pemberton, Henry. *A view of Sir Isaac Newton's philosophy*. S. Palmer, 1728.

John Theophilus Desaguliers, 1728

> *Saturn*, *Jupiter*, *Mars*, the *Earth*, *Venus* and *Mercury*, are called *Primaries*, or *Primary Planets*, because they move round the *Sun*; but the five *Moons*, or *Planets*, which move about *Saturn*, and the four which move about *Jupiter*, and the *Moon* which goes round our Earth, as they all attend their *Primaries* in their Revolution about the *Sun*, and are called the *Secondary Planets*, or *Satellites*.
>
> NOW these *Satellites* are kept in the Orbits, by the *Attraction* of their *Primaries* and hindered from flying out in a streigh [sic] *Line* or *Tangent*, in the same manner as the *Primaries* are carried round the *Sun*, and has been explain'd in the last Note.

Desaguliers, John Theophilus. *The Newtonian System of the World the Best Model of Government: an Allegorical Poem. With a Plain and Intelligible Account of the System of the World, by Way of Annotations: with Copperplates: to which is Added, Cambria's Complaint Against the Intercalary Day in the Leap-year*. A. Campbell, 1728.

John Keill, 1730

> To this Sublime Genius [Isaac Newton] we owe, that now we know the Cause why such a constant and regular Proporation is observed by both Primary and Secundary Planets in their Circulations round their Central Bodies… [p. v]
>
> THREE of the Planets, *viz.* The *Earth*, *Jupiter* and *Saturn*, have other lesser Planets which continually accompany them, these are called Secundary [sic] Planets, Moons or Concomitants; for they constantly keep close to their respective Primaries, and always attend upon them in their Circulation round the Sun; and in the mean Time each of them performs his proper Revolution round his proper Primary. [p. 24]
>
> The most sagacious *Kepler* was the first who discovered this great Law of Nature in all the Primary *Planets*; and afterwards the *Astronomers* observed that the Secondary *Planets* did likewise regulate their Motions by the same Law; and that in the two Systems of Bodies revolving about *Jupiter* and *Saturn*, this Rule is constantly observed, that the Squares of their Periodical times are as the Cubes of their Distances from their respective Primaries… [p. 33]
>
> SINCE therefore all *Astronomers* do unanimously agree that the Law we have above explained is constantly observed by 14 great Bodies, of which there are more than one that turn round a common Center, *viz.* five Primary *Planets* and nine Secondaries; and since the *Moon* turns round the *Earth*; if the *Sun* did likewise perform his Circiuts round it, according to this Law of Nature, the *Moon* and *Sun* ought to regulate their Motions in the same Manner ; and therefore since the *Moon* finishes her Course in 27 Days, and the *Sun* in 365, and the Distance of the *Moon* is known… [p. 34]
>
> The Primary *Planets* have the *Sun*, which they regard as a Center, for the Regulator of their Motions ; and sometimes they approach us nearly, at other Times they move away to a great Distance from us. But the *Moon* like an Earthly Body is kept in our Neighbourhood by a natural Propension or Gravity towards us; by the Means of which it is constantly Turned out of a rectlininear Course, and is obliged to perform its Revolution round about us, in the Space of 27 Days and seven Hours… [p. 90]
>
> HITHERTO we have contemplated the Motions of the *Earth* and *Moon*, and have given an Account of many Appearances that arise from them. The *Moon* indeed is no primary *Planet*, but a secondary, which does no other ways go round the *Sun*,

> the true Center of our System, than by accompanying our *Earth* to who she properly belongs, in her annual Course round the *Sun*.
>
> BUT the chief and primary *Planets* of our System, whichh perform the Circulations round the *Sun*, without regarding any other Body, are in Number six, *viz. Mercury* [symbol], *Venus* [symbol], the *Earth* [symbol], *Mars* [symbol], *Jupiter* [symbol], and *Saturn* [symbol], whose Motions and Appearances are now to be explained. [p. 155]
>
> For because the Diameter of the Moon is somewhat more than a fourth Part of the Diameter of the Earth; if the Parallax of the Sun were 15 Seconds, then the Body of the Moon would be greater than that of *Mercury* , but it sees incongruous that a secondary Planet should be greater than a primary Planet. [p. 343]

Keill, John. *An Introduction to the True Astronomy: Or, Astronomical Lectures Read in the Astronomical School of the University of Oxford*. Bernard Lintot, 1730.

Thomas Morgan, 1730

[A medical textbook that is convinced the gravity of all the solar system bodies is what controls our bodies' health]

p. 20:

PROPOSITION XI.

THE primary Planets revolve about the Sun, the Moon about the Earth, and the Satellites of Saturn *and* Jupiter *about* Saturn *and* Jupiter, *as their true and proper Centres: And the Law of their Revolution is ſuch, that the Squares of their periodical Times are as the Cubes of the Diſtances from their different and reſpective Centres.*

THIS Propoſition is matter of Fact and Experience; and therefore it will be a ſufficient

cient demonſtration of it, to ſet down here the periodical Times and proportional Diſtances, as they are obſerv'd and computed by the beſt modern Aſtronomers.

THE periodical Times of the primary Planets about the Sun, and their proportional Diſtances from the Sun's Centre, are as follows:

	revolves about the SUN in the Space of	d.	h.	′	Proportional diſtances from the Centre of the SUN.
SATURN		10759	06	36	953806
JUPITER		4332	12	20	520116
MARS		686	23	27	152399
The EARTH		365	06	09	100000
VENUS		224	16	49	72333
MERCURY		87	23	16	38710

SATURN has five Satellites or ſecondary Planets revolving about him, whoſe periodical Times and proportional Diſtances are thus determined:

	revolves in the ſpace of	d.	h.	′	″	Proportional Diſtances.
The firſt		1	21	18	26	181
The ſecond		2	17	41	10	231
The third		4	12	25	10	323
The fourth		15	22	41	28	749
The fifth		79	07	46	00	2182

THE four Satellites of *Jupiter* revolve about him in the periodical Times, and at the proportional Diſtances following:

	revolves in the Space of	d.	h.	′	″	Propor. Ds.
The firſt		1	18	27	36	292
The ſecond		3	13	13	42	454
The third		7	3	42	36	725
The fourth		16	16	32	09	1276

p. 23:

PROPOSITION XII.

LET two or more Bodys be ſuppoſed to revolve about the Earth at different Diſtances, and to be retain'd in their Orbits by their Weight, or accelerating Forces towards the Earth's Centre; and I ſay, that the Law of their Revolution will be ſuch, that the periodical Times will be in the ſeſquialterate Ratio of the Diſtances; or the Squares of the one, as the Cubes of the other.

THE Earth having but one ſingle Satellite or ſecondary Planet, the Moon revolving about her, we cannot here compare the Motions of any two Bodys actually revolving and

 reſpecting

reſpecting the Centre of the Earth, as has been done with reſpect to the *Sun*, *Saturn*, and *Jupiter*. But ſince we know in fact, that the accelerating Velocity of all Bodys near the Earth's Surface is after the rate of 16 1

p. 27:

PROPOSITION XV.

THERE is in all Bodys, and the ſeveral Parts of which they are compoſed, a mutual Attraction, Gravitation, or Conatus mutuò accedendi; *which Force is of the ſame nature and kind with that which we call* GRAVITY *or* Weight, *by which Bodys tend to the Centre of the Earth; and is ever in a Ratio compounded of the Quantitys of Matter in the Bodys themſelves directly, and the Squares of their Diſtances reciprocally.*

THAT theſe attracting or gravitating Forces at the ſame or equal Diſtances, are as the Quantitys of Matter in the Bodys themſelves, has been proved in the laſt Propoſition; and with reſpect to the ſame central or attractive Body, the centripetal Forces are as the Squares of the Diſtances reciprocally, by *Prop.* 13. Therefore univerſally, thoſe Forces muſt be in a Ratio compounded of both theſe, or as the Quantitys of Matter directly, and the Squares of the Diſtances reciprocally. Now that this Force is univerſal, and equally affects the Sun, the Earth, the Moon, and all the primary and ſecondary Planets, is evident from what has been hitherto demonſtrated: but ſince the Weight of Bodys here with us, is an accelerating Force; and at the Earth's Surface, or equal Diſtances from the Centre, as the

the Quantitys of Matter in the Bodys themſelves, by *Prop.* 5. and ſince alſo the periodical Time of a Body revolving about the Earth, at the Diſtance of one Semidiameter, and retain'd in its Orbit by its own Gravity or Weight, would be to the periodical Time of the Moon revolving likewiſe about the Earth, in the ſeſquialterate Ratio of the Diſtances, by *Prop.* 12. which is the ſame Law that has been prov'd to obtain, with reſpect to the primary Planets about the Sun, and the Satellites of *Saturn* and *Jupiter* about their primary ones: 'tis plain from hence, that this Force is of the ſame nature and kind with the Gravity or Weight of Bodys, obtaining univerſally thro'out the whole Solar Syſtem, and acting according to the general Law which has been here demonſtated.

COROLLARY.

FROM hence it follows, that the Earth revolves, as a Planet, annually about the Sun; and conſequently, that the Sun remains fix'd, as the true and proper Centre of the whole Syſtem. For,

SUPPOSING the Earth to revolve about the Sun, its periodical Time and Diſtance will exactly correſpond to the Length of our ſolar Year, according to the general Law of Nature, by *Prop.* 11. that is, the periodical Time of the Earth, compared with thoſe of the other primary Planets, will be preciſely in the ſeſquialterate Ratio of the Diſtances.

But

p. 38:

their Diſtances from the Sun. And ſince this Proportion appears ſo remarkable, and with ſo little Variation in the Earth, *Jupiter* and *Saturn*, which having other Bodys revolving about them, admit of demonſtrative Calculation, as above; 'tis reaſonable enough to ſuppoſe from the Analogy, Uniformity and Simplicity of Nature, that the ſame Proportion obtains likewiſe with reſpect to *Mars*, *Venus* and *Mercury*: and tho for want of any diſcoverable Satellites or ſecondary Planets revolving about theſe latter, the thing cannot be determined with certainty and to a Demonſtration; yet, where Nature is found to keep to ſome certain general Law, ſo far as our Inquirys and Obſervations can reach, 'tis very reaſonable to conclude, that the ſame Law obtains alſo ſtill farther, and where the like Obſervations cannot be made.

Now this being admitted or ſuppoſed, the Quantitys of Matter, and Denſitys of the Sun and Planets, taken all together, will be as here ſet down.

	Quantitys of Matter.	*Denſitys.*
The SUN	170000	100
SATURN	49	33
JUPITER	154	73
MARS	$\frac{1}{3}$	260
The EARTH	1	400
The MOON	$\frac{1}{39}$	500
VENUS	1	550
MERCURY	$\frac{1}{3}$	1000

PRO-

p. 45:

PROPOSITION XXII.

IF a Body revolving about a given Centre, has its Motion disturb'd by the Attraction of some other Body drawing it to a different Centre; 'tis requir'd to find the general Laws and Proportions of the perturbating Forces.

IN *Fig.* 6. let S represent the Sun, T a primary Planet, as the Earth revolving about the Sun in the Orbit *e e*; and L a secondary Planet, as the Moon, revolving about T, in the Orbit ABCD. Let ST represent the Attraction of T towards S, and likewise the Attraction of L towards S, at its mean Distance. Take S*r* to ST, in the duplicate Ratio of ST to SL; and S*n* to ST, in the same duplicate Ratio of ST to S*l*: then will S*r* and S*n* expound the Attractions of

the

the Body L towards S, in the Points L and *l* respectively. Complete the Parallelograms MSG*r*, and *t* S *g n*; then the Force, as *r* S, which expounds the Attraction towards S at the Point L, will by *Prop.* 3. be resolved into the two Forces *r* M and MS; and the Force *n* S, which expounds the Attraction towards S at the Point *l*, will be resolved into the Forces *n t* and *t* S.

Morgan, Thomas. *Philosophical Principles of Medecine*. Osborn, 1730.

B. Martin, 1754

> …the Moons, either of *Jupiter* or *Saturn* appear only as small Stars, and nearly in a right Line, because the Planes of their Orbits are nearly the same, and parallel to the Plane of the Earth's Orbit. As these Moons may be sometimes in the Shadow

of their Primaries, sometimes behind and before them, and sometimes one may intercept the View of another, it must happen that we can very rarely see them all together.

37. Such are the primary and secundary [sic] Planets, which compose our System. Of the Comets I shall speak by and by. Of all the primary Planets we know but little, excepting the *Earth* on which we live… [p. 97]

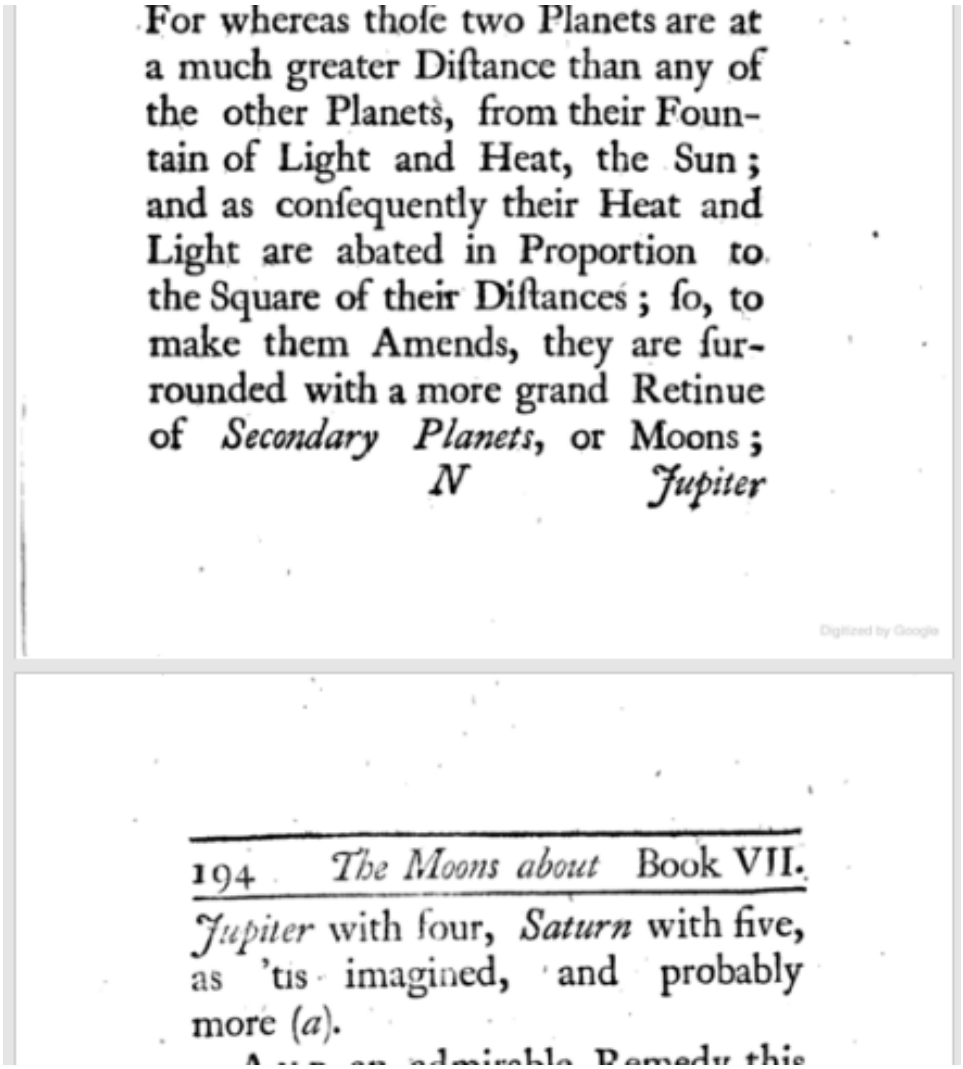
Martin, B., 1754. *A Plain and Familiar Introduction to the Newtonian Philosophy*. W. Owen.

William Derham, 1758

p. 188:

returneth again. Thus, as the Moon is a Moon to us, ſo the Earth is with great Reaſon concluded by the Philoſophers, to be a Moon to the Moon; not indeed a Secondary Planet moving periodically about her, but ſuch a Planet, as reflects the Light of the Sun to her, and perhaps makes ſuch like Returns of Influx, as I ſaid the Earth receives from her. For it is not to be doubted, if the Earth reflects Light, and gravitates to the Moon, as well as the Moon to the Earth (which is highly probable) but that there is a mutual Intercourſe and Return of their Influences, and good Offices. And this

p. 193:



For whereas thoſe two Planets are at a much greater Diſtance than any of the other Planets, from their Fountain of Light and Heat, the Sun; and as conſequently their Heat and Light are abated in Proportion to the Square of their Diſtances; ſo, to make them Amends, they are ſurrounded with a more grand Retinue of *Secondary Planets*, or Moons;

N *Jupiter*

194 *The Moons about* Book VII.

Jupiter with four, *Saturn* with five, as 'tis imagined, and probably more (*a*).

Derham, William. *Astro-theology*. J. Richardson, 1758.

Jean le Rond d'Alembert, ca. 1765

In the Encyclopédie, the famous encyclopedia of Enlightenment science:

> SATELLITE in Astronomical terms means secondary planets which move around a primary planet [*des planetes secondaires qui se meuvent au-tour d'une planete premiere*], like the Moon does in relation to the Earth. They are called so because these planets [*ces planetes*] always accompany their primary planet and make their revolution around the Sun with it… The Satellites of Jupiter are four small secondary planets [*quatre petites planetes secondaires*] which revolve around this planet as it itself revolves around the Sun… Galileo, to honor his patron, called

> these planets [*ces planetes*] the astra Medicea… The Satellites of Saturn are five small planets [*cinq petites planetes*] which turn around Saturn … One of these planets [*Une de ces planetes*], namely the fourth counting from Saturn, was discovered by M. Huygens on March 25, 1655… [transl. from French]

d'Alembert, Jean le Rond (ca. 1765). "Satellite." In: *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.*, eds. Denis Diderot and Jean le Rond d'Alembert. University of Chicago: ARTFL Encyclopédie Project (Autumn 2017 Edition), Robert Morrissey and Glenn Roe (eds), http://encyclopedie.uchicago.edu/.

An Anonymous Editor, 1767

A 1767 reprint with additions: de Fontenelle, M., *Conversations on the Plurality of Worlds, a New Translation from the Last Edition of the French, with Great Additions Extracted from the Best Modern Authors, on Many Curious and Entertaining Subjects*. T. Caslon (London: 1767).

[The following is from the "Great Additions", so this is current terminology to 1767:]

> The other sixteen are called *Planets.*
>
> *These are divided into two classes; six are called the* Primary Planets; *ten are called the* Secondary Planets. When we speak of the Planets without any distinction, we always understand the primary ones.
>
> *The Primary Planets move round the* Sun, and are carried at different distances from it, in curves that return into themselves.
>
> *A Secondary Planet revolves round a primary one,* and accompanies it in its motion round the *Sun*.

[Note the double use of "Planets" without adjective. It can mean all planets, or it can mean just the primary ones. For example, the footnote following is clear that it means both primary and secondary, but this is because it made the distinction in the following phrase:]

> The number of Planets, primary and secondary, their revolutions, distances, &c, &c, are particularly shewn in the Additions." [Footnote on P. 210.]

[Another passage from the text:]

> *Of the primary Planets, there are accompanied by secondary ones.*
>
> Five Planets, called Satellites, move about *Saturn*; four about *Jupiter*; one about the *Earth (viz.)* the *Moon.*

The secondary Planets, except the *Moon*, are not visible to the naked Eye.

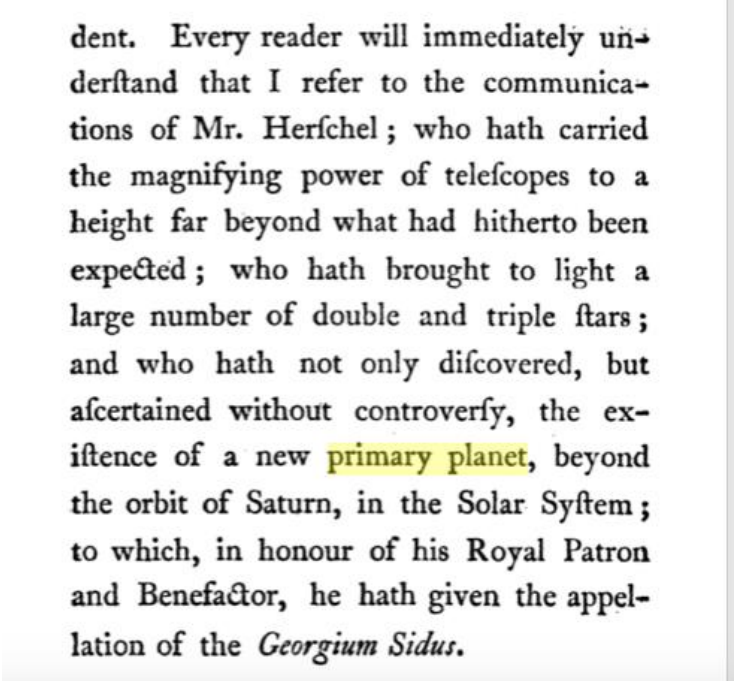
The Satellites, by lines drawn to the centre of the primary Planets, describe areas about them, proportional to the times; as hath been said of the primary Planets, with respect to the centre of the *Sun.*" p.61.

The section "On Comets" says that comets may actually be planets in highly eccentric orbits. A footnote on p. 103 also hints of this.

Anonymous. Additions to the 1767 edition. In: de Fontenelle, M., *Conversations on the Plurality of Worlds, a New Translation from the Last Edition of the French, with Great Additions Extracted from the Best Modern Authors, on Many Curious and Entertaining Subjects*. T. Caslon (London: 1767).

John Pringle and Andrew Kipp, 1783

[Note, in the following it was necessary to say primary because readers might assume otherwise that it was a secondary; because discovery of secondaries was well expected, and the word "planet" alone could thus be understood to mean a satellite.]

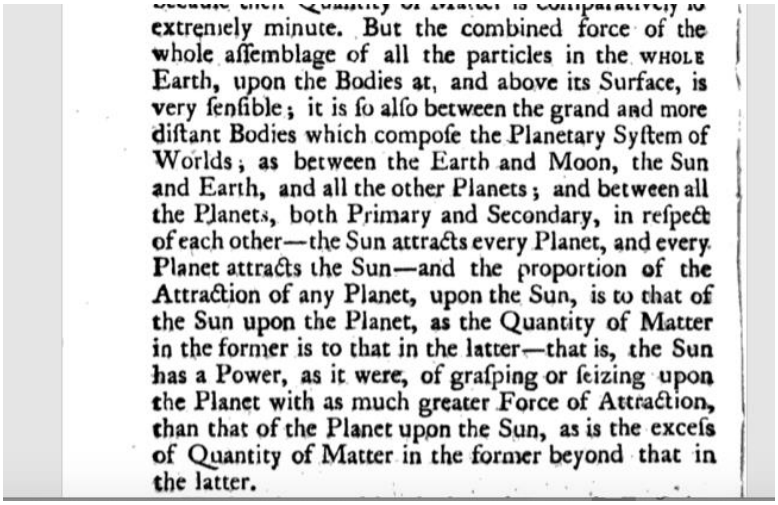


dent. Every reader will immediately underſtand that I refer to the communications of Mr. Herſchel; who hath carried the magnifying power of teleſcopes to a height far beyond what had hitherto been expected; who hath brought to light a large number of double and triple ſtars; and who hath not only diſcovered, but aſcertained without controverſy, the exiſtence of a new primary planet, beyond the orbit of Saturn, in the Solar Syſtem; to which, in honour of his Royal Patron and Benefactor, he hath given the appellation of the *Georgium Sidus*.

Pringle, John, and Andrew Kippis. *Six Discourses*. W. Strahan and T. Cadell, 1783.

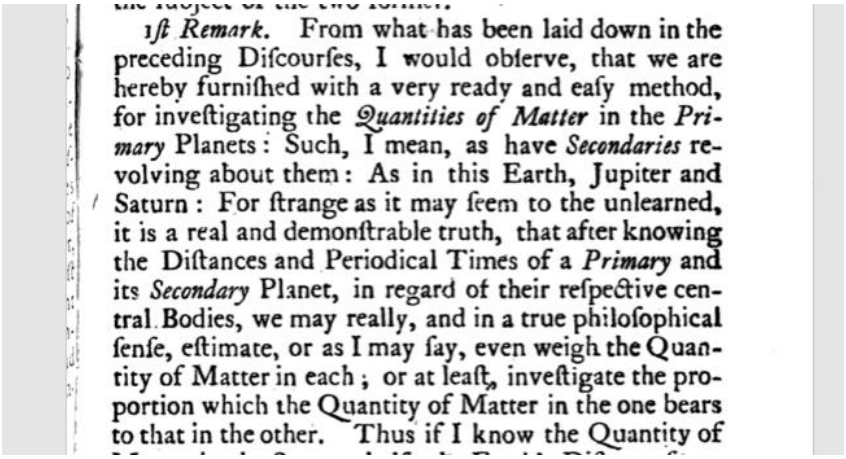
Nehemiah Strong, 1784

p. 10



extremely minute. But the combined force of the whole aſſemblage of all the particles in the WHOLE Earth, upon the Bodies at, and above its Surface, is very ſenſible; it is ſo alſo between the grand and more diſtant Bodies which compoſe the Planetary Syſtem of Worlds; as between the Earth and Moon, the Sun and Earth, and all the other Planets; and between all the Planets, both Primary and Secondary, in reſpect of each other—the Sun attracts every Planet, and every Planet attracts the Sun—and the proportion of the Attraction of any Planet, upon the Sun, is to that of the Sun upon the Planet, as the Quantity of Matter in the former is to that in the latter—that is, the Sun has a Power, as it were, of graſping or ſeizing upon the Planet with as much greater Force of Attraction, than that of the Planet upon the Sun, as is the exceſs of Quantity of Matter in the former beyond that in the latter.

p. 35:



1ſt Remark. From what has been laid down in the preceding Diſcourſes, I would obſerve, that we are hereby furniſhed with a very ready and eaſy method, for inveſtigating the *Quantities of Matter* in the *Primary* Planets: Such, I mean, as have *Secondaries* revolving about them: As in this Earth, Jupiter and Saturn: For ſtrange as it may ſeem to the unlearned, it is a real and demonſtrable truth, that after knowing the Diſtances and Periodical Times of a *Primary* and its *Secondary* Planet, in regard of their reſpective central Bodies, we may really, and in a true philoſophical ſenſe, eſtimate, or as I may ſay, even weigh the Quantity of Matter in each; or at leaſt, inveſtigate the proportion which the Quantity of Matter in the one bears to that in the other. Thus if I know the Quantity of

Strong, Nehemiah. *Astronomy Improved: Or, A New Theory of the Harmonious Regularity Observable in the Mechanism Or Movements of the Planetary System. In Three Lectures, Read in the Chapel of Yale-college, in New-Haven. Begun February 17, 1781...* Thomas & Samuel Green, 1784.

Jacques Antoine Joseph Cousin, 1787

> The celestial bodies that make up our planetary system are divided into primary planets [*planetes principales*] with the Sun as the center of their motion, and secondary planets [*planetes secondaires*], called *satellites* [italic in original], which revolve around the main planet… the moon's speed of rotation would be

> equal to the average speed of this planet around the earth…Before this explanation of the liberation of the moon, which M. de la Grange first gave in his memoir of 1764, we were obliged to suppose that the primitive speed of rotation, imparted to this planet, was exactly equal to its average speed of translation around the earth…. The Royal Academy of Sciences of Paris proposed, for the subject of the prize of the year 1774, to examine whether, having regard not only to the action of the sun, the earth and the other planets on the moon, but even to the non-spherical figure of the moon and the earth, one could explain by the sole theory of gravitation why the moon appears to have a secular equation. M. de la Grange, author of the winning piece, contents himself with examining the effect which may result from the non-sphericity of the two planets…" [transl. from French]

Cousin, Jacques Antoine Joseph. *Introduction à l'étude de l'astronomie physique*. De l'imprimerie de Didot l'ainé, chez la veuve Dessaint, 1787.

William Herschel, 1787

> …during those nine hours I saw this satellite faithfully attend its primary planet…I confess that this scene appeared to me with additional beauty, as the little secondary planets [Titania and Oberon] seemed to give a dignity to the primary one [Uranus], which raises it into a more conspicuous situation among the great bodies of our solar system.

Herschel, William. "XVI. An account of the discovery of two satellites revolving round the Georgian planet." *Philosophical Transactions of the Royal Society of London* 77 (1787): 125-129.

W. Nicholson, 1787

> Seven planets, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and the Georgium Sidus [footnote: This planet was discovered in the year 1781, by William Herschel, Esq. a native of Hanover.], revolve about the sun in orbits included within each other, in the order here used in mentioning their names, Mercury being nearest the Sun. These are called primary planets, besides which, there are ten which are called secondary planets, Moons or Satellites. The secondary planets respect the primary planets, performing their revolutions about them, but are at the same time carried round the Sun in the orbit of the primary. Saturn is attended by five Moons, Jupiter by four, and the Earth by one, all which, except the last, are invisible to us, by reason of their smallness and distance, unless telescopes be made use of. Without this instrument, it would likewise be impossible to ascertain the apparent diameters of any of the cœlestial bodies, the Sun and Moon excepted. The following table exhibits some of the affections of the primary planets. [pp. 124-125]

> Every primary planet moves with such a velocity and direction, that a line joining the centers of the planet and the Sun describes equal areas in equal times. Whence it follows, that the centripetal forces which retain these planets in their orbits are directed to the Sun's center.
>
> The periodical times of the primary planets are such, that their squares are directly inn proportion to the cubes of their mean distances from the Sun. Their orbits are elliptical, and their apsides quiescent. From these phenomena it is proved, that the centripetal forces are inversely as the squares of the distances from the Sun. Every secondary planet moves with such a velocity and direction, that a line joining the center of the secondary with that and its primary, describes equal areas in equal times. The centripetal forces retaining these bodies in their orbits consequently are directed to the centers of their respective primaries. [pp. 207-8]

Nicholson, W., 1787. *An introduction to natural philosophy* (Vol. 1). J. Johnson.

Achille Pierre Dionis Du Séjour, 1789

> The example of our Moon had learned that a Primary Planet could be accompanied by Secondary Planets which serve it as Satellites. [transl. from French]

Du Séjour, Achille Pierre Dionis. *Traité Analytique Des Mouvemens Apparens Des Corps Célestes: 2*. Vol. 2. Valade, 1789.

Johann Hieronymus Schröter, 1791

> Unter allen Planeten unsers Sonnensystems ist daher eine genauere Erforschung der Mondfläche vorzüglich geschickt, ihren Gang auch in andern Weltkörpern zu belauschen und daraus nach und nach die wichtigsten Folgerungen für das Ganze zu ziehen.

Translation:

> Among all the planets of our solar system, a more detailed exploration of the Moon's surface is therefore extremely well-suited for peering into the ways of nature on other world bodies, and to gradually draw the most important conclusions for the whole.

Schröter, Johann Hieronymus. *Selenotopographische Fragmente zur genauern Kenntniss der Mondfläche, ihrer erlittenen Veränderungen und Atmosphäre, sammt den dazu gehörigen Specialcharten und Zeichnungen*. Vol. 1. Verf., 1791.

William Herschel, 1795

The sun, viewed in this light, appears to be nothing else than a very eminent, large, and lucid planet, evidently the first, or in strictness of speaking, the only primary one of our system ; all others being truly secondary to it. Its similarity to the other globes of the solar system with regard to its solidity, its atmosphere, and its diversified surface; the rotation upon its axis, and the fall of heavy bodies, leads us on to sup pose that it is most probably also inhabited, like the rest of the planets, by beings whose organs are adapted to the peculiar circumstances of that vast globe.

… now I think myself authorized, *upon astronomical principles,* to propose the sun as an inhabitable world, and am persuaded that the foregoing observations, with the conclusions I have drawn from them, are fully sufficient to answer every objection that may be made against it.

… I shall now endeavour, by analogical reasonings, to support the ideas I have suggested concerning the construction and purposes of the sun; in order to which, it will be necessary to begin with such arguments as the nature of the case will admit, to shew that our moon is probably inhabited. This sa tellite is of all the heavenly bodies the nearest, and therefore

most within the reach of our telescopes. Accordingly we find, by repeated inspection, that we can with perfect confidence give the following account of it.

It is a secondary planet, of a considerable size ; the surface of which is diversified, like that of the earth, by mountains and vallies. Its situation, with respect to the sun, is much like that of the earth ; and, by a rotation on its axis, it enjoys an agreeable variety of seasons, and of day and night. To the moon, our globe will appear to be a very capital satellite:; undergoing the same regular changes of illuminations as the moon does to the earth. The sun, the planets, and the starry constellations of the heavens, will rise and set there as they do here; and heavy bodies will fall on the moon as they do on the earth. There seems only to be wanting, in order to complete the analogy, that it should be inhabited like the earth.

To this it may be objected, that we perceive no large seas in the moon; that its atmosphere (the existence of which has even been doubted by many) is extremely rare, and unfit for the purposes of animal life ; that its climates, its seasons, and the length of its days, totally differ from ours; that without dense clouds (which the moon has not), there can be no rain ; perhaps no rivers, no lakes/ In short, that, notwithstanding the similarity which has been pointed out, there seems to be a decided difference in the two planets we have compared.

> … Suppose also that the inhabitants of the satellites of Jupiter, Saturn, and the Georgian planet, were to look upon the primary ones, to which they belong, as mere attractive centres, to keep together their orbits, to direct their re volution round the sun, and to supply them with reflected light in the absence of direct illumination.
>
> … It is true that analogy may induce us to conclude, that since stars appear to be suns, and suns, according to the common opinion, are bodies that serve to enlighten, warm, and sustain a system of planets, we may have an idea of numberless globes that serve for the habitation of living creatures. But if these suns themselves are primary planets, we may see some thousands of them with our own eyes; and millions by the help of telescopes; |when at the same time, the same analogical reasoning still remains in full fbrcd, with regard to the planets which these suns may support.
>
> … lt should seem, therefore, highly probable that they, exist for themselves ; and, are, in fact, only very capital, *lucid*, primary planets, connected together in one great system of mutual support.
>
> … It seems, therefore, upon the whole not improbable that, in many cases, stars are united in such close systems as not to leave much room for the orbits of planets, or comets; and that consequently, upon this account also, many stars, unless we would make them mere useless brilliant points, may them selves be lucid planets, perhaps unattended by satellites.

[Note, considering sunspots to be volcanoes that peep above the sun's atmosphere, he calls stars "planets" upon conclusion that they are geologically complex and even supporting life. Note also then that the planets of those stars become "satellites" or attendants to their central star-planet.]

Herschel, William. "III. On the nature and construction of the sun and fixed stars." *Philosophical Transactions of the Royal Society of London* 85 (1795): 46-72.

Henry Patillo, 1796

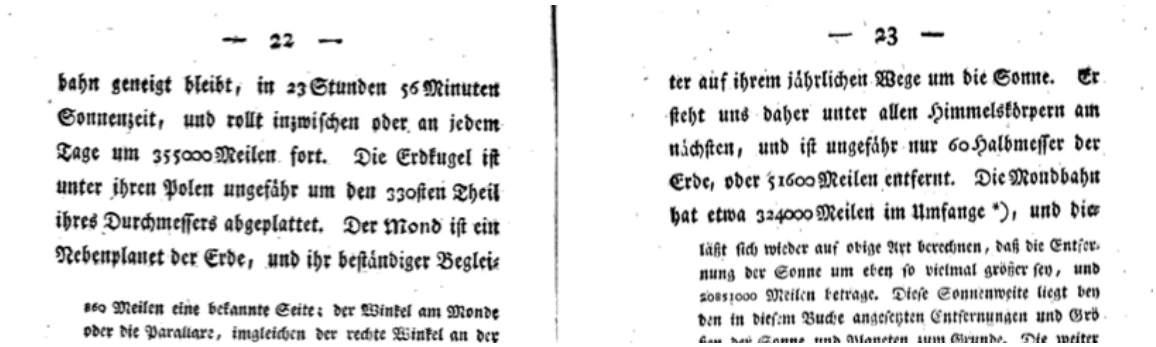
From a geography textbook:

> Q. 70. What is the distinction of primary and secondary, among the planets?
>
> A. The Earth is a primary planet; the Moon is a secondary, called a satellite, guard or attendant; and so of the rest.

Pattillo, Henry (1796). *A Geographical Catechism*. Halifax: Abraham Hodge, 1796. Reprinted in: Walker, N.S., and M. C. S. Noble, eds. *Patillo's Geographical Catechism,* University Reprints No. 1. Chapel Hill, N.C.: The University Press, 1909.

Examples from the 1800s:

<u>Johann Elert Bode, 1801</u>



— 22 —

bahn geneigt bleibt, in 23 Stunden 56 Minuten Sonnenzeit, und rollt inzwischen oder an jedem Tage um 355000 Meilen fort. Die Erdkugel ist unter ihren Polen ungefähr um den 330sten Theil ihres Durchmessers abgeplattet. Der Mond ist ein Nebenplanet der Erde, und ihr beständiger Begleis

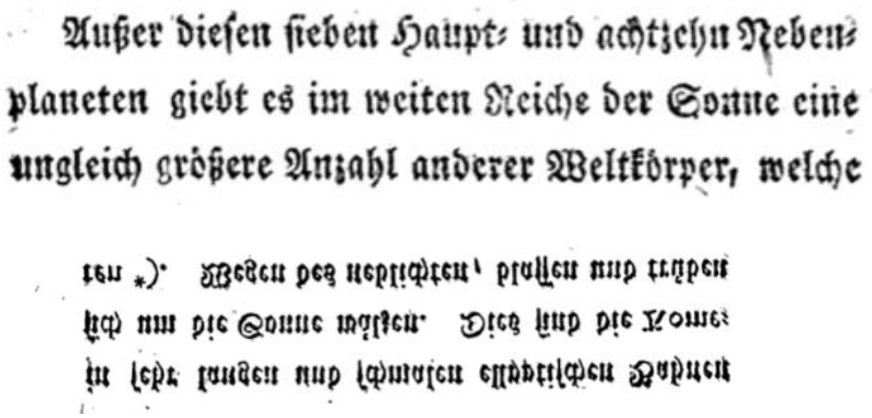
860 Meilen eine bekannte Seite: der Winkel am Monde oder die Parallaxe, imgleichen der rechte Winkel an der

— 23 —

ter auf ihrem jährlichen Wege um die Sonne. Er steht uns daher unter allen Himmelskörpern am nächsten, und ist ungefähr nur 60 Halbmesser der Erde, oder 51600 Meilen entfernt. Die Mondbahn hat etwa 324000 Meilen im Umfange *), und dies

läßt sich wieder auf obige Art berechnen, daß die Entfernung der Sonne um eben so vielmal größer sey, und 20851000 Meilen betrage. Diese Sonnenweite liegt bey den in diesem Buche angesetzten Entfernungen und Grö

Google Translation: "The moon is a subsidiary planet of the earth, and its constant companion on its annual journeys around the sun."



Außer diesen sieben Haupt- und achtzehn Neben-
planeten giebt es im weiten Reiche der Sonne eine
ungleich größere Anzahl anderer Weltkörper, welche

Google translation: In addition to these seven main and eighteen secondary planets there are in the vast realm of the sun a disproportionately larger number of other celestial bodies which roll around the sun in very long and narrow elliptical stretches. These are the comets

Bode, Johann Elert. *Allgemeine Betrachtungen ueber das Weltgebäude*. Himburg, 1801.

A. B. Woodward, 1801

> In addition to this general and common vortex, he [Descartes] assigned to each particular primary and satellitary planet, an appropriate subordinate vortex, which occasioned its axual [sic] revolution; and still another, to account for the circumvolution of the satellitary round the primary planets… Herschell [sic] of Germany, by his discovery of five additional planetary bodies in our system, two new satellites to a primary before known, and a new primary attended by new satellites, has in rendering that essential service to science, given immortality to his own name… We have unequivocal evidence that the body of each primary planet, and the body of the Sun, have a tendency to come to the same place. We have the same evidence that the body of each satellitary planet, and the body of its primary, have a similar tendency to come to the same place. We have also reason to believe that all the planets, both primary and satellitary, have a tendency to coalesce and occupy one place; because they are found, in their approximations, to disturb the motions of one another…

Woodward, A.B., 1801. *Considerations on the Substance of the Sun*. Metropolis of the United States of America: Printed by Way and Groff, September.

G. Adams, 1812

> Proceeding with attention in thus exploring and examining the heavens, he [a person examining the heavens from the position of the sun] will perceive that the Earth is always accompanied by a small star, Jupiter by four, Saturn by seven, and the Georgium Sidus by two: these sometimes precede, as others follow; now pass before, and then behind the planets they respectively attend. These small bodies he will call *secondary planets*, *satellites*, or *moons*. [p. 11]
>
> Dr. *Herschel* has since discovered that it is attended by six satellites: a discovery which gave him considerable pleasure, as the little secondary planets seemed to give a dignity to the primary one, and raise it into a more conspicuous situation among the great bodies of our solar system. [p. 52]
>
> OF THE SATELLITES OF JUPITER, SATURN, AND THE GEORGIUM SIDUS.
>
> The existence of all the satellites, except the moon, must have remained unknown, without the assistance of the telescope. By the assistance of this instrument, Jupiter is found to be attended by four, Saturn by seven, and the Georgium Sidus by six.
>
> The satellites are distinguished according to their places; into first, second, &c.; the first being that which is nearest to the planet. They revolve round their respective primaries in elliptic orbits, the primary planets being in the focus.

> The planes of the orbits of the secondary planets produces, intersect the heliocentric orbits of their primaries in two opposite points; which are called their nodes. [pp. 126-127]

Describing construction of an orrery:

> About the primary planets are placed the secondary planets, or moons, which are in this instrument only moveable by hand; but when the instrument is fitted upon a large scale, and in a more expensive form, even these are put in motion by the wheel-work…When the pupil has been gratified by putting the instrument in motion, and making his own observations on those motions, it will be proper to acquaint him with the names of the different planets, and of their division into primary and secondary, to shew him how they were first distinguished from the fixed stars, and how the length of their period revolution was discovered. [p. 394]

Adams, G., 1812. *Astronomical and Geographical Essays: Containing a Full and Comprehensive View, on a New Plan, of the General Principles of Astronomy, the Use of the Celestial and Terrestrial Globes... the Description and Use of the Most Improved Planetarium, Tellurian, and Lunarium, and Also an Introduction to Practical Astronomy*. Printed for, and sold by W. & S. Jones.

Guillaume von Freygang, 1804

> Can a volcano placed on the surface of the moon give these stones an impulse capable of transporting them beyond the sphere of activity of this planet (*planète*) [the Moon] into that of the earth? [transl. from French]

von Freygang, William [de Freygang, Guillaume] (1804). *Idées sur le phénomène des Aérolithes*. Göttingue: Henri Dieterich.

Noah Webster, 1807

> The moon is a small planet revolving around the earth.

Webster, Noah. *Elements of Useful Knowledge. Volume 1. Containing a historical and geographical account of The United States*. *For the Use of Schools.* 3rd Ed. New London: O.D. Cooke, 1807.

Johann Georg Prändel, 1813

> 1. Was sind Planeten?
>
> Antw. Es sind eine Art von Sternen, die ihren Ort am himmel beständig verändern. Sie haben kein eignes light, sondern werden von der Sonne erleuchtet.

Betrachtet man sie durch Fernröhre, so erscheinen sie als runde Scheiben, die mit einem matten, nicht funfelnden, mondähnlichen Lichte glänzen.

2. Mit welchen Sternen stehen demnach die Planeten im Gegensaze?

Antw. Mit den Fixtsternen; denn diese ändern ihren Ort nie gegen einander, haben ihr eignes Licht, und erscheinen durch die besten Fernröhre nicht scheibenartig, sondern immer nur als funkelnde Puntte.

3. Wo kommt das Wort Planet eigentlich her?

Antw. Es ist griechischen Ursprungs, und wird zunächst von planetoi, ein Irrender, abgeleitet. Zu Deutsch heissen sie also Wandel-sterne oder Irrsterne

4. Wie werden die Planeten abgetheilt?

Antw. In Hauptplaneten und Nebenplanetetn, Jene bewegen sich regelmässig um die Sonne, und diese um einen der hauptplaneten. Leztere werden auch zumweilen Trabanten genannt.

(…)

10. Worin irrten diessfalls die Alten?

Antw. Das sie Sonne und den Mond unter die Planeten aufnamen, da doch erstere wie bereits gesagt worden, ein Fixtstern, un lezterer nur ein Nebenplanet oder Trabant der Erde ist. Sie mussten auch nicht, dass die Erde selbst ein Planet sen, und Nebenplaneten liessen sie sich gar nichts träumen.

(…)

111. Welche Geschwindigseit habe diese Trabanten?

Antw. Der erste is nach Beispiele der eils hauptplaneten nicht allein unter seinen übrigen Gefährten, sondern auch unter allen Weltkörpern, die den Namen Planeten führen, der Geschwindeste; denn er hinterlegt jede Sekunde einen Weg von 8 1/8 Meilen.

TRANSLATION:

1. What are planets?

Answer: They are a kind of stars that are constantly changing their location in the sky. They do not have their own light, but are illuminated by the sun. When

viewed through a telescope, they appear as round disks that shine with a matt, non-sparkling, moon-like light.

2. With which stars are the planets in opposition?

Answer: With the fixed stars; for these never change their position against each other, have their own light, and do not appear disc-like through the best telescope, but always only as a sparkling point.

3. Where does the word planet actually come from?

Answer: It is of Greek origin, and is first derived from *planetoi*, a mistaken one [better: wandering one]. In German, they are called change stars or astronomical stars

4. How are the planets divided?

Answer: In major and minor planets, those move regularly around the sun, and these around one of the main planets. The latter are sometimes called satellites.

(…)

10. In which case were the earlier people wrong?

Answer: That they took the sun and the moon under the planets, since the former, as already said, is a fixed star, the latter is only a minor planet or satellite of the earth. Neither did they have to have the earth itself a planet, and they had no concept of secondary planets.

[Note how he calls satellites “secondary planets” and yet he says they were wrong for thinking the Moon to be a “planet”. The idea is that they did not recognize the Moon was a secondary planet because they had no concept of such a thing, and they were wrong for thinking the Moon was the same thing as the primaries. This does not mean he thinks secondary planets are not truly planets because his item 4, above, makes it clear that they are.]

(…)

111. What is the speed of these satellites? Answer: The first is, according to the examples of the main planet, not only among its other companions, but also among all the bodies of the world that bear the name "planet"; because it travels 8 1/8 miles every second.

Prändel, Johann Georg. *Das Wissenswürdigste unsers Planetensystems: Ein Seitenstud zur Prändl'schen Globuslehre. Zum Gebrauche aus Realscchulen und zur Selbstelehrung.* München: Franz Seraph Hübschmann, 1813.

B. Davies, 1815

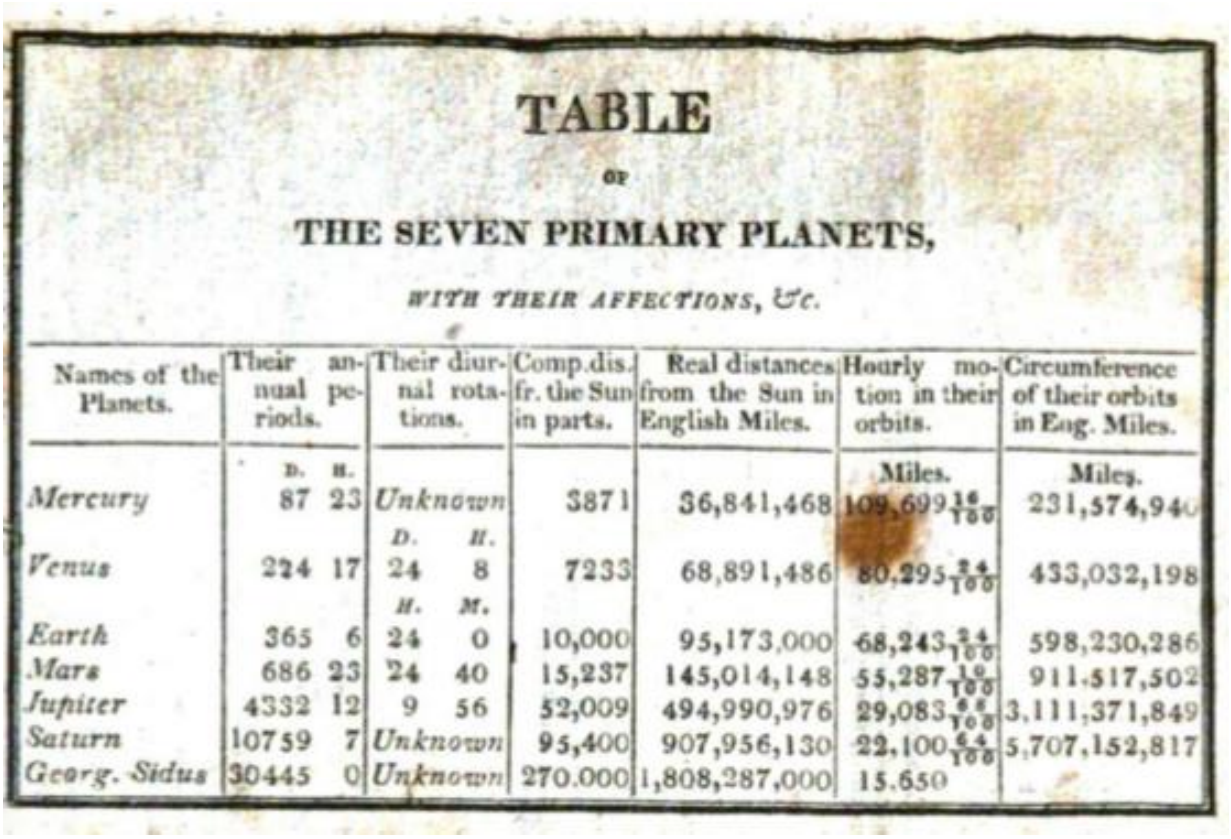
> The solar System consists of the Sun, seven *primary* planets, ten moons, and several comets; the number of the latter is not yet certainly known. [p. xiii]

Note: "primary" is in italic in the original, perhaps to emphasize that they are not the only planets.

> The names of the planets, in the order of their approximation to the centre of the Sun, are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and the Georgium Sidus." [p. xiii]

Note: it used "planet" only for the primary ones in the above context, although he has just introduced the "primary planet" terminology. Perhaps having just emphasized it he feels it is not necessary to repeat the adjective again?

The list of planets is labeled "THE SEVEN PRIMARY PLANETS":



TABLE

OF

THE SEVEN PRIMARY PLANETS,

WITH THEIR AFFECTIONS, &c.

Names of the Planets.	Their annual periods.	Their diurnal rotations.	Comp.dis. fr. the Sun in parts.	Real distances from the Sun in English Miles.	Hourly motion in their orbits.	Circumference of their orbits in Eng. Miles.
	D. H.				Miles.	Miles.
Mercury	87 23	*Unknown*	3871	36,841,468	109,699 16/100	231,574,940
		D. H.				
Venus	224 17	24 8	7233	68,891,486	80,295 24/100	433,032,198
		H. M.				
Earth	365 6	24 0	10,000	95,173,000	68,243 24/100	598,230,286
Mars	686 23	24 40	15,237	145,014,148	55,287 10/100	911,517,502
Jupiter	4332 12	9 56	52,009	494,990,976	29,083 66/100	3,111,371,849
Saturn	10759 7	*Unknown*	95,400	907,956,130	22,100 64/100	5,707,152,817
Georg. Sidus	30445 0	*Unknown*	270.000	1,808,287,000	15,650	

No mention of asteroids or Ceres in these lisst. Apparently, these had not been worked into the text, although Ceres was discovered in 1801. Versions of this book include 1805, 1810, 1814, 1815, 1822 (others?). The 1822 edition adds this:

> *Asteroids*. These bodies were entirely unknown, till the commencement of the present century. They appear the size of stars of the 8th magnitude. It was owing to their diminutive size, that Herschel refused them a place among the planets, and gave them the name of Asteroids, though they are really primary planets, revolving round the sun.

Note, he said it was not their sharing of orbits but their diminutive size that made Herschel want to demote them. This was an oversimplification of Herschel's position, but it represented what Davies in 1822 thought was Herschel's important point. Davies himself was happy keeping such small bodies as planets, or more likely he was representing that *the astronomical community* was happy with that choice, showing that their *primary planet* concept at the time included smaller bodies. He added "revolving around the sun" to this statement, which should have been obvious, so its inclusion was apparently intended as the justification for keeping asteroids as small planets. It is not a complete definition of *primary planet* because it says nothing about comets, but it shows inclusiveness for things orbiting the Sun regardless of their size. His assumption that this single phrase was a self-evident justification reveals that this was probably the broadly accepted view at the time.

Davies, B., 1815. *A New System of Modern Geography: Or, A General Description of the Most Remarkable Countries Throughout the Known World... Containing Many Important Additions to the Geography of the United States, that Have Never Appeared in Any Other Work of the Kind*. Johnson & Warner.

William Phillips, 1817

> Of all the planets, the path of no one is more delusive than that of the Moon.

Phillips, William. *Eight familiar lectures on astronomy intended as an introduction to the science, for the use of young persons, and others not conversant with the mathematics*. London: William Phillips, 1817.

T. Squire, 1818

This is only a work for lower-level schools, but it reflects the same view scientists were demonstrating.

> 67. The Solar system consists of the Sun [symbol] in the Centre ; of seven *primary planets*, Mercury [symbol], Venus [symbol], the Earth [symbol], Mars ♂, Jupiter [symbol], Saturn [symbol], and Herschel [symbol] ; and of four *Asteroids*, or minor planets, Vesta [symbol], Juno [symbol], Ceres [symbol], and Pallas [symbol]. (*See Fig.* 10, *Plate 11.*)

68. It contains, besides *secondary planets*, the *one* Moon of the Earth, the *four* Satellites, or Moons of Jupiter, the *seven* Satellites of Saturn, and *six* belonging to the planet Herschel ; and also of a considerable number of Comets. [p. 28]

(…)

117. The primary Planets of the Solar System are those which revolve round the Sun as a common centre. The number already known is seven : Mercury, Venus, Terra, (the Earth,) Mars, Jupiter, Saturn, and Herschel. *(Art.* 67*)*

118. The four small telescopic Planets, which Dr. Herschel has called *Asteroids*, moving between the orbits of Mars and Jupiter, are properly *primary* Planets ; their names are Vesta, Juno, Ceres, and Pallas. *(Art.* 67*)*

[now in smaller font] *Obs.* The above are called primary Planets, in contradistinction to the secondary Planets or Satellites, which revolve about their respective primaries. (*Art.* 68) [p. 47]

(…)

Vesta [symbol].

129. This small telescopic Planet completes its revolution round the Sun in 1335 days, 4 hours, 55 minutes, 12 seconds, at the mean distance of 225,435,000 miles. *(Art.* 73.*)* [p. 55]

(…)

These anomalous bodies, so unlike the other primary planets, Dr. Herschel has denominated Asteroids. Probably they are the fragments of some comet ; or perhaps other similar bodies abound the solar system, though they have hitherto, from their smallness or darkness, escaped observation. [p. 57]

(…)

152. The Satellites, or secondary planets, are those which accompany and move round some primary planets, as their centre of motion, in the same manner as the primary planets move round the sun. [new paragraph] 153. The number of Satellites in the Solar System, at present known, is eighteen ; namely, the moon ; four belonging to Jupiter, seven to Saturn, and six to Uranus. [new paragraph] 154. The motion of a secondary planet is not so uniform as that of a primary, owing to the unequal action of the sun upon it in different parts of its orbit. [p. 67]

Squire, T., 1818. *A Popular Grammar of the Elements of Astronomy: Adapted to the Use of Students and Public Schools*. J. Souter.

J. Mitchell, 1819.

> By it [gravitation] also the satellites of Jupiter, Saturn, and Hershel, are kept near their primaries.

Mitchell, J., 1819. *The Elements of Natural Philosophy: Illustrated Throughout by Experiments which May be Performed Without Regular Apparatus*. T. and J. Allman.

O. Gregory, 1824

> Correctly speaking, the Satellites are Planets, as well as those round which they revolve: for *planet* is a Greek word, signifying any thing that wanders. Agreeably to this acceptation, the Sun itself is a Planet; as it, like the others, has a two-fold motion. And indeed, to complete the similarity, Dr. Herschel has (in a paper which will be presently more largely spoken of) asserted, that his body is opaque, and that it is diversified with hills and valleys. [pp. 6-7, footnotes]

Note that he prefaced this with "Correctly speaking", which implies that there was "incorrect" speaking occurring at that time listing only the primaries as planets, which he wanted to correct. This suggests that the public by this time was developing the folk taxonomy, although it has not yet shown up in print outside of the astrological almanacs.

> This beautiful luminary [the Moon], whose gentle beams render the summer evenings more agreeable, and the winder nights less unpleasant, is a secondary planet; being a satellite to the Earth we inhabit, about which she revolves… [p. 47]

> *Apoge* [sic] is that place in which the Sun, or a planet primary or secondary, is at its greatest distance from Earth." [p. 47 in the footnote]

> Besides these seven primary planets, there are fourteen others, called secondary planets, or satellites, which move round their primaries in the same manner as those move round the sun. [p, 397]

Gregory, O., 1824. *Lessons, Astronomical and Philosophical, for the Amusement and Instruction of British Youth: Being an Attempt to Explain... the Most Usual Appearances in Nature...* BJ Holdsworth.

William Cole, 1823

adopted.

It is said that more than five hundred comets have been noticed, as appearing in our system, of which only three are supposed to have regularly returned. If this be correct, their number must be very great; a circumstance that appears very extraordinary, if they be considered as permanent parts of our system, especially when compared with the number of the primary planets.

We know nothing of the uses of comets

Cole, William. *Philosophical Remarks on the Theory of Comets: To which is Subjoined, a Dissertation on the Nature and Properties of Light*. J. Barfield, 1823.

William Coldwell, 1826

> In astronomy, we have a central sun, primary planets, and secondary also: but every primary planet has not its secondary ; yea, while some primary planets have no secondary, others have more than one.

Coldwell, Wm. "ANALYSIS OF GEOLOGY." *The Imperial magazine* 8, no. 96 (1826): 1113-1119.

Richard Brookes, 1827

The Secondary Planets.

Beside the primary planets, there are eighteen others, called secondary planets, satellites, or moons, which revolve round their primaries in the same manner as those primaries do round the Sun; namely, the Moon, which attends our Earth; the four satellites of Jupiter; the seven that belong to Saturn; and the six that attend the Georgian. From the continual change of their phases or appearances, it is evident that they also are opaque bodies, and shine only by the reflecting the light which they receive from the Sun.

The MOON, which is the constant attendant of our globe, is the most conspicuous of these satellites. She accompanies the Earth in its annual progress through the heavens, and revolves round it continually by a different motion, in 29 days, 12 hours, and 44 minutes, which is called a month. The diameter of the Moon is 2180 miles; her distance from the Earth

Brookes, Richard. *The general gazetteer: or, Compendious geographical dictionary...* C. and J. Rivington, 1827.

John Vose, 1827

p. xiv:

The Copernican system is now universally received by astronomers. The revolution of Mercury and Venus round the sun, was discovered by some of the ancient Egyptians. Afterwards, Pythagoras,

500 years before the christian era, privately taught his disciples the true solar system. But it was rejected and nearly lost, till revived by Copernicus, a native of Thon, in Polish Prussia, and by him published in 1530. " Here the sun is placed in the centre of the system, about which the planets revolve from west to east. Beyond these, at an immense distance, are placed the fixed stars. The moon revolves round the earth; and the earth turns about its axis. The other secondary planets move round their primaries from west to east, at different distances, and in different periodical times."

It will be seen, that the satellites of Herschel form an exception to the regular motion of secondaries.

P. 31:

The word *Planet*, is derived from the Latin *Planeta*.—This is of Greek origin, being derived from PLANAŌ, *I wander, or cause to wander*. The root, or original word, seems to be a Greek primitive, PLANEE, *error or wandering*. Eleven primary planets have been discovered; Mercury, Venus, the Earth, Mars, Vesta, Juno, Ceres, Pallas, Jupiter, Saturn, and Herschel. These all revolve round the sun from west to east in elliptical orbits. (*Plate I. Fig.* 1.)

There are eighteen secondary planets. The earth has one; Jupiter, four; Saturn, seven; and Herschel, six.—The discoveries of the last half century warrant the expectation, that the number of planets, both primary and secondary, may yet be greatly increased.

All the primary planets are subject to two great fundamental laws, discovered by Kepler, and from him called the great laws of Kepler.

Note: "…the number of planets, both primary and secondary…"

PALLAS.

Pallas was discovered by Dr. Olbers on the 28th of March, 1802. It is nearly of the same magnitude as Ceres; but of a less ruddy colour. It is surrounded with a nebulosity, similar to that of Ceres, and almost equally extended. It resembles Juno in the eccentricity of its orbit. This planet is distinguished from all the rest of the primary planets, by the great inclination, of its orbit to the ecliptic, being about 35°; nearly five times greater than that of Mercury.

The primary planets can be eclipsed by their secondaries only ; and the secondaries, by their primaries. The earth's shadow eclipses the moon ; the moon's shadow the earth ;— eclipses of the sun, as they are called, being more properly eclipses of the earth. Sanctioned by long established usage, however, the term "eclipses of the sun" will be retained.

Vose, John. *A System of Astronomy: On the Principles of Copernicus*. JB Moore, 1827.

Francis Baily, 1827

THE number of satellites in our system, at present known, is eighteen: namely, the *Moon* which revolves round the Earth, *four* that belong to Jupiter, *seven* to Saturn, and *six* to Uranus. The moon is the only one visible to the naked eye.

They all move round their respective primary planets, as their centre, by the same laws as those primary ones move round the sun: namely,

1°. The orbit of each satellite is an ellipse, of which the primary planet occupies one of the foci.

2°. The areas, described about the primary planet, by the radius vector of the satellite, are proportional to the times employed in describing them.

3°. The squares of the times of the revolutions of the satellites, round their respective primary planets, are to each other as the cubes of their mean distances from the primary.

THE number of planets belonging to our system is eleven. Six of these have been known and recognised from time immemorial: namely *Mercury*, *Venus*, the *Earth*, *Mars*, *Jupiter*, and *Saturn*. But, the remaining five, which are not visible to the naked eye, have lately been discovered by the help of the telescope; and are therefore called *telescopic planets*: namely,

Uranus, discov. by	Sir W. Herschel,	March 13, 1781.
Ceres, ...	M. Piazzi,	January 1, 1801.
Pallas, ...	M. Olbers,	March 28, 1802.
Juno, ...	M. Harding,	Septem. 1, 1804.
Vesta, ...	M. Olbers,	March 29, 1807.

All these planets revolve round the sun, as the centre of motion: and in performing their revolutions they follow the fundamental laws of planetary motion so happily discovered by Kepler; and which have been fully confirmed by subsequent observations. These laws are,

1°. The orbit of each planet is an ellipse; of which the

Baily, Francis. *Astronomical tables and formulæ together with a variety of problems explanatory of their use and application: to which are prefixed the elements of the solar system*. John Richardson, 1827.

A. Picquot, 1828

ARTICLE 1.—*Of the Secondary Planets in general.*

624. THE secondary planets, moons, or satellites, are those that circulate round some of the primary planets, and accompany them in their revolutions round the sun. There are eighteen secondary planets; of which

one, the moon, belongs to the earth; four to Jupiter, seven to Saturn, and six to Herschel. Of these the moon, being the most apparent, has been known from the earliest period, and has, probably, served to divide time into months: but the satellites of Jupiter, Saturn, and Herschel, have been discovered only since the invention of the telescope, without the aid of which they cannot be perceived, at least generally speaking, for we have known persons who saw the largest satellite of Jupiter with their naked eye. These satellites have not had any names assigned to them; they are distinguished only by that of first, second, third, &c. satellite, according to their relative distances from their primary planet.

625. The secondary planets have all a true, or real, motion round their primaries, from west to east, and describe elliptical orbits, in the lower focus of which the primary is situate; but, owing to the situation of Jupiter, Saturn, and Herschel, beyond the orbit of the earth, the motion of their satellites is subject to the same apparent irregularities, that are observed from the earth in respect to the inferior planets: we see them, therefore, move

sometimes from west to east, sometimes from east to west, whilst, at other times, they remain stationary. The motion of these satellites is direct only when they are situate in the upper part of their orbits, or in that part of it that is most distant from the earth: when they happen to be in the lower part of their orbits, their motion appears retrograde, or from east to west.

626. Since the secondary planets move in elliptical orbits, one of the foci of which is occupied by the primary round which they circulate, they must be evidently further from the centre of their motion at one period of their revolution, than at the other. This is found to be the case in respect to the moon, whose distance from the earth in apogee, and in perigee (409), is in the ratio of 19 to 17. It is, however, necessary to observe here, that the motions of the secondary planets are less uniform than those of the primary planets: this irregularity, which renders all calculations relative to the satellites

more difficult, arises, not only from the combined attractions of their primaries, but also from that of the sun, which must sensibly operate upon these small masses, and which is greater or less, according as the primary and his satellites are more or less distant from the sun. Notwithstanding the irregularities arising from these perturbations, it is still found that the laws by which the motions of all the secondary planets are regulated, resemble, in every respect, those that regulate the motions of the primary planets; and that the celebrated laws of Kepler apply equally both to the one and to the other. It must be, therefore, laid down as a principle: 1st, That the secondary planets move in elliptical orbits (371); 2d, That they describe equal areas of their orbits in equal times (372); and 3d, That the squares of their periodical times are to one another, as the cubes of their mean distances from their primary planets (373).

627. The revolution of a secondary planet is either *periodical* or *synodical* (470). The periodical revolution of a satellite is the time it employs in revolving round its primary, in respect to a fixed point of the heavens, or the time that elapses between the departure of the satellite from any star or point, to its return to this same star, after one complete revolution about its primary planet. The synodical revolution of the moon is the interval of time between one of her conjunctions with the sun, and her next similar conjunction; and the synodical revolution of the other satellites is the time between any two of their inferior conjunctions with their respective primaries. If the primary planets were at rest, there would be no difference between these periodical and these synodical revolutions; but as, whilst the secondary planets are revolving round their primaries, the latter pursue their course in their orbits round the sun, before they can be again in conjunction, or correspond to the same point of the heavens, the satellites must pass over the different arcs, through which their primaries have moved during the revolution of the former round the latter. Hence, the synodical revolution of a secondary planet exceeds its

periodical revolution, by the time that the former employs in overtaking the latter, and in once more corresponding to the same fixed point of the heavens. Thus, the moon completes her periodical revolution in 27 days, 7 hours, 43 minutes; but she employs 29 days, 12 hours, 44 minutes, in accomplishing her synodical revolution.

628. It has been ascertained, that the moon, and the satellites of Jupiter, turn upon their axes in the same time they employ in revolving round their respective primaries.

629. The distance of the other satellites from the earth is so very considerable, that it has not been yet ascertained whether they have a rotation or not; analogy leads us to conclude, however, not only that they have this motion, in common with all the other planets, but moreover that their rotation is performed in the same space of time that they employ in completing their respective revolutions round their primary planets: whence we are, perhaps, justified in drawing as a conclusion, that a perfect equality, in the time of their rotation and of their revolution, is a general law of the motion of the secondary planets.

This same book (above), earlier listed only the primary planets calling them simply “planets”, so it was not uncommon to use that as shorthand even when no intention existed to make the moons into non-planets:

501. There are eleven planets, viz.

Mercury	☿	Juno	⚵
Venus	♀	Vesta	⚶
The Earth	⊕	Jupiter	♃
Mars	♂	Saturn.....	♄
Ceres	⚳	Herschel	♅
Pallas	⚴		

A few paragraphs later this book introduces secondary planets:

505. The planets are generally divided into *primary* and *secondary* planets.

506. The primary planets are those which move round the sun, who is placed in one of the foci of their orbits: they are Mercury, Venus, the Earth, Mars, Ceres, Pallas, Juno, Vesta, Jupiter, Saturn, and Herschel, or Georgium Sidus.

507. The secondary planets, satellites, or moons, are those that turn round some one of the primary planets, and accompany them in their revolution round the sun: they are the moon, and the satellites of Jupiter, of Saturn, and of Herschel.

Picquot, A. *Elements of Astronomy: Containing an Accurate... Description of the General Phœnomena of the Heavens... To which is Prefixed, an Historical Sketch of the Rise and Progress Astronomy...* J. Poynton, 1828.

John Herschel, 1834

I. On the Satellites of *Uranus*. By Sir J. Herschel.

This paper, dated from Portsmouth, on the eve of the author's departure for the Cape of Good Hope in November last, contains an investigation of the motions of two of the satellites of *Uranus*.

Notwithstanding the remarkable peculiarities presented by the satellites of this planet, in the great inclinations of their orbits to the orbit of the primary planet, and their retrograde motions, they have never been observed, or even seen (so far as the author is aware), except in the telescope with which they were originally discovered. In a paper of the late Sir William Herschel, published in the *Philosophical Transactions* for 1815, and containing the whole series of his observations on these satellites, the existence of at least two of them appears to be placed beyond a doubt. But since that time the unfavourable situation of the planet, to the south of the equator, has opposed a serious obstacle to their re-observation, even with telescopes of the highest optical capacity. Since the year 1828, the author has made repeated observations upon two of the satellites with the 20-feet reflector at Slough, from which he has deduced an approximate determination of their orbits.

Herschel, John. "On the satellites of Uranus." *Monthly Notices of the Royal Astronomical Society* 3 (1834): 35-38.

Theodore Strong, 1836

The application of what has been done to the solar system is easy, for in the case of a primary planet or a comet disturbed by the attractions of the other planets, we are to consider M′ as denoting the sun's mass, m that of the disturbed planet or comet, and m', m'', &c. as the masses of the disturbing planets; but in the case of a secondary planet revolving around its primary, and disturbed in its motion by other secondaries revolving around the same primary,

M′ will denote the mass of the primary, m that of the secondary, which is disturbed, and m', m'', &c. will denote the masses of the disturbing secondaries; but as the method of finding the integrals which are indicated in (B), and in the values of δr, δv, δs, is too long to be inserted here, we shall refer to p. 362, Vol. I of Pontecoulant's Systeme du Monde, where the value of F which he has given, denotes the value of R, that is to be used in computing the sec-

Strong, Theodore. American Journal of Science and Arts (1820-1879); New Haven Vol. 30, Iss. 2, (Jan 3, 1836): 248.

Wilhelm Beer and Johann Heinrich Madler, 1837

Der Mond, der einzige von allen Himmelskörpen der sich wirklich um unsere Erde bewegt, gehört zur Klasse der Nebenplaneten oder Trabanten, welche die Hauptplaneten auf ihrer Reise um die Sonne begleiten.

(…)

Von der ersten blos sinnlichen Wahrnemung unseres Nebenplaneten bis zu dem grossen Weisen, der uns die innersten Geheimnisse der Schöpfung durch seine allgewaltige Analysis aufschloss und das Dunkel, was die schlecht viele Stufen zu Wahrheit auf.

(…)

Nicht wahrscheinlich ist es, dass auf unserm Nebenplanetem Alles, bis ins Kleinste hinein, so starr und unveränderich sein sollte als es sich im Grossen und Ganzen zeicht, und wenn fast gegen alle bischerigen aus solche Veränderungen sich beziehended Behauptungen unsre Opposition geltend machen zu müssen geglaubt haben, so möchten wir doch andrerseits keinesweges von weiteren Forschungen abschrecken, die gewiss aller Angstrengung werth sind.

Google translation (not very good):

> The Moon, the only one of all celestial bodies [*Himmelskörpen*] that really moves around our earth, belongs to the class of secondary planets [*Nebenplaneten*] or satellites, which accompany the main planets [*Hauptplaneten*] on their journey around the sun.
>
> (…)
>
> From the first purely sensual perception of our secondary planet [*Nebenplaneten*] to the great sage who unlocked the innermost secrets of creation for us through his all-powerful analysis and the darkness, which uncovered many levels of truth.
>
> (…)
>
> It is not probable that everything on our neighboring planet [*Nebenplanetem*], down to the smallest detail, should be as rigid and unchangeable as it is on the whole, and if almost all minor statements relating to such changes believe that our opposition must be asserted on the other hand, we do not wish to deter further research, which is certainly worth all efforts.

Beer, Wilhelm, and Johann Heinrich Madler. *Der Mond nach seinen komischen und individuellen Verhaltnissen oder allgemeine vergleichende Selenographie: mit besondrer Beziehung auf die Verfassern herausgegebene Mapppa Selenographica*. Schropp, 1837.

Johann Michael Fick, 1837

> One divides the Planets:
> 1) in Main-Planets [Haupt-Planeten], and
> 2) in Lesser-Planets [Neben-Planeten], satellites or moons. [transl. from German]

Fick, Johann Michael. *Allgemein faßliche und vollständige Globus-Lehre: für den öffentlichen und Privat-Unterricht...:* mit 8 Abb. in Steindr. Kollmann, 1837.

Thomas Dick, 1838

> A secondary planet or satellite is a body which revolves around a primary planet as the centre of its motion, and which is at the same time carried along with its primary round the sun. [p. 224]
>
> No *moon* or secondary planet has yet been discovered about Mars ; yet this is no proof that it is destitute of such an attendant ; for as all the secondary planets are much less than their primaries, and as Mars ranks among the smallest planets of the system, its satellite, if any exist, must be extremely small. [p. 122]

> It is probable that all these four bodies [asteroids] are less in size than the secondary planets, or the satellites of Jupiter, Saturn, and Uranus. [p. 138]
>
> It was a law discovered by Kepler, by which all the planets, both primary and secondary, are regulated, "That the squares of the periodic times of the planets' revolutions are as the cubes of their distances. [p. 40]

Dick, Thomas. Celestial Scenery. (Harper & Brothers, New York), 1838.

R. G. Parker, 1838

> The solar system consists of the sun, which is in the centre ; [new line] Of seven *primary* planets, named Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Herschel ; [new line] Of four Asteroids, or smaller planets, namely, Ceres, Pallas, Juno, and Vesta ; [new line] Of eighteen secondary planets or moons, of which the Earth has one, Jupiter four, Saturn seven, and Herschel six ; and [new line] Of an unknown number of comets. [p. 173]

Having introduced the seven as "primary planets", the rest of the text mostly calls them just planets without explanation for the dropped adjective.

Asteroids are considered a type of planet, as this shows:

> Fig. 135 represents a section of the plane of the ecliptic, showing the inclination of the orbits of the planets. As the zodiac extends only eight degrees on each side of the ecliptic, it appears from the figure that the orbits of some of the planets are wholly in the zodiac, while those of others rise above and descend below it. Thus, the orbits of Juno, Ceres, and Pallas rise above, while those of all the other planets are confined to the zodiac. [p. 179]

[Note it includes Vesta in the figure as one of the planets that is confined to the zodiac.]

> It appears to be a general law of satellites, or moons, that they turn on their axes in the same time *in which they revolve around their primaries.* On this account, the inhabitants of secondary planets observe some singular appearances, which the inhabitants of primary planets do not. Those who dwell on the side of a secondary planet next to the primary, will always see that primary ; while those who live on the opposite side will never see it. Those who always see the primary, will see it constant in very nearly the same place. [p. 193]
>
> The moon is a secondary planet, revolving about the earth, in about 27 ¼ days. [p. 197]
>
> The word comet is derived from a Greek word, which means *hair* ; and this name is given to a numerous class of bodies, which occasionally visit, and appear to

> belong to the solar system. These bodies seem to consist of a nucleus, attended with a lucid haze, sometimes resembling flowing hair ; from whence the name is derived. Some comets seem to consist wholly of this hazy or hairy appearance, which is frequently called the *tail* of the comet. [p. 193]
>
> It has been argued that comets consist of very little solid substance, because, although they sometimes approach very near to the other heavenly bodies, they apper to exert no sensible attractive force upon those bodies. [p. 194]

Parker, R. G. *The Boston School Compendium of Natural and Experimental Philosophy*. (1838).

[The 15th edition was printed in 1846.]

Gustave de Pontécoulant, 1840

> Some of the planets are accompanied by smaller stars which circulate around them like the moon around the earth. These secondary planets [planètes secondaires] are called satellites … Secondary planets which circulate around some of the principal planets [planètes principals]. [transl. from French]

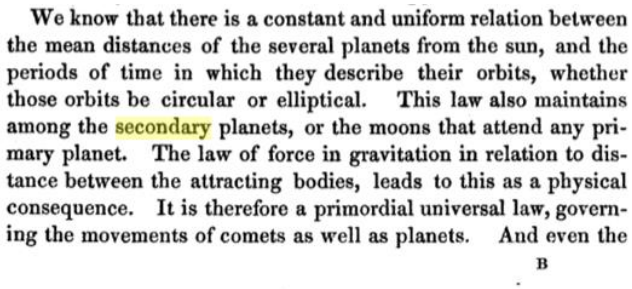
de Pontécoulant, Gustave. *Traité élémentaire de physique céleste, ou Précis d'astronomie théorique et pratique, servant d'introduction à l'étude de cette science.* Vol. 2. Carilian-Goeury, 1840.

John Hubbard Wilkins, 1841

> The true Solar system, or, as it is sometimes called, the Copernican system, consists of the sun and an unknown number of bodies opaque, like our earth; all of which bodies revolve round the sun, and some of which at the same time revolve round others. Those which revolve round the sun only, are called primary planets and comets. Those which revolve round a primary planet, at the same time that they are revolving round the sun, are called secondary planets moons or satellites…. The sun and all the planets, primary and secondary, are globular, though not perfect globes.

Wilkins, John Hubbard. *Elements of astronomy*. Boston: SG Simpkins, 1841.

John Wallis, 1845



We know that there is a constant and uniform relation between the mean distances of the several planets from the sun, and the periods of time in which they describe their orbits, whether those orbits be circular or elliptical. This law also maintains among the secondary planets, or the moons that attend any primary planet. The law of force in gravitation in relation to distance between the attracting bodies, leads to this as a physical consequence. It is therefore a primordial universal law, governing the movements of comets as well as planets. And even the

B

Wallis, John. *A Brief Examination of the nebulous Hypothesis, with strictures on a work [by R. Chambers] entitled Vestiges of the natural history of Creation*. R. Groombridge & Sons, 1845.

James Cornwell, 1847

> The Sun, with the bodies which go round it, compose the Solar system. These bodies are either Planets or Comets….The Planets are either Primary or Secondary… The Secondary Planets are the moons of the primary planets, round which they revolve. The Earth has one moon, Jupiter four, Saturn seven, and Herschel [Uranus], perhaps, six.

Cornwell, James. *A School Geography*. London: Simpkin, Marshall & Company; Hamilton, Adams & Company, 1847.

J. C. Adams, 1847

> In consequence of the near commensurability of the mean motions of *Uranus* and *Neptune*, their mutual perturbations, when fully developed, will greatly exceed any others which occur in the system of the primary planets.

Adams, J. C. "Ephemerides of Neptune." *xy* 7 (1847): 285.

J. S. C. Abbott, 1847

This is a book for younger grade levels but it reflects knowledge of the taxonomy used by scientists.

> All those solid celestial bodies resembling the Earth, which revolve round the Sun, are called planets. They are divided into the primary and the secondary. The primary planets are those which revolve around the Sun as a centre. There are twelve of them now discovered ; Mercury, Venus, the Earth, Mars, Vesta, Astrea, Juno, Ceres, Pallas, Jupiter, Saturn and Herschel…The secondary planets are those which revolve around a primary planet as a centre. There are eighteen secondary planets : they are the Earth’s moon, the four moons of Jupiter, the

seven moons of Saturn, and the six moons of Herschel. Thus there are thirty planets now known as belonging to the Solar system. There may be others, also, which have not as yet been discovered. [pp. 24-25]

A MOON, or satellite, is a planetary body which revolves around a primary planet as its centre. It is sometimes called a secondary planet. [p. 40]

Jupiter has four moons. They have received the names, in the order of their distance from the planet, of Hebe, Ganymede, Themis and Metis. These names are, however, but little used. [Obviously, they were later renamed.]… Metis revolves around its primary in four hundred hours, or in forty of Jupiter's days…. All these satellites, if inhabited at the rate of two hundred and eighty inhabitants to a square mile, would support a population thirty-three times greater than that of this Earth. These satellites can never be seen by the naked eye. [p. 62]

When one of the satellites of Jupiter disappears from an observer on the Earth, as it goes behind the planet, it is said to be occulted or hidden. When it comes between Jupiter and the Earth, thus apparently passing over the surface of the planet, it is said to transit the disc of its primary. [pp. 63-64]

Saturn has seven satellites. They can, however, only be seen with the most powerful telescopes, as the planet is at such an immense distance from the Earth. The diameters of the satellites of Saturn have never yet been accurately measured. Four of the moons of Saturn revolve nearer the planet than is our moon to the Earth, and they appear, to an observer on Saturn, from twice to ten times as large. The largest of the moons of Saturn is at the greatest distance from the planet. Each of these moons probably revolves upon its own axis, in the same time in which it revolves around its primary. [p. 66]

The magnitude of the satellites of Herschel has never yet been precisely ascertained. It is probable, however, that these satellites are considerably larger than our moon, else they could hardly be seen, even with the telescope, at such a vast distance from the Earth. If these six moons are three thousand miles in diameter, they will sustain, unitedly, a population of more than sixty times as many as now dwell upon the Earth. It is a remarkable peculiarity in these satellites, that they all revolve around their primary from east to west, while every other primary and secondary satellite in the Solar system revolves around its central body in an opposite direction — from west to east. [p. 73]

There is connected with the Solar system, besides the planets, a large number of mysterious bodies, culled Comets. Comets are bodies having no definite shape, and consisting mainly., not of solid, but vaporous or aeriform substance, which usually appear unexpectedly in our system, and rushing, with great velocity, around the Sun, again disappear in the depths of space. The meaning of the word

> Comet, is a hairy star. They are so tailed because they are usually accompanied by a long train resembling luminous hair
>
> Respecting the physical constitution of Comets but little is known. They usually consist of three parts. The first is a brilliant spot called the nucleus. This is probably a highly condensed gaseous or vaporous substance. The nucleus may, in some cases, be solid ; but that this is not usually the case is evident from the fact, that stars can be often seen through the nucleus. The nucleus is generally surrounded by a hazy or nebulous covering, called the envelope, or coma. And there is usually connected with this nucleus a long [next page] fan-like appendage, called the train of tail. The en fan-like appendage, called the train of tail. The envelope and train are always composed of a substance somewhat resembling the thinnest fog. [pp. 75-76]
>
> Whether, in any case, the nucleus of a Comet is solid, is a question not yet decided. Comets vary so much in appearance, that while some have no nucleus, others have no train or tail. [p. 77]
>
> Others have supposed that they [comets] were embryo worlds, which, in process of time, by union and consolidation, would form new suns and planets. These are, however, merely conjectures. [p. 81]
>
> Whether Comets shine by their own light, like suns, or by reflected light, like the planets, has been long undecided. [p. 81]

Abbott, J. S. C. *The young astronomer; or, The facts developed by modern astronomy: collected for the use of schools and the general reader*. JC Riker (1847).

W. Lassell and O. Struve, 1848

> The satellites of *Uranus* were first seen by Sir W. Herschel on Jan. 11, 1787, six years after his discovery of the primary planet. By a continued series of observations that year he established the undoubted existence and the approximate distance and periodic time of two *principal* satellites.

Lassell, W., and O. Struve. "Observations of satellites of Uranus." *Monthly Notices of the Royal Astronomical Society* 8 (1848): 43.

Ormsby MacKnight Mitchel, 1848

> Hence every satellite which revolves about its primary planet gives us the means of weighing that primary.

Mitchel, Ormsby MacKnight. *A Course of Six Lectures on Astronomy: Delivered in the City of New York*. Greeley & McElreath, 1848.

Sears C. Walker, 1850

With this value of $\varkappa$, using the data above mentioned, interpolating the a, m, and θ of the fifth or hypothetical planet, called Kirkwood, and three masses, viz.: of Mercury, Mars, and Uranus, the following normal elements of the primary system are obtained, in which all of the above four fundamental conditions are fulfilled for each middle planet of five. For Neptune, Mr. W. had used his own value of the mean distance, and Prof. Peirce's mass from Bond's measures of the elongation of the satellite. The interpolated values are enclosed in parentheses.

(…)

After Mr. Walker had concluded, Mr. George P. Bond inquired of Mr. W. as to the applicability of his remarks on primary rings to the case of the secondary ring in the system of Saturn.

Mr. W. replied, that in the case of the breaking up of a primary ring, the day of the new planet would be equal to the year of the ring, provided the new diameter was the same as that of the generating figure, and the same law of decrease of density from centre to surface was preserved. In this case we should have

$$K = rmv = r'mv'$$
$$v = v'$$

and therefore

$$p = p'$$

Such, however, is not the case in fact with the primary planets. The new diameter is contracted by the more immediate action of the central mass, more than it is expanded by the increase of free caloric. The new diameter is, therefore, so much smaller than the primitive D, that p' is changed into p, and v', or the yearly mean angular velocity, is changed into v for the daily value.

consequently of $s = s'$.

pe preserved, in order to maintain a constant value of $p = p'$, and the generating figure and law of relative density of layers should that upon the breaking up of the ring, the primitive diameter of Neptune and Kirkwood's hypothesis, it would only be necessary no conjecture as to the cause of the primitive ellipticity. On the lipsation sets in toward a state of perfect ellipticity; but he offered Lagrange showed that if these values were once nearly equal, a are the same. This fact has remained hitherto unexplained. must apply to both. In the secondary systems the day and month ogy to the secondary systems. If they are laws of nature, they

We may extend the Neptune hypothesis, and Kirkwood's anal-

Walker, Sears C. "ART. III.--Examination of Kirkwood's Analogy." *American Journal of Science and Arts (1820-1879)*10, no. 28 (1850): 19.

James M'intire, 1850

A textbook for high schools and academies:

> The Planets and their Satellites. The Planets are opaque bodies like our earth, moving round the sun, and shining by the reflection of his light. They are distinguished into primary and secondary.
>
> The Primary Planets move round the sun as their centre of motion. There are seventeen primary planets known, namely, eight large planets, and nine small ones, called asteroids. The large planets are, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune; and the asteroids are, Vesta, Juno, Ceres, Pallas, Astræa, Hebe, Flora, Iris, and Metis.
>
> The Secondary Planets, Satellites, or Moons, move round the primary planets as their centre of motion. There are eighteen secondary planets or satellites known. The Earth has one, Jupiter four, Saturn seven, and Uranus six.

M'intire, James. *A new treatise on astronomy, and the use of the globes, in two parts...* AS Barnes & Company, 1850.

Hiram Mattison, 1851

A textbook:

> 133. How are the Planets divided?
> Into Primary and Secondary.
> 134. What are the Primary Planets?
> Such as revolve around the Sun only, as their center of motion.
> 135. What are the Secondaries?
> They are small planets that revolve around the Primaries, and accompany them in their revolution around the sun.

Mattison, Hiram. *A Primary Astronomy*. New York: Mason brothers, 1851.

Daniel Kirkwood, 1851

ART. XLIV.—*On the Law of the Rotation of the Primary Planets;* by DANIEL KIRKWOOD.

IN the American Journal of Science and Arts, for March, 1851, I notice an article by Prof. Loomis, calling in question the truth of the recently discovered analogy in the periods of rotation of the primary planets. The reasons assigned by Professor Loomis for withholding his assent to this law are:—

I. That it gives an improbable period of rotation to Uranus.

Kirkwood, Daniel. "ART. XLIV.--On the Law of the Rotation of the Primary Planets." *American Journal of Science and Arts (1820-1879)* 11, no. 33 (1851): 394.

Sears C. Walker, 1853

> It was naturally to be presumed that the inclination and eccentricity of this primary planet were small, and that with a radius vector nearly twice that of Herschel, the sun's power to impress daily variations of the radius vector, and orbital motion must be comparatively small

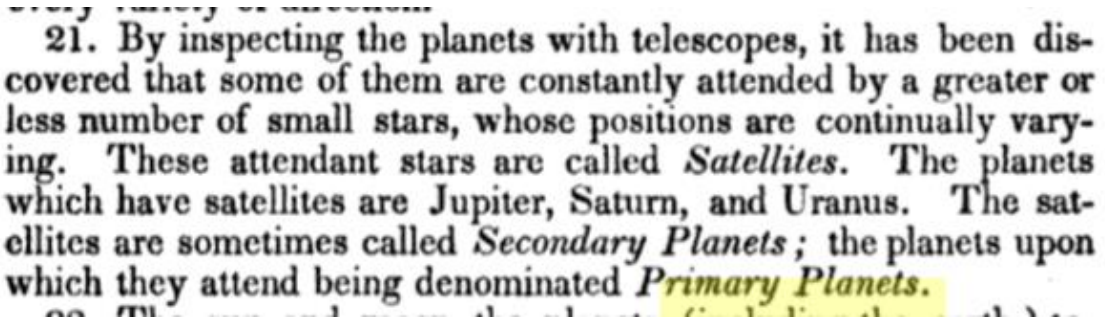
Walker, Sears C. "Investigations which led to the Detection of the Coincidence between the Computed Place of the Planet Leverrier, and the Observed Place of a Star Recorded by Lalande, in May, 1795." *Transactions of the American Philosophical Society* 10 (1853): 141-153.

James Robert Christie, 1853

consequence to us to study. The Moon, then, revolves round the Earth in a period of 27 *days* 7 *hours* 43 *minutes* and 11·5 *seconds*, her orbit being, as with the primary planets, slightly elliptical, and the direction of her motion being from west to east. Ordinary ob-

Christie, James Robert. *An introduction to the elements of practical astronomy*. 1853.

William Augustus Norton, 1853



21. By inspecting the planets with telescopes, it has been discovered that some of them are constantly attended by a greater or less number of small stars, whose positions are continually varying. These attendant stars are called *Satellites*. The planets which have satellites are Jupiter, Saturn, and Uranus. The satellites are sometimes called *Secondary Planets;* the planets upon which they attend being denominated *Primary Planets.*

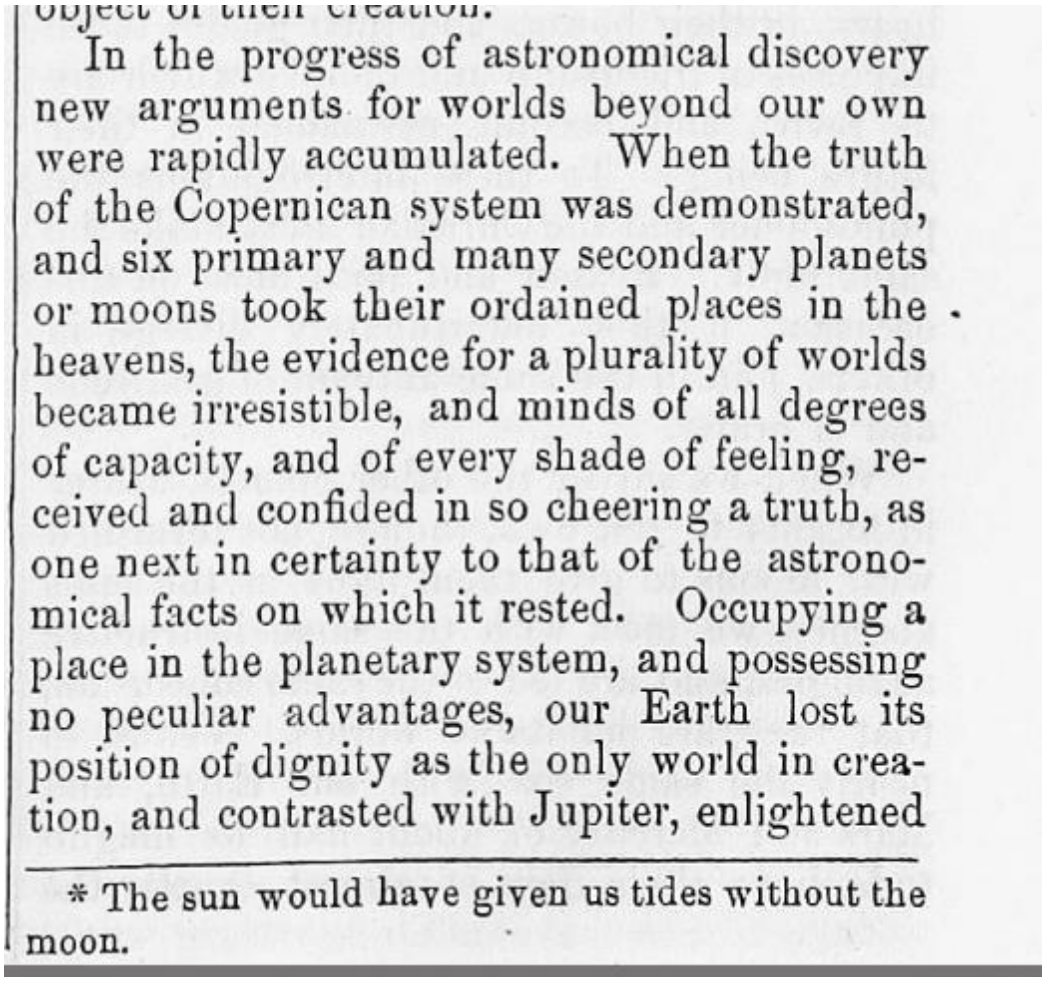
Norton, William Augustus. *An Elementary Treatise on Astronomy: In Four Parts. Containing a Systematic and Comprehensive Exposition of the Theory, and the More Important Practical Problems; with Solar, Lunar, and Other Astronomical Tables. Designed for Use as a Text-book in Colleges and Academies*. J. Wiley, 1853.

W. Newton, 1854

> Of the *primary* planets, which have the sun as the centre of their orbits, the smallest, and nearest to that luminary, is called Mercury.
>
> Earth is attended by a *secondary* planet, the Moon…
>
> [The Moon] is not a primary planet, like the earth, revolving round the sun, but a secondary planet or satellite, travelling round the earth as her centre of revolution, and accompanying the earth in her annual course round the sun.

Newton, W., 1854. *The Use of the Globes: with a Familiar Introduction to the Science of Astronomy, Illustrated by Numerous Diagrams.*.

David Brewster, 1854



object of their creation.

In the progress of astronomical discovery new arguments for worlds beyond our own were rapidly accumulated. When the truth of the Copernican system was demonstrated, and six primary and many secondary planets or moons took their ordained places in the heavens, the evidence for a plurality of worlds became irresistible, and minds of all degrees of capacity, and of every shade of feeling, received and confided in so cheering a truth, as one next in certainty to that of the astronomical facts on which it rested. Occupying a place in the planetary system, and possessing no peculiar advantages, our Earth lost its position of dignity as the only world in creation, and contrasted with Jupiter, enlightened

* The sun would have given us tides without the moon.

Brewster, David. review of "Of the Plurality of Worlds. An Essay." North British review, 21 (1854), 31

Asa Smith, 1856

A textbook:

Q. How many planets are in the solar system?
A. Fifty-two is the number known at present.
Q. How are they divided with respect to their motions?
A. They are divided into two classes, primary and secondary.
Q. What is a primary planet?
A. It is a planet which revolves around the sun only.
Q. What is a secondary planet?
A. It is a planet which revolves around its primary, and with it around the sun.
Q. What are the secondary planets usually called?

A. They are called satellites or moons.
Q. How many primary planets are there?
A. 8 large planets and 23 asteroids or small planets.
Q. What are their names, beginning at the sun?
A. Mercury, Venus, the Earth, Mars, (Twenty-three Asteroids or small planets,) Jupiter, Saturn, Herschel, or Uranus, Leverrier, or Neptune.
Q. How many secondary planets are there?
A. Twenty-one.

Smith, Asa. *Smith's Illustrated Astronomy, Designed for the Use of the Public Or Common Schools in the United States: Illustrated with Numerous Original Diagrams*. Daniel Burgess & Company, 1856

Daniel Vaughan, 1858

> Secondary planets which revolve at comparatively small distances from great central orbs, experience very singular effects from a kind of disturbing action, which is either wholly imperceptible on the primaries themselves, or is only manifested in producing an alternate rise and fall of their extensive oceans…In the Saturnian system, where many attendants are much closer to the primary, they must be more seriously affected by its unequal attraction on their parts. Were the size of the orbit below a certain limit, the disturbing influence of the central body would so far neutralize the attractive power of the satellite in two directions as to render it incapable of maintaining the usual planetary form ; and it appears that, in the zone occupied by Saturn's rings, no large secondary planets could roll in security unless they were considerably more dense than the kind of matter which predominates in that part of the solar domain…In calculating the dimensions of the smallest orbit in which it is possible for a secondary planet to hold its parts together by the tie of gravity, we are necessarily restricted to the cases most favourable for stability
>
> (…)
>
> Each primary and secondary planet, by imperceptible contractions of their orbits during innumerable years, must ultimately arrive in the immediate vicinity of their respective central spheres

Vaughan, Daniel. "LVII. On luminous meteors and temporary stars." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 16, no. 110 (1858): 500-503.

Denison Olmsted, 1860

same places with respect to each other. The planets known from a high antiquity, are Mercury, Venus, Earth, Mars, Jupiter, and Saturn. To these, in 1781, was added Uranus,‡ (or *Herschel*, as it was formerly called, from the name of its discoverer,) and, as late as 1846, another large planet, Neptune, was added to the list, making eight in all of the regular series. Besides these, there are found between Mars and Jupiter, a remarkable group of small planets, called *Asteroids*, numbering at present thirty-seven. Of these, four—Ceres, Pallas, Juno, and Vesta—were discovered near the commencement of the present century; and the remaining twenty-nine, Astrea, Hebe, Iris, Flora, Metis, Hygeia, Parthenope, Victoria, Egeria, Irene, Eunomia, Psyche, Thetis, Melpomene, Fortuna, Massalia, Lutetia, Calliope, Thalia, Themis, Phocea, Proserpina, Euterpe, Bellona, Amphytrite, Urania, Euphrosyne, Pomona, Polymnia, Circe, Leucothea, Fides, and Atalanta, have been discovered since the year 1845.

The foregoing are called *primary* planets. Several of these have one or more attendants, or satellites, which revolve around them as they revolve around the sun. The Earth has one satellite, namely, the moon; Jupiter has four; Saturn, eight; Ura-

* Bowditch's La Place, II. 797. ‡ From the Greek ...

nus, six;* and Neptune, one. These bodies also are planets, but in distinction from the others they are called *secondary* planets. It appears, therefore, that the whole number of planets known at present are 54, viz., 8 primary, 20 secondary, and 26 asteroids.

297. The primary planets all (with the exception of the asteroids) have their orbits nearly in the same plane, and are never seen far from the ecliptic. Mercury, whose orbit is most inclined of all, never departs further from the ecliptic than about 7°, while most of the other planets pursue very nearly the same path with the earth, in their annual revolution around the sun. The asteroids, however, make wider excursions from the plane of the ecliptic, amounting, in the case of Pallas, to 34½°.

(…)

176. Now it appears from article 168, that it is a *fact*, derived from observation, that the earth's radius vector describes equal areas in equal times; and by similar observations the same is found to be true of each of the primary planets about the sun, and of each of the satellites about its primary. Hence, it is inferred, that the primary planets all gravitate towards the sun, and that the secondary planets all gravitate towards their respective primaries.

Olmsted, Denison. *An Introduction to Astronomy: Designed as a Text Book for the Students of Yale College*. Collins & Brother, 1860.

Daniel Vaughan, 1860

In calculating the dimensions of the smallest orbit in which it is possible for a **secondary planet**
to hold its parts together by the tie of gravity, we are necessarily restricted to the cases most
favourable for stability…

Vaughan, Daniel. "LV. On the form of satellites revolving at small distances from their primaries." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 20, no. 135 (1860): 409-418.

Daniel Vaughan, 1861(A)

From late researches, however, I am convinced that a want of these peculiar conditions would not seriously affect the fate of a large satellite when brought into dangerous proximity to its primary ; and would not change, to any great extent, the magnitude of the orbit in which its dismemberment must be inevitable.

A homogeneous fluid satellite, having its motions adapted for keeping one part of its surface in perpetual conjunction with the primary, must find repose in a form differing little from an ellipsoid.

This must have the ultimate effect of establishing a synchronism of the orbital and diurnal movements, together with a coincidence of the planes in which they are performed ; so that the disturbing force may give the secondary planet a permanent elongation,…

> The condition which matter must ultimately assume in the central zone, where it can no longer exist as one great satellite or in a limited number of smaller ones, must depend in some degree on the form of the primary planet.

Vaughan, Daniel. "XLII. On the stability of satellites in small orbits, and the theory of Saturn's rings." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 21, no. 140 (1861): 263-274.

Daniel Vaughan, 1861(B)

> Static and Dynamic Stability in the Secondary Systems.
>
> So small are the primary planets compared with their distances from the sun, that they are regarded as material points in the investigations of physical astronomy, and that no effects arising from the unequal intensity of solar attraction on their parts can vitiate in any sensible degree the results which analysis gives for their movements. But in the systems of Jupiter and Saturn many satellites are exposed to an enormous tidal force in consequence of their proximity to their primaries ; and the planet ary theory requires some modification when applied to the revolutions of these minor worlds. My chief object at present is to show that the unequal attraction of a primary occasions slow secular changes in the orbits of its attendants, especially when the presence of fluids on their surfaces brings tidal commotions into play. But I deem it first necessary to prove what I have assumed in my former communications, in regard to the physical necessity for a synchronism of the orbital and rotatory motions of these bodies, and for the small inclination of their equators to the planes of their orbits.
>
> On previous occasions I endeavoured to show that such an arrangement would be the ultimate consequence of excessive tides, when a satellite contained large bodies of fluid, or when, from its close proximity to the primary, the solid matter of which it may be composed were not possessed of sufficient cohesive force to withstand the effects of the great disturbance….
>
> By another investigation, which brevity compels me to omit, I have arrived at the same results in regard to the secular changes which the rotation of a secondary body must experience until it keeps pace with the orbital revolution.
>
> Although the influence of distant bodies in changing the plane of the orbit may prevent I from sinking to zero, yet we must recognize the tendency to the peculiar arrangement which reduces to the lowest scale the dynamic effects of the disturbing force on their surfaces of secondary planets.
>
> This will appear evident when we consider that these tides could not reach their higheat level on the parts of the satellite in conjunction with the primary, until some time after the disturbing force which produced them attained its greatest

> intensity ; and the subordinate world would thus present a greater deviation from a true sphere, in passing from the lower to the higher apsis, than in returning to the former point. It would accordingly feel the restraint of the centripetal force more intensely when retiring from the primary than when approaching him ; and its motion would be retarded during the former period to an extent slightly greater than that to which it is accelerated during the latter.
>
> It thus appears that the duration of the secondary planets is much dependent on the absence of tides from their surfaces; and perhaps the vast number of these attendants belonging to the remote planets may be indebted for their present existence to the intense cold, which keeps their oceans in perpetually frozen condition.

Vaughan, Daniel. "LXIII. Static and dynamic stability in the secondary systems." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 22, no. 150 (1861): 489-497.

Daniel Vaughan, 1861(C)

> In my last article, I have shown that the instantaneous manner in which a secondary or a primary planet must undergo a total dismemberment on coming into fatal proximity with the central sphere harmonizes in a very decided manner with the astonishing rapidity with which temporary stars attain their greatest brilliancy.
>
> How far observation of primary or secondary worlds give evidence of un-periodical changes in our system has not been yet determined with positive certainty.

Vaughan, Daniel. "LXXIV. On phenomena which may be traced to the presence of a medium pervading all space." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 21, no. 143 (1861): 507-515.

Josiah Crampton, 1863

> …scattered over the [lunar] plain, an infinite number of circular pits…sink in the body or crust of the planet…to a vast distance over the surface of the planet…The moon, although the humble servant of the earth…acknowledges a superior authority in the sun…This kind of solar influence is common to both planets… Satellites are small planets attached to the larger ones, called their primaries…

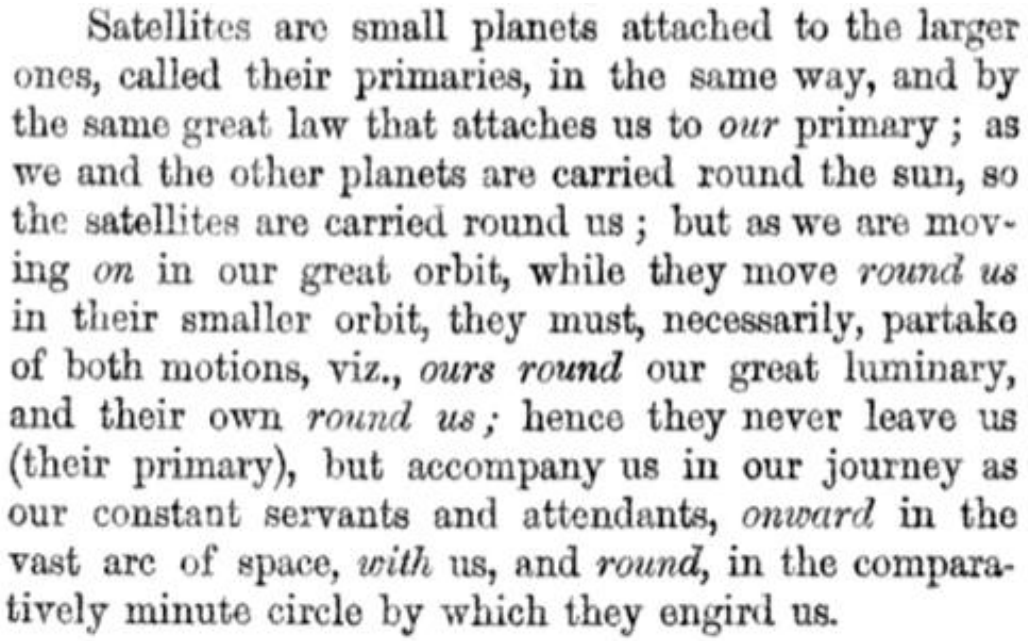
It is a well established fact, that the earth is one only of a number of planetary bodies whose nights are thus relieved and cheered by moons—*i. e.*, by planetary satellites or attendants, acting as reflectors (not originators of light), and differing in number and in size, according to the magnitude of the primary planet, and in proportion to its distance from the sun. Thus, while Mercury and Venus, from their proximity to that body in whose beams they bask, need none, the Earth possesses one, Jupiter four, Saturn eight, Uranus six (as yet discovered), but probably more. Contrivance

...

David Brewster's views and arguments for a lunar atmosphere and inhabitants. And in the first place I may here remark, that I have by no means given up the idea of the possibility of some kind of atmosphere to the moon, contending only that if it *be* there, it can bear no analogy or resemblance whatever to that which envelopes our planet; and that whatever be its constituents or ingredients, it must be of so great tenuity as to be equivalent to what is called here a vacuum. That some gas or gases may exist in a solid, fluid, or even aeriform state round the moon is, I think, quite possible, or even probable;

but granting that, to what does it amount? or what possible semblance or analogy could such a gaseous envelope bear to that of the earth and the other primary planets, whose atmospheres are plainly perceptible to the telescope? It is wonderful, indeed, how small an amount of air the

…



Satellites are small planets attached to the larger ones, called their primaries, in the same way, and by the same great law that attaches us to *our* primary; as we and the other planets are carried round the sun, so the satellites are carried round us; but as we are moving *on* in our great orbit, while they move *round us* in their smaller orbit, they must, necessarily, partake of both motions, viz., *ours round* our great luminary, and their own *round us;* hence they never leave us (their primary), but accompany us in our journey as our constant servants and attendants, *onward* in the vast arc of space, *with* us, and *round*, in the comparatively minute circle by which they engird us.

Crampton, Josiah. *The Lunar World*. A. and C. Black, 1863.

J. Carpenter, 1864

> The moon is the earth's only satellite. A satellite in astronomical parlance is a small or secondary planet revolving round a larger or its primary, and forming thus a subordinate system in which the greater solar system is, as it were, reproduced on a smaller scale;… (p. 655)

Carpenter, J. "THE LESSER LIGHT." *Once a week* 11, no. 284 (1864): 654-658.

Trowbridget, 1865

Regarding Laplace's Nebular Hypothesis of planet formation discussing commonality of formation processes for primaries and secondaries:

> After the rings from which the planets were formed were broken up, and all the parts of any one ring reduced to a planet, such planet as we have shown, would have a rotation on an axis….[A] secondary ring would be abandoned by such planetary bodies….These secondary rings would, in general, break up and form secondary planets, or satellites….In consequence of the forces acting on the

planets, both primaries and secondaries, they will become spheroidal in shape as soon as the rings from which they are made are broken up and the parts united.

43. After the rings from which the planets were formed were broken up, and all the parts of any one ring reduced to a planet, such planet, as we have shown, would have a rotation on an axis. This axis would, necessarily, be a *natural* or *principal*

...

44. After the parts of the broken-up rings had united, and the resulting bodies commenced their rotatory motion, the cooling of the masses, in consequence of the radiation of heat, would cause their rotatory velocities to be increased, and this process would continue till, in most instances, a secondary ring would be abandoned by such planetary bodies." The outer planets being larger and much less dense than the inner ones, would abandon *several* secondary rings. In reference to the number of these secondary rings cast off by each of the planets, all that we can

at present conclude on, with any degree of certainty, is, that the number should, upon the whole, increase from the sun outward. We cannot, at present, say that the outermost planet ought to have abandoned the greatest number of rings. These secondary rings would, in general, break up and form secondary planets, or satellites. Under certain conditions—such as Prof. Peirce has found to exist in the System of Saturn—a ring, or rings might remain entire, or at least, not break up into a single satellite. According to this view, rings, if they exist, must be found interior to several satellites. In every case—unless changed by disturbing forces—the planet should rotate on its axis in less time than is required for any ring or satellite to revolve around the primary. The same must hold in the case of the sun and the planets.

45. When the last ring has been abandoned by any one of the planets, the remaining part[46] must cool down and thus form a primary planet. The outer portions being exposed to the low temperature of space—at least 50° below zero Fah.—they will cool much more rapidly than the inner parts, and after the whole is reduced to a liquid, a crust would, comparatively soon, form around the liquid planet, and further radiation would take place very slowly compared with its former rate. A certain amount of heat would be received from the other bodies, particularly the sun, (whatever might be its condition), and finally a balance would be reached beyond which the planet would not cool,—or at most very slowly,—and thus the inner parts would remain liquid. The outer planets being from the beginning less dense than the others, a crust would, perhaps, be formed so comparatively early as to leave the mean density of the planet comparatively small. We should, therefore, look for an increase in mean density from the outermost planet to the innermost. We see no reason, however, to believe that any simple law regulates this variation of mean density from one planet to another.

46. It would at first seem as if the satellites of the primaries

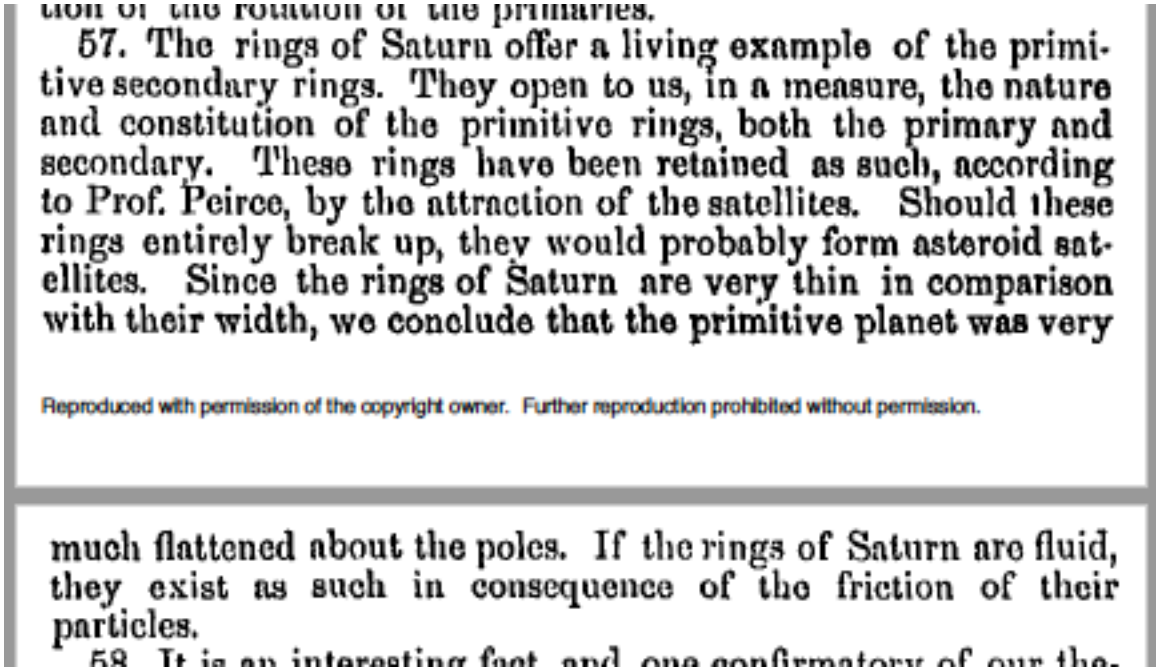
46. It would at first seem as if the satellites of the primaries should follow the same law of rotation that the primaries themselves do; but we must recollect that the numbers representing the distances of the former, expressed in radii of the latter, may differ very considerably from the numbers representing the distances of the latter expressed in radii of the sun. Again, the rings from which the satellites were formed, were abandoned when the primaries were much reduced in temperature, and condensed, when compared with the condition of the primary rings

[49] In the Nebular Hypothesis, after a fluid body has abandoned all the rings possible, there *must* remain a central body of comparatively large dimensions, and of a mass far greater than the sum of the masses of all the rings separated. How would the author of the meteoric theory as given in the 204th number of the North American Review, account for the fact that our Solar System is constructed upon this principle?

when they were separated from the primitive solar spheroid. All the satellites will be much smaller than the primaries; and, being comparatively small bodies, they will cool down and become solid much sooner than the primaries will. In consequence of the forces acting on the planets, both primaries and secondaries, they will become spheroidal in shape as soon as the rings from which they are made are broken up and the parts united. The attraction of the primaries on the fluid satellites, will raise the fluid particles into great tidal-waves; and as the waves on opposite sides are slightly unequal, the result will be a retardation of the rotatory velocity of the secondaries. William

56. In examining the secondary planets, we see a general increase in number to each primary planet, as we go from the sun to the extremity of the system. The Earth has 1, Jupiter 4, Saturn 8, Uranus 6 and perhaps 8, Neptune 2 that have probably been seen. We cannot tell with certainty the number of satellites belonging to each of the last two planets, owing to the difficulty of observing such bodies at so remote distances. The satellites of Jupiter are distributed in the Jovian system very similarly to the primary planets in the Solar System. We find the masses to increase as the distance from the center of Jupiter increases, till we arrive at the third satellite, where we reach the maximum. The fourth satellite is the second in mass. The third satellite is also the largest, and the fourth the next in size, but the second, although it is of greater mass, yet is of smaller size than the first. The satellites of Saturn follow a similar general law. *Titan*, the 6th in the order of distance from the primary, is the largest, and *Japetus*, the most distant of them all, is next in size. Of the others we cannot so well judge, but it seems not improbable that they decrease in size as they are nearer the primary. We know still less of the satellites of Uranus, but the second and fourth, so-called, are very probably the largest. But within the second, (in the order of distance according to Sir William Herschel's discoveries), two, and possibly three, exist. We thus see it to be a general principle of the planetary system that the largest bodies are within some, and without some of the orbits of the others. We also observe this fact in reference to some of the secondary planets, viz: if we divide the distance of the remotest satellite of any primary, from the center of the planet, by the diameter of the sphere of attraction (which we shall consider to be the same as the breadth of the ring, or the diameter of the primitive planet,) we shall find that, in general, the quotient decreases from the earth to Uranus. We may therefore conclude that the outer planets had to condense much more than the inner ones before a satellite-ring was abandoned. It is a fact, also, that, so far as observation has determined, the satellites rotate on their axes in the same direction and in the same time in which they revolve around their respective primaries. All these motions are in the direction of the rotation of the primaries.

57. The rings of Saturn offer a living example of the primi-



tion of the rotation of the primaries.

57. The rings of Saturn offer a living example of the primitive secondary rings. They open to us, in a measure, the nature and constitution of the primitive rings, both the primary and secondary. These rings have been retained as such, according to Prof. Peirce, by the attraction of the satellites. Should these rings entirely break up, they would probably form asteroid satellites. Since the rings of Saturn are very thin in comparison with their width, we conclude that the primitive planet was very

much flattened about the poles. If the rings of Saturn are fluid, they exist as such in consequence of the friction of their particles.

58. It is an interesting fact, and one confirmatory of our the-

Trowbridge, David. "ART. IV.--On the Nebular Hypothesis." *American Journal of Science and Arts* (1820-1879) 39, no. 115 (1865): 25.

Richard Anthony Proctor, 1865

> Four years before, on March 25th, 1655, Huygens had made another important discovery; by aid of the 12-feet telescope already mentioned, he had detected a satellite attending on Saturn…As this discovery raised the number of secondary planets to six (including our moon); and as but six primary planets (including the sun) were known to Huygens, he sought for no more satellites – sharing the idea, then commonly entertained, that the number of primary and secondary members of the solar system must certainly be equal. Otherwise, with the powerful telescopes he subsequently constructed, he could hot have failed to detect two (if not all) of the four satellites discovered by Cassini. (p. 49)
>
> The question of the moon's habitability – interesting to astronomers on its own account – acquires an additional interest if we consider that on its solution depends the opinion we shall form of the habitability of the important secondary systems attending on Saturn, Jupiter, and Uranus. (p. 207)
>
> On the other hand, arguments are not wanting in support of the hypothesis that the Moon has an atmosphere. In the first place, we might infer from the analogy of our earth, and of the larger planets, that all the members of the solar system are surrounded by atmospheres of greater or less density and extent. (pp 208-9)

> …The length of time required to effect such changes would depend on the mass of the planet's globe—a large planet would obviously require a longer time to part with its internal warmth than a small planet [*NOTE: he is talking about the Moon here*]. What relation such time would bear to the mass of a planet could not be easily determined, but it is certain that some such relation exists. Now on Laplace's hypothesis on the development of the solar system, the moon was formed before the earth;… (p 212)

Yet we also see the author using "planets" to mean just the primary ones. Table V is "Elements of Saturn's Satellites", while Table VI is "Elements of the Planets" (which only includes the primary ones.)

In the appendix, "EXPLANATION OF ASTRONOMICAL TERMS USED IN THE BODY OF THE WORK." :

> Planets, Minor.— See Asteroids.
>
> Planets, Primary.—The planets which revolve about the sun as centre.
>
> Planets, Secondary.—The satellites which revolve about some of the primary planets.
>
> Satellite.—A moon attending on a primary planet.
>
> Transit of a Satellite.—The passage of a satellite across the disc of its primary…

Proctor, Richard Anthony. *Saturn and Its System: Containing Discussions of the Motions (real and Apparent) and Telescopic Appearance of the Planet Saturn, Its Satellites, and Rings; the Nature of the Rings; the Great Inequality of Saturn and Jupiter; and the Habitability of Saturn. To which are Appended Notes on Chaldæan Astronomy, Laplace's Nebular Theory, and the Habitability of the Moon; a Series of Tables with Explanatory Notes; and Explanations of Astronomical Terms*. Longman, Green, Longman, Roberts, & Green, 1865.

W. T. Lynn, 1867

> This discovery is somewhat noteworthy, as completing the number of one hundred known primary planets in our solar system.

Lynn, W. T. "The Hundredth Planet." *Astronomical register* 5 (1867): 189-190.

Daniel Kirkwood, 1867

JUPITER, the first planet exterior to the asteroids, is nearly five hundred millions of miles from the sun, and revolves round him in a little less than twelve years. This planet is ninety thousand miles in diameter and contains more than twice as much matter as all the other planets, primary and secondary, put together. Jupiter is attended by four moons or satellites.

(…)

of revolution."* Such, according to the theory of Laplace, is the history of the formation of the most remote planet of our system. That of every other, both primary and secondary, would be precisely similar.

In support of the nebular hypothesis, of which the

(…)

UNTIL about the middle of the present century the rings of Saturn were universally regarded as solid and continuous. The labors, however, of Professors Bond and Pierce, of Cambridge, Massachusetts, as well as the more recent investigations of Prof. Maxwell, of England, have shown this hypothesis to be wholly untenable. The most probable opinion, based on the researches of these astronomers, is, that they consist of streams or clouds of meteoric asteroids. The zodiacal light and the zone of small planets between Mars and Jupiter appear to constitute analogous *primary* rings. In the latter, however, a large proportion of the primitive matter seems to have collected in distinct, segregated masses. These meteoric zones have probably presented what are

Kirkwood, Daniel. *Meteoric astronomy a treatise on shooting stars, fireballs and aerolites*. 1867.

William Henry Smyth, 1867

ASTEROIDS. The name by which the minor planets between the orbits of Jupiter and Mars were proposed to be distinguished by Sir W. Herschel. They are very small bodies, which have all been discovered since the commencement of the present century; yet their present number is over eighty.

INFERIOR PLANETS. This name, the opposite of superior, is applied to Mercury and Venus, because they revolve in orbits interior to the earth's path.

MINOR PLANETS. *See* ASTEROIDS.

PLANETS, PRIMARY. Those beautiful opaque bodies which revolve about the sun as a centre, in nearly circular orbits. (*See* INFERIOR, MINOR and SUPERIOR.)

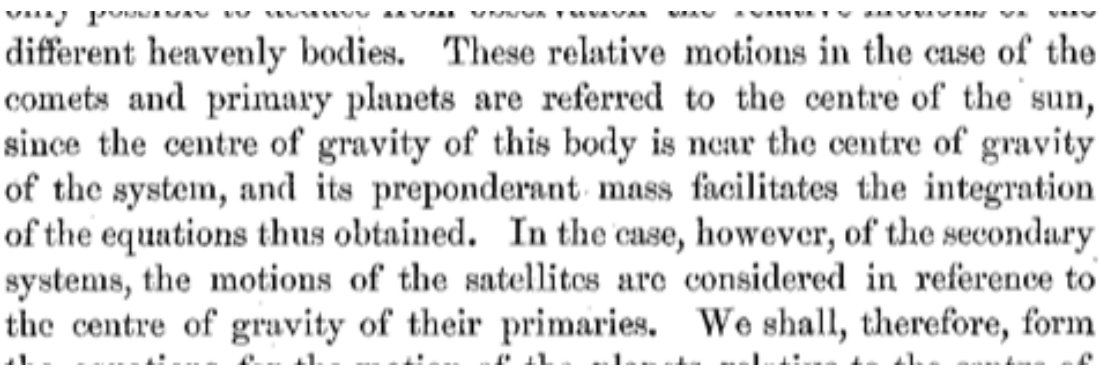
PLANETS, SECONDARY. The satellites, or moons, revolving about some of the primary planets—the moon being our satellite.

SATELLITES. Secondary planets or moons, which revolve about some of the primary planets. The moon is a satellite to the earth.

SUPERIOR PLANETS. Those which revolve about the sun as a centre, outside the earth's orbit; the opposite of *inferior*.

Smyth, William Henry. *The Sailor's Word-book: An Alphabetical Digest of Nautical Terms, Including Some More Especially Military and Scientific... as Well as Archaisms of Early Voyagers, Etc*. London: Blackie and son, 1867.

James Watson, 1868



different heavenly bodies. These relative motions in the case of the comets and primary planets are referred to the centre of the sun, since the centre of gravity of this body is near the centre of gravity of the system, and its preponderant mass facilitates the integration of the equations thus obtained. In the case, however, of the secondary systems, the motions of the satellites are considered in reference to the centre of gravity of their primaries. We shall, therefore, form

Watson, James. *Theoretical astronomy relating to the motions of the heavenly bodies*. 1868.

John Davis, 1868

"1. This system of worlds and heavenly bodies is the one to which our earth belongs, and is now known to contain eight primary planets, eighty-five asteroids or smaller planets, twenty-one satellites, moons, or secondary planets, a great number of comets, and the sun also, which is the controlling centre of them all.

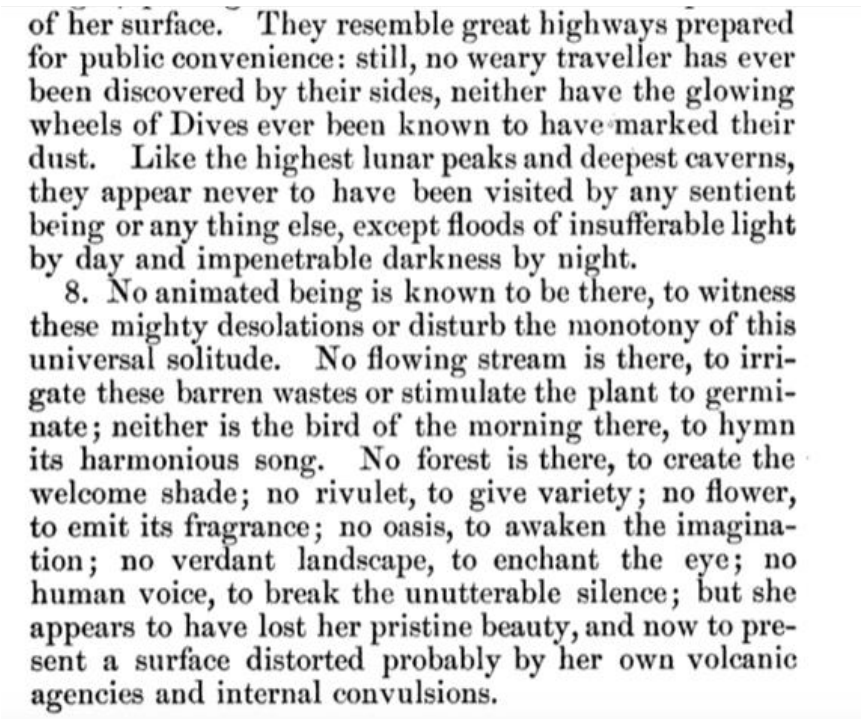
2. The primary planets are of different magnitudes, and revolve around the sun in different periods and at different differences from him….

6. The secondary planets are small bodies that revolve around some of the primary planets as they travel around the sun. Our moon is one of them, and the only one that revolves around the earth.

[Footnote provides definitions: "Planet—a wanderer. Asteroid—a small planet. Satellites, moons, or secondary planets, are those that revolve around the primary planets…Primary planet—a large planet."]

[Whereas Galileo argued from the Earth and Moon's common planet-hood that the Moon and all planets probably contain life, as did others of that era, this author knows the Moon is barren, and so he argues that only the Primary Planets will be like the Earth in having vegetation, sentient beings, and civilizations.]

From Page 53:



of her surface. They resemble great highways prepared for public convenience: still, no weary traveller has ever been discovered by their sides, neither have the glowing wheels of Dives ever been known to have marked their dust. Like the highest lunar peaks and deepest caverns, they appear never to have been visited by any sentient being or any thing else, except floods of insufferable light by day and impenetrable darkness by night.

8. No animated being is known to be there, to witness these mighty desolations or disturb the monotony of this universal solitude. No flowing stream is there, to irrigate these barren wastes or stimulate the plant to germinate; neither is the bird of the morning there, to hymn its harmonious song. No forest is there, to create the welcome shade; no rivulet, to give variety; no flower, to emit its fragrance; no oasis, to awaken the imagination; no verdant landscape, to enchant the eye; no human voice, to break the unutterable silence; but she appears to have lost her pristine beauty, and now to present a surface distorted probably by her own volcanic agencies and internal convulsions.

At the end of the section on each planet on p 74 he finishes with:

6. Hence, if the ministrations of nature to our wants are so abundant, may we not infer that there are millions of other intelligent beings on other planets, capable of enjoying the rich provision of comforts which, no doubt, crowd upon their surfaces?

Then he argues by the common membership in Primary Planets with Earth that the other primaries have life:

The Earth one of a Class.

1. THE earth is one of a class; and that class is the primary planets, whose physical constitutions are much the same. If the earth is composed of solid material, and is warmed by the heat of the sun, so are all the other planets. If the earth has an atmosphere, and is visited with rain and hail and snow and frost, so are they. If she has rivers, oceans, seas, and continents, in like manner do they possess the same. If she runs an annual course around the sun and is constantly bathing herself in light, so do they.

2. But it may be said that an inadequate quantity of light and heat to answer the purposes of life reaches some of these planets, and that they are buried in the abysmal depths of eternal night and winter. Follow the rays of heat and light which emanate from the sun to the farthest boundaries of our system, and still their influences are not entirely lost. A brilliancy equal to that of a hundred of our moons would be on Neptune,

and, by a slight change in his atmosphere from ours, he might experience as much heat as we enjoy.

3. Science is familiar with the fact that the capacity of some substances on the earth to receive and retain caloric is greater than the capacity of others. Consider this to be the case with all the planets, and they may have different capacities for the same purpose, which may be conducive to their general well-being and the well-being of their inhabitants. The substance of caloric may be more abundant in bodies that are more remote than in those that are nearer to the sun, and it may be productive of sensible heat, even by a very slight influence of the solar ray.

Then following immediately is the next section:

SECTION XXXI.

Planets Inhabited.

1. On the hypothesis noticed above, which is corroborated by a great variety of facts and experiments, there may be a sufficient amount of heat even on Neptune to satisfy all the demands of animal and vegetable life. And if there should be no substance there to operate on light in a similar manner, provision to supply this want may have been made in the animated beings themselves.

2. The brilliancy of a day, or of light, depends to a very great degree upon the size of the pupil of the eye and the sensitiveness of the seat of vision. If the pupils of our eyes were comparatively small, and the pupils of the eyes of beings more remote from the

sun than we are, were comparatively large, their day might be more brilliant to them than ours is to us. A slight diversity in the composition and nature of the various bodies of the solar system, and also in the construction of the organs of sight, would render every known planet as suitable and comfortable a habitation as we ourselves enjoy.

3. In view of what is reasonable to suppose, and the striking analogy of the planets, not only in relation to their motions, but also in their physical constitutions, are we not led almost to the irresistible conclusion that there are not only worlds which declare the glory of their Maker, but immortal and intelligent beings not far distant, who adore the perfections and chant the highest symphonies of praise to the honor of the Most High.

4. Why is there such provision made, and such an adaptation of things to the comfort and happiness of life, as we observe pervading these worlds, if there are no beings to enjoy them? Why such an exercise of almighty power in their production? Why such a demonstration of divine wisdom in their adaptation? Why such a glorious display of infinite goodness in their arrangement, if they were to be uninhabited solitudes and forever destitute of rational and intelligent beings, who may magnify the perfections of the Creator in the contemplation of his wonderful works and in the fulfilment of the great end of their existence?

In the appendix, “EXPLANATION OF TERMS AND PHRASES”:

> Planet—An opaque body that has the sun for its centre of motion.
>
> Satellite—The moon. A secondary planet.
>
> Secondary Planets—Those that revolve around the primary planets.

Davis, John. *Elements of astronomy*... JB Lippincott & Company, 1868.

Francisco Gavarrete, 1868

From a Guatemalan textbook:

> Q. What is the other way the planets are divided?
> A. They are divided into primary and secondary.
> Q. What are the primary planets [planetas primarios]?
> A Those already named, so called because they only revolve around the sun.
> Q. What are secondary planets [planetas secundarios]?
> A. Those that revolve around a primary, also called satellites. [transl. from Spanish]

Gavarrete, Francisco. *Geografía de la República de Guatemala*. Guatemala: Imprenta de la Paz c. de Guadalupe, 1868.

Henry Kiddle, 1870

From a textbook, showing how multi-teir taxonomies kept moons are planets:

> There are two kinds of planets; Primary and Secondary Planets…Primary Planets are those which revolve around the sun only…Secondary Planets, generally called Satellites, are those which revolve around their primaries, and with them, around the sun… There are eight large primary planets in the solar system, besides a great number of smaller ones, called Minor Planets, or Asteroids…The Minor Planets are very small planets which revolve around the sun, between the orbits of Mars and Jupiter. Ninety-six have been discovered (1868)…Major and Terrestrial Planets.—The first four of these planets, it will be seen, are very much larger than the remaining four, and are, for this reason, sometimes called the Major Planets; while the others, being in the vicinity of the earth, are sometimes called the Terrestrial Planets.

Kiddle, Henry. *A New Manual of the Elements of Astronomy: Descriptive and Mathematical*... Ivison, Phinney, Blakeman, & Company, 1870.

Daniel Vaughn, 1871

> In supposing that the same side of a satellite is always turned towards its primary, there might appear some dealing in uncertainty ; for the arrangement which our moon and other secondary planets exhibit could not be assumed as the result of a general law…
>
> (…)
>
> In the case of the supposed secondary planet, with an incessant change in the gravity at its surface and in the pressure on its internal parts, the resulting oscillations must be accompanied by the production of heat ; and this being necessarily gene- rated at the expense of motion

Vaughan, Daniel. "LXIV. On secondary planets in small orbits." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 41, no. 276 (1871): 508-519.

Henry Kiddle, 1873

> 7. There are two kinds of planets; *Primary* and *Secondary Planets*
>
> 8. PRIMARY PLANETS are those which revolve around the sun only.
>
> 9. SECONDARY PLANETS, generally called SATELLITES, are those that revolve around their primaries, and, with them, around the sun.
>
> The moon is an example of a secondary planet. It is the earth's satellite, its revolution around the earth being clearly indicated by the changes which it undergoes each month.
>
> 10. The Solar System is thus composed of the sun, the primary planets, the secondary planets, and the comets; which the stars are bodies situated at an immense distance beyond the system.
>
> 13. There are eight large primary planets in the solar system, besides a great number of smaller ones, called MINOR PLANETS, or ASTEROIDS.
>
> 14. The names of the eight large primary planets, in the order of their distances from the sun, are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.
>
> 15. All the primary planets except the earth are divided into two classes, INFERIOR and SUPERIOR PLANETS.

17. The MINOR PLANETS are very small planets which revolve around the sun, between the orbits of Mars and Jupiter. *Ninety-six* have been discovered (1868).

a. These small planets were at first, and have been, generally, called ASTEROIDS; they have also been called PLANETOIDS. The name above given has, however, been extensively used by astronomers, and appears to be the most significant and appropriate.

18. All the primary planets revolve around the sun in the direction which is designated *from west to east.*

19. Secondary planets, or satellites, have two motions: one around their primaries, and another, with them, around the sun.

[NOTE: this author divides the primary planets into Major Planets, Terrestrial Planets, and Minor Planets.]

33. The centripetal force which acts upon the primary planets is the attraction of the sun; that which acts upon the secondary planets is the attraction exerted by their respective primaries.

[talking about Kepler's Laws] This law applies to the *secondary* as well as the primary planets.

50. Of all the primary planets, Mercury moves in its orbit with the greatest velocity…

[An example of thinking geophysically about these bodies:]

Some have accounted for this [absence of surface water] by supposing that the internal heat of the moon was once very great, as is that of the earth at the present time; but that having cooled, the moon contracted in volume, and that vast caverns have thus been formed in its interior, into which the water has penetrated, and, of course, disappeared. Indeed it is obvious that only great internal heat could keep an ocean upon the surface of a body like the earth or moon. [p. 124]

Are there people in the Moon?—This question has often been discussed, but idly; since no positive evidence can be adduced on one side or the other. The distance of the moon is too great for us to detect any artificial structures, as buildings, walls, roads, etc., if there were any; and certainly, without air or water, no animals such as inhabit our own planet could exist there… [p. 128]

[Speaking of the satellites of Saturn:] The following are their periods and distances from the primary… [p. 190]

> 286. SATELLITES—Uranus is known to be attended by four satellites, which differ from all the other planets of the solar system, by revolving in their orbits from east to west. [p. 194]
>
> Their orbits are inclined to the plane of that of the primary at an angle of 79°… [p. 194]
>
> 305. Since the attraction of gravitation is reciprocal, the sun is attracted by the planets, and each primary planet is attracted by its satellites; and, therefore, instead of revolving one around the other *as a centre*, they in fact revolve around their common *centre of gravity*. [p. 207]

Kiddle, Henry. *A New Manual of the Elements of Astronomy: Descriptive and Mathematical...* Ivison, Blakeman, Taylor, & Company, 1873.

David Page, 1873

> As the secondary planets revolve round their primaries, and these, again, round the sun, so the solar system itself may revolve round some vaster centre, and this order of things through systems and centres that baffle the grasp of our infinite conceptions. [p. 16]
>
> In these movements of annual revolution and daily rotation, the earth is attended by a minor or secondary body, which revolves round her as she round the great central luminary of the system. This secondary planet or *satellite* (Lat. *satelles*, an attendant) is the moon… [p. 17]

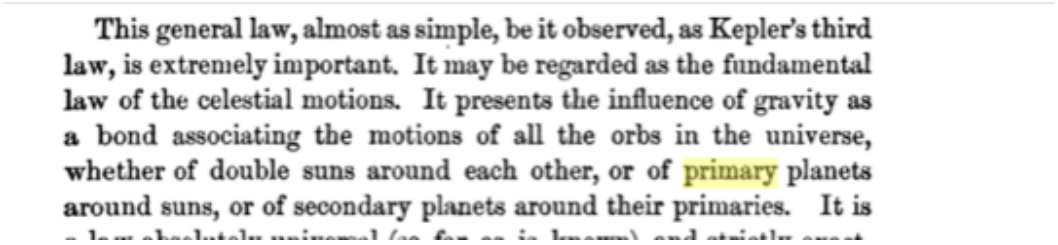
Page, David. *Introductory text-book of physical geography*. W. Blackwood, 1873.

John Isaac Plummer, 1873

> The first example of a secondary planet or satellite which we meet with in the solar system, and by far the most important, is our own moon. (p 97)

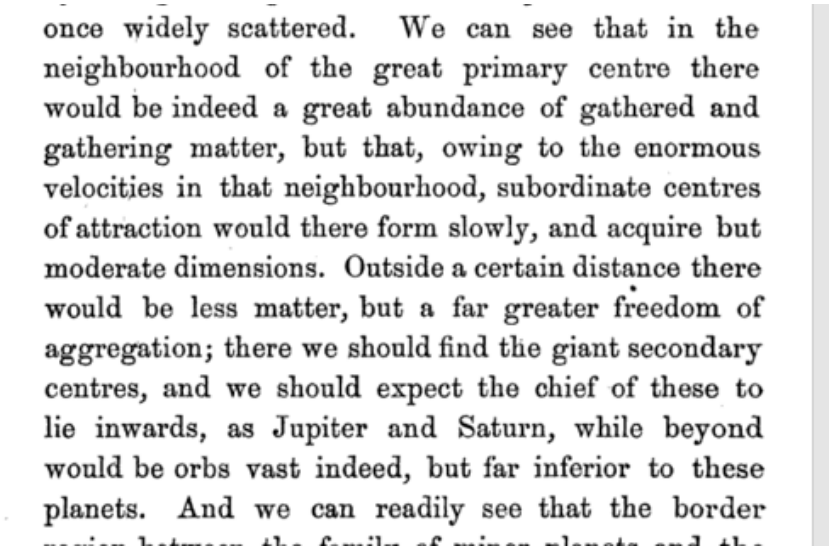
Plummer, John Isaac. *Introduction to Astronomy: For the Use of Science Classes and Elementary and Middle Class Schools*. Vol. 25. GP Putnam's sons, 1873.

Richard Anthony Proctor, 1873



This general law, almost as simple, be it observed, as Kepler's third law, is extremely important. It may be regarded as the fundamental law of the celestial motions. It presents the influence of gravity as a bond associating the motions of all the orbs in the universe, whether of double suns around each other, or of primary planets around suns, or of secondary planets around their primaries. It is

He also mentions "the great primary centre" and "the giant secondary centres" for the primary and secondary systems:



once widely scattered. We can see that in the neighbourhood of the great primary centre there would be indeed a great abundance of gathered and gathering matter, but that, owing to the enormous velocities in that neighbourhood, subordinate centres of attraction would there form slowly, and acquire but moderate dimensions. Outside a certain distance there would be less matter, but a far greater freedom of aggregation; there we should find the giant secondary centres, and we should expect the chief of these to lie inwards, as Jupiter and Saturn, while beyond would be orbs vast indeed, but far inferior to these planets. And we can readily see that the border

Proctor, Richard Anthony. *The Moon: Her motions, aspect, scenery, and physical condition*. Longmans, Green, 1873.

Richard Anthony Proctor, 1874

> But the same authors have, on another account, somewhat increased this distance; for inasmuch as the moon's diameter is a little more than the fourth part of the diameter of the earth, if the sun's parallax should be supposed 15 seconds, it would follow that the body of the moon is larger than that of Mercury; that is, that a secondary planet would be greater than a primary, which would seem inconsistent with the uniformity of the mundane system. [p. 33]

Proctor, Richard Anthony. *Transits of Venus*. 1874.

Alexander Davidson and Bernard Stuvé, 1874

[The primary & secondary systems are organically connected through Laplace's Nebula theory:]

GEOLOGY traces the history of the earth back through successive stages of development to its rudimental condition in a state of fusion. Speculative astronomy extends it beyond this to a gaseous state, in which it and the other bodies of the solar system constituted a nebulous mass, without form and motion. When, in the process of development, motion was communicated to the chaotic matter, huge fragments were detached from its circumference, which formed the primary planets. These retaining the rotary motion of the sun, or central mass, in turn threw off other and smaller fragments, thus forming the secondary planets, as in the case of the moon which attends the earth. All these bodies are similar in form, have a similar motion on their axes, move substantially in a common plain and in the same direction, the result of the projectile force which detached them from the parent mass. These facts are strong evidence that the sun, and the planetary system that revolves around it, were originally a common mass, and became separated in a gaseous state, as the want of cohesion among the particles would then favor the dissevering force. From the loss of heat they next passed into a fluid or plastic state, the point in the history of the earth where it comes within the range of geological investigation.

Davidson, Alexander, and Bernard Stuvé. *A Complete History of Illinois from 1673 to 1873: Embracing the Physical Features of the Country, Its Early Explorations, Aboriginal Inhabitants...* Illinois Journal Company, 1874.

James Nasmyth and James Carpenter, 1874

They wrote a book called *The Moon Considered as a Planet, a World, and a Satellite*. This is useful to see how the three concepts (*planet*, *world*, and *satellite*) were understood by astronomers at the end of the 19th century as distinct concepts and to see clearly what they each meant.

Chapters 1-12 describe the Moon as a "planet". The topics in these chapters include planet formation, geothermal energy in the lunar core, atmosphere, crater morphology, volcanism, and other geophysical aspects of the Moon. Thus, considering it as a planet meant considering the geophysics of the Moon.

Chapter 13 describes the Moon as a "world", having the chapter title, "THE MOON AS A WORLD: DAY AND NIGHT UPON ITS SURFACE" [all caps in the original]. This chapter deals with habitability conditions on the Moon, appearance of the sky seen from the lunar surface, dead silence of the surface, and other features that would be experienced by a human

standing on the surface. Thus, considering the Moon as a "world" mean considering the questions of habitability and what it would be like for a human to stand on its surface.

Chapter 14 describes the Moon as a "satellite", having the chapter title, "THE MOON AS A SATELLITE: ITS RELATION TO THE EARTH AND MAN" (all caps in the original). The topics in this chapter include the illumination the Moon provides to the Earth, the tides and their benefit to Earth, how the Moon helps navigation on Earth, and other ways the Moon affects the Earth and the civilization on the Earth. Thus, considering the Moon as a satellite meant considering its interactions with a primary.

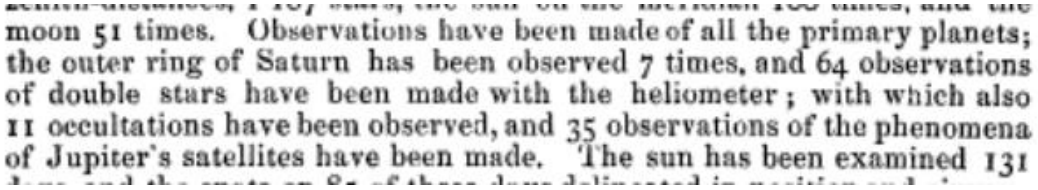
See Table 1 on next page for summary of topics in this book.

Nasmyth, James, and James Carpenter. *The Moon considered as a Planet, a World, and a Satellite*. London: John Murray, 1874.

Table 1. Topics Covered in *The Moon Considered as a Planet, a World, and a Satellite.*

As a Planet	As a World	As a Satellite
Planet formation	Habitants on planets in general	Providing illumination to Earth
Source of Heat in the Core	Habitability conditions	Cleansing Earth's waters via tidal motion
Lunar Contraction from Cooling	Inhabitability of the Moon	Providing locomotion for tidal river transport
Surface features of contraction	Lunar day/night cycle on the surface	Providing tidal power, including inland
Mass and density	Absence of twilight	Guiding navigators
Atmosphere	Blackness of sky	Providing means to find longitude
General aspects of the lunar surface	Appearance of Earth from the Moon	The Moon's motions in Earth's sky
Topographic features	Lunar landscape appearance seen from the surface	Providing long-period timekeeping; months
Crater morphology and volcanism	Desolation of scenery; no vestige of life	Providing eclipses as historic markers in chronologies
Ring basins	Color of volcanic products	Providing view of the solar corona during solar eclipses
Peaks and mountains ranges	Blackness of shadows	Providing comparative planetology with Earth to elucidate geological processes
Cracks and streaks	Extremes of heat and cold	Abuses of the Moon: superstitions like "lunacy"
Color features on the surface	Dead silence	Abuse: belief the Moon controls weather
The question of ongoing change on the surface	Visibility of the Moon's shadow on the Earth	Possible tidal influence on Earth's atmosphere
	The night sky from the Moon	Possible radiative transfer to Earth's upper atmosphere
	No meteors in the sky; impacts are dark	
	Lunar landscape by night	
Summary		
"As a Planet" = the emergently complex geophysics of the body	"As a World" = the immersive surface environment experienced by creatures there	"As a Satellite" = the effects the body induces upon its primary

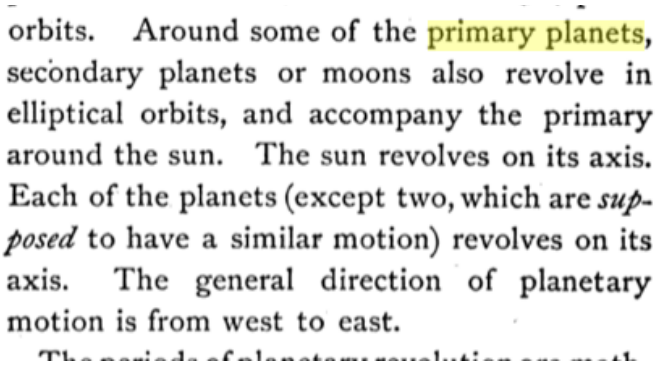
Anonymous, 1876



moon 51 times. Observations have been made of all the primary planets; the outer ring of Saturn has been observed 7 times, and 64 observations of double stars have been made with the heliometer; with which also 11 occultations have been observed, and 35 observations of the phenomena of Jupiter's satellites have been made. The sun has been examined 131

Anonymous. *Report of the Radcliffe Observer to the Board of Trustees*, read at their meeting, held July 11, 1876. *Astronomical register*, vol. 14, pp. 264-5 (1876).

William Bradner Slaughter, 1876



orbits. Around some of the primary planets, secondary planets or moons also revolve in elliptical orbits, and accompany the primary around the sun. The sun revolves on its axis. Each of the planets (except two, which are *supposed* to have a similar motion) revolves on its axis. The general direction of planetary motion is from west to east.

Slaughter, William Bradner. *The Modern Genesis: Being an Inquiry Into the Credibility of the Nebular Theory, of the Origin of Planetary Bodies, the Structure of the Solar System, and of General Cosmical History*. Nelson & Phillips, 1876.

Richard Anthony Proctor, 1880

> THE moon, commonly regarded as a mere satellite of the earth, is in truth a planet, the least member of that family of five bodies circling within the asteroidal zone, to which astronomers have given the name terrestrial planets. There can be no question that this is the true position of the moon in the solar system. In fact, the fashion of regarding her as a mere attendant of our earth may be looked upon as the last relic of the old astronomy in which our earth figured as the fixed center of the universe, and the body for whose sake all the celestial orbs were fashioned…Precisely as the study of the giant planets, Jupiter and Saturn, has led astronomers to infer that certain peculiarities must result from the vastness of dimensions, so to the study of the dwarf planets, Mars, our moon, and Mercury, may indicate the relations we are to associate with the inferiority of size.
>
> …the small planet which we call 'our moon' may be described as in the very decrepitude of planetary existence, nay (some prefer to think), as even absolutely

> dead, though its lifeless body still continues to advance upon its accustomed orbit, and to obey the law of universal attraction. [p. 82]
>
> It appears reasonable to regard the moon, after her first formation as a distinct orb, as presenting the same general characteristics that we ascribe to our earth in its primary stage as a planet. In one respect the moon, even at that early stage, may have differed from the earth….[new para]…Adopting this view, we see that at the first stage of its existence as an independent planet, rhe moon must have been and intensely heated gaseous globe, glowing with inherent light, and undergoing a process of condensation… [p. 84] [Note: he believed a capture theory for the Moon]

Proctor, Richard Anthony. *Rough Ways Made Smooth: A Series of Familiar Essays on Scientific Subjects*. R. Worthington, 1880.

Samuel Fleming, 1881

> Previous to the present century, the solar system included seven primary planets as having at that time been discovered. In the year 1800 a new planet was discovered, and designated an asteroid, or small star,—but it is more properly called a planetoid, or small planet. The name by which this is known is Ceres… The problem still to be determined has been whether these planetoids are 'fragments of a broken world,' as formerly supposed, or separate condensations from cosmic matter, instead of forming one large body, as in the case of other primary planets.
>
> …Newton, eighty years afterward, studying this principle, and at the suggestion, it is said, of the fall of an apple, found that there was a definite increase of velocity of bodies approaching the earth, and also that the same kind of attractive force must apply to the moon, while a centrifugal force, either generated from the attractive force, or originated from an extraneous force, continued this secondary planet around the earth.

Fleming, Samuel. "Recent Progress of Science." *Science* 2, no. 34 (1881): 76-78.

David Page, 1883

> In these movements of annual revolution and daily rotation, the earth, like several other of the primary planets, is attended by a minor or secondary body, which revolves around her, as she revolves around the great central luminary of the system. This secondary planet or *satellite* is the Moon,…As the secondary planets [next page] revolve round their primaries, and these, again, round the sun, so the solar system itself may revolve around some vast centre,… [pp. 20-21]

Page, David. *Advanced Text-book of Physical Geography*. William Blackwood and Sons, 1883.

Asahel Phelps Pichereau, 1884

[Calls the Moon a secondary planet one time.]

Pichereau, Asahel Phelps. *Machinery of the heavens: A system of physical astronomy*. Plaindealer Printing Company, 1884.

Richard Anthony Proctor, 1884

This interesting paper tries to look at the solar system with fresh eyes to overthrow hang-ups that persisted since pre-Copernicanism. His goal is to explain the asteroid belt as normal rather than abnormal within its architecture. His main argument is that the solar system is 5 main bodies (the sun and the four giant planets), each of which has a system of small planets, and two of which (the Sun and Saturn) have a belt of leftover planet formation material maintained by gravitational perturbations. He argues the clinging pre-Copernicanism is a desire for a simple, ordered solar system:

> [p. 445:] Until the Copernican theory was established, astronomers not only did not--they could not -- form any idea whatever of the relative sizes of the different planets ; for they had no notion of the relative distances of these bodies. Thus men's views as to the nature and character of the several planets were formed in the course of ages, during which it was not known whether Jupiter or Saturn were the larger, or whether Mercury or Venus or Mars might not be very much larger than those planets which we now know to be the giants of the solar system. This was [p 446] unfortunate; because, when the Copernican theory was established, and when, later, the telescope showed the globe forms of all the planets and the systems of subordinate bodies which attend upon them, it did not seem to occur to any astronomers to indicate how completely these discoveries modified the aspect of the whole system. Later, other discoveries were made, including the recognition of the zone of asteroids and the discovery of Uranus and Neptune, which should still further have modified the views of astronomers. But settled as men's ideas were in a particular groove, no marked effect was produced; and beyond the suggestion that probably the zone of asteroids marked the place where a single planet had once traveled, astronomers were led to no new thoughts about the planetary system. The planet which was supposed to have burst illustrated, indeed, their unwillingness to change their views ; for, by imagining such a planet, they were able to conceive the original condition of the solar system as even more uniform than it had appeared to be, either when as yet none of the asteroids had been discovered or when the asteroids were not explained conveniently.
>
> Yet every one of the discoveries made by astronomers since the time of Copernicus, including the discovery of the truth of the Copernican theory itself, has given evidence of great variety and complexity of structure within the solar system. The theory of Copernicus, and the light which it threw on the dimensions

of the solar system, proved that Jupiter and Saturn are bodies so much larger than the earth, Venus, Mars, and Mercury, that they must be set in a different class. The invention of the telescope, and the discoveries made by its means, proved that Jupiter and Saturn are the centers of systems resembling, though on a smaller scale, the solar system itself. The calculations by which the masses of the planets were determined proved that in mass, as well as in volume, enormous differences exist. The successive discoveries of the ring system of Saturn, of the zone of asteroids, of the small moons of Mars, of the systems of meteors, of planetary comets, and others, point unmistakably to a variety of structure within the solar system such as the earlier astronomers had never imagined. Yet no new survey of the solar system, no new effort to classify its members and to determine if possible their real nature and significance, was ever systematically attempted, or if attempted was held to belong rather [p. 447] to the region of speculation than of observation,-- as though anything could possibly have been more wildly speculative than the belief that the planets are such as they were imagined to be by the astronomers of Ptolemy's school.

Let us try to take such a view of the solar system as probably astronomers would have taken if their first ideas had been formed when they were in possession of the facts which have come to our own knowledge." [end long quote]

(…)

A globe [*Jupiter*] is found more than three hundred times as massive as the earth, and not far from two hundred times as massive as all the planets yet mentioned put together. It is girt round by a system of worlds, comparable rather with Mars and Mercury than with bodies of inferior class. [*inferior class = satellites. He says the satellites of Jupiter are comparable to the sun's family of terrestrial planets, at least the two smaller primary terrestrial planets. Note he calls Jupiter a "globe" rather than planet because he is taking a fresh look and is making it comparable to the sun. Note he uses "class" for those moons since he is dealing with taxonomy, classification*.] with Mars and Mercury than with bodies of inferior class. The least of them has a surface equal to North and South America taken together, and is fit, therefore, to be the abode of many millions, nay, rather millions of millions, of living creatures. Oddly enough, the system of Jupiter and his satellites so closely resembles, though of course on a much smaller scale, the system of four bodies, Mercury, Venus, Earth, and Mars, around the sun as center, that a picture of one serves well as the picture of the other.* [*his footnote*: " * Once when an assistant had unluckily broken a lantern slide showing the orbits of Mercury, Venus, Earth, and Mars about the central sun, I for the occasion substituted a slide showing the orbits of Jupiter's four moons about their central planet. No one detected the change.] We next come, at a distance [p. 448] nearly twice as great from the sun, to a body less, indeed, than Jupiter, but belonging to the same class,— the ringed giant Saturn, a hundred times as massive as the earth, and circled round by eight worlds, the largest of which exceeds Mercury in size,

besides a ring system, akin in some respects to the ring of asteroids. Again we pass over nearly as great a distance as we had already reached, and come upon the orbit of Uranus, with his family of four worlds as yet discovered ; and though Uranus is much less than Saturn, he is a giant compared with the earth. Lastly, after passing over half the distance at which Uranus travels, we come on the orbit of the most distant planet, Neptune, a giant planet (brother to Uranus, in size and mass), attended by but a single yet discovered moon. [*Note how he is using "planet" only sparsely in this fresh look. Jupiter is a "globe", Saturn is a "body…belonging to the same class", Uranus is a "giant". Only for Neptune does he use the word "planet". Their satellites he calls "system of four bodies", "circled round by eight worlds", "family of four worlds". For Neptune he emphasizes that there might be more moons discovered later so it too might eventually look like a miniature solar system*.]

We have so fallen into the habit of regarding this system as represented by a central body with a series of circles set round it [*which we inherited from Geocentrism*], that we find it difficult to picture it as it would appear to one who, visiting our sun's neighborhood from outer space, should view the system as it would appear at any instant of time. He would not recognize that relationship of all the bodies in the system to a central mass, which appears to us the most striking feature of the planetary family. Instead of that, he would see five leading bodies, each attended by a family of small worlds. These five would not include our earth. They would be, first, the sun, attended by five worlds (two of which would be seen to form a double planet), Mercury, Venus, Earth and Moon, and Mars ; secondly, Jupiter attended by a family of four worlds ; Saturn with eight attendant worlds and a ring system ; Uranus with his family; and Neptune with his, (for we may well believe that the discovered moon of Neptune has fellows which yet remain to be detected).

[p 456] We may also find, in the exceptional circumstances of the outermost region of the solar system, an explanation of the circumstance that the satellite systems of Uranus and Neptune, only, show a movement of circulation around their primary in a direction contrary to that observed throughout the rest of the solar system,— not only in the movements of the planets around the sun, and of the satellites around their primaries, but also in the rotation of individual planets (including our moon) upon their axes.

[Note he uses the "primaries" terminology and also he directly includes Earth's Moon as a planet, which is consistent with his other arguments that the Earth-Moon system is a double planet. Note his taxonomy is derived by reductionist thinking seeking to overthrow inherited pre-Copernicanism, not simple descriptivist dynamical categorizing.]

[p. 456]: Inside the zone where a planet failed altogether to attain the fullness of independent planetary life, we might expect to find a region where, though a planet formed with difficulty and acquired but a small mass [Mars], it yet

> succeeded, despite the per- [p 457] turbing influences of Jupiter, in gathering up its substance and becoming a primary though small member of the solar family. Possibly in the conditions prevailing here [*viz*., within Jupiter's gravitational perturbation where the asteroid belt did not condense into a planet] we may find an explanation, also, of the circumstance that Mars alone, of all the primary planets, has two bodies attending on him which, though we may call them moons, are in reality far too small to be set in the same class as the moons of Jupiter and Saturn,* and the companion planet of our earth. [*his footnote includes the following: "…Thus Hyperion, to appear as bright as one of the Martian moons, must have a surface 14,400 times as great, corresponding to a diameter 120 times as great, and a volume 1,728,000 times as great,--which assuredly sets him in a different class of created orbs…" I.e., it is planet-like, while the Martian moons are not. His thinking supports taxonomical judgement that large moons are in a category with planets while smaller moons are not.]
>
> It is noteworthy, also, how the largest member [i.e., Earth] of the sun's special family [i.e., the terrestrial planets of the inner solar system], thus formed where the conditions seem most favorable, is attended by a companion body, the only secondary planet, properly so called, in the whole region inside the orbit of the giant Jupiter. [p. 458]

[Note: for further context on Proctor's views in this period, in particular regarding his view of asteroids as planets, see the appendix to this document.]

Proctor, Richard A. "A ZONE OF WORLDS." *The North American Review (1821-1940)* 138, no. 330 (1884): 445.

<u>Laurence Johnstone, 1887</u>

From a textbook on logic:

> Secondary planets move round their primaries ;
> But the moon is a secondary planet ;
> Therefore the moon moves round its primary.
>
> (…)
>
> Planets can only be satisfactorily studied through a telescope;
> But the moon is a planet;
> Therefore the moon can only be satisfactorily studied through a telescope, – and I must study it through a telescope.
>
> (…)

> A term may be **absolute** or **relative**. An absolute term denotes a thing in itself, *e.g.*, man, book, star ; a relative term denotes a thing in relation to some other thing, *e.g.*, father, master, which denote man in relation to children or subordinates—satellite which denotes a secondary planet in relation to its primary. Terms so related are called **correlatives**.
> The moon is a satellite;
> But every satellite is a planet;
> Therefore the moon is a planet;
> Planets shine by reflected light;
> Therefore the moon shines by reflected light;
> That which shines by reflected light is not self-luminous;
> Therefore the moon is not self-luminous.

Johnstone, Laurence. *A Short Introduction to the Study of Logic*. Longmans, Green, 1887.

William Thynne Lynn, 1891

> In its annual journey round the Sun, the Earth is accompanied by a smaller planet called the Moon, the movement of which relatively to the Earth being in the nature of a motion in an elliptic orbit round the latter, she is considered as a satellite or secondary planet thereto.

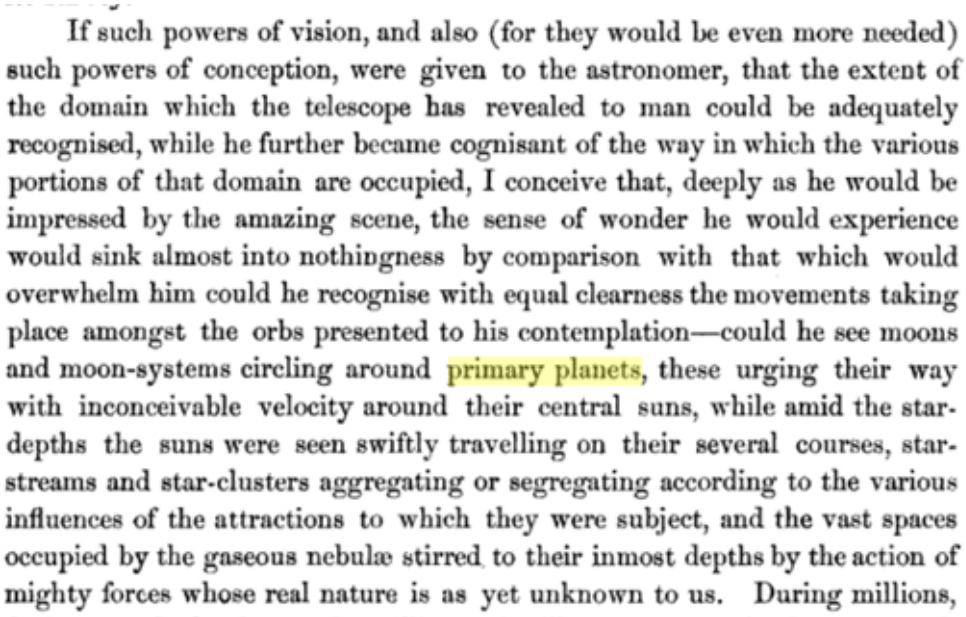
Lynn, William Thynne. *Celestial motions: A handy book of astronomy*. Edward Stanford, 1891.

Robert S. Ball, 1892

> This fact at the time of its announcement was unique in the whole solar system. There was never a case known before in which a secondary planet accomplished a revolution in less time than the primary accomplished a rotation.

Ball, Robert S. "JUPITER'S NEW SATELLITE." *Fortnightly* 52, no. 312 (1892): 733-745.

Richard Anthony Proctor and Arthur Cowper Ranyard, 1892



If such powers of vision, and also (for they would be even more needed) such powers of conception, were given to the astronomer, that the extent of the domain which the telescope has revealed to man could be adequately recognised, while he further became cognisant of the way in which the various portions of that domain are occupied, I conceive that, deeply as he would be impressed by the amazing scene, the sense of wonder he would experience would sink almost into nothingness by comparison with that which would overwhelm him could he recognise with equal clearness the movements taking place amongst the orbs presented to his contemplation—could he see moons and moon-systems circling around primary planets, these urging their way with inconceivable velocity around their central suns, while amid the star-depths the suns were seen swiftly travelling on their several courses, star-streams and star-clusters aggregating or segregating according to the various influences of the attractions to which they were subject, and the vast spaces occupied by the gaseous nebulæ stirred to their inmost depths by the action of mighty forces whose real nature is as yet unknown to us. During millions,

Proctor, Richard Anthony, and Arthur Cowper Ranyard. *Old and new astronomy*. Longmans, Green and Company, 1892

John Ellard Gore, 1893

An astronomical glossary:

Planets, Minor or **Asteroids.** The group of small planets which revolves round the sun in orbits lying between those of Mars and Jupiter. They are very small bodies. The diameter of the largest, Vesta, probably does not exceed 200 miles. The number now know (1893) amounts to over 300.

Planets, Primary. The planets which revolve round the sun as a centre. These are in order of distance from the sun: (1) Mercury, (2) Venus, (3) the Earth, (4) Mars, (5) the Group of Minor Planets, (6) Jupiter, (7) Saturn, (8) Uranus, (9) Neptune.

Planets, Secondary. The satellites which revolve round the primary planets as a centre. Our moon is a secondary planet, or satellite of the earth, but from its relatively large size and other reasons, it may almost be considered a primary planet. Mars has 2 satellites, Jupiter 5, Saturn 8, Uranus 4, and Neptune 2 : a total of 22 secondary planets.

Gore, John Ellard. *An Astronomical Glossary*. Crosby Lockwood and Son, 1893.

William North Rice, 1894

A characteristic example of such a series of changes as may properly be called Evolution is to be found in the growth of the individual plant or animal from its primitive condition of a single protoplasmic cell to the complexity of its adult condition. On a larger scale, the origin of primary and secondary planets from a primitive nebula, as explained by the nebular theory, is a case of the evolution of a planetary system. [pp 59-60]

Rice, William North. *Twenty-five Years of Scientific Progress and Other Essays*. TY Crowell, 1894.

John Thornton, 1897

P. 32:

22. **Classification of the Planets.**—The planets have been divided into primary, minor primary (called also planetoids or asteroids), and secondary. The primary planets are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. These are subdivided into inferior and superior planets. Mercury and Venus are called *inferior* planets because their orbits are included within the orbit of the earth, while the others, whose orbits lie beyond that of the earth, are spoken of as *superior* planets. The minor planets, or asteroids, consist of a number of small bodies moving between the orbits of Mars and Jupiter. The first of these was discovered by a Sicilian astronomer on January 1, 1801. He called it Ceres. Next year another was found and named Pallas; Juno, the third, was discovered in 1804; and in 1807 Vesta, the largest and brightest of the group, was seen. For a time discovery of these bodies ceased, but since 1845 almost every year has added to the number, so that at the beginning of 1897, 420 of these bodies will be catalogued. The inclination of their orbits to the plane of the ecliptic averages about 8°, but many of them exceed this considerably, that of Pallas being 35°. In size they vary from Vesta, whose diameter has been estimated at about 300 miles, to bodies of about five miles in radius. The secondary planets are satellites or moons revolving round a primary planet, and accompanying it in its revolution round the sun. Twenty-one such bodies are now known. Of these the Earth has one, Mars two, Jupiter five, Saturn eight, Uranus four, and Neptune one.

Humboldt divided the primary planets into two groups, which he called

Humboldt divided the primary planets into two groups, which he called *terrestrial* planets and *major* planets. The terrestrial planets are Mercury, Venus, the Earth, and Mars. Speaking broadly, these have much in common in their physical constitution. Water and an atmosphere possibly exist on all, and, leaving out Mercury, which probably exceeds considerably the average density of the other three, their density is nearly the same. The major planets are Jupiter, Saturn, Uranus, and Neptune. These are much larger bodies than the terrestrial planets and have a much smaller density, and appear to present to us only a cloudy surface. Three of them, moreover, are the centres of a complex system of their own.

Thornton, John. *Advanced physiography*. Longmans, Green and Company, 1897.

Richard Anthony Proctor, 1897

occupied by our own moon. The largest of Jupiter's moons has a mass less than the 110,000th part of Jupiter's; our moon, on the contrary, is about equal to the eightieth part of the earth. As respects mass, our moon is in fact rather to be regarded as the fifth and smallest member of the inner family of planets, than as occupying a totally inferior position as a body of another order. The earth exceeds Mercury very much more, as well in mass as in volume, than Mercury exceeds the moon. Jupiter's moons, on the other hand, belong as distinctly to an inferior order, when compared with him or his fellow giants among the planets, as our earth when compared with the sun.

Proctor, Richard Anthony. *The Expanse of Heaven: a Series of Essays on the Wonders of the Firmament*. Longmans, Green, 1897.

W. T. Lynn, 1898

Speaking of Halley:

> Considering that it was not probable the size of Mercury (a primary planet) would exceed that of the Moon (a secondary planet) and that the size of Venus (a planet without a satellite) would probably be less than that of the Earth (a planet with a satellite) he thought that the Sun's parallax might be take to be between 10" and 20".

Lynn, W. T. "Solar parallax and transits of Mercury." *The Observatory* 21 (1898): 312-313.

Examples from Early 1900s:

C. L. Doolittle, 1901

This uses just “planets” for the primaries:

> The eighteenth century ended with a list of known planets numbering 7 not including satellites. (p.3)

But this uses “secondary planets”:

> Of satellites, or secondary planets, seven have been added to the list during the century, one of Saturn, by Bond of Cambridge, September, 1848; one of Neptune, by Lassell, soon after the discovery of the planet itself; two of Uranus, also by Lassell, 1851; Bonaparte. This may explain the fact that two of Mars, by Hall, of Washington, August, 1877; one of Jupiter, by Barnard, of the Lick Observatory, September, 1892. We should perhaps include an eighth in this category, an additional satellite of Saturn having been announced by W. H. Pickering two years ago, but as it has not yet been confirmed, judgment must be suspended for the present. [p. 4]

Doolittle, C. L. "Some Advances Made in Astronomical Science During the Nineteenth Century." *Science* 14, no. 340 (1901): 1-12.

David Peck Todd, 1901

> In its annual journey round the Sun, the Earth is accompanied by a smaller body called the Moon; her movement relatively to the Earth being in the nature of a motion in an elliptic orbit round the latter, she is considered as a satellite or secondary planet thereto.

Todd, David Peck. *Stars and Telescopes: A Hand-book of Popular Astronomy, Founded on the 9th Edition of Lynn's Celestial Motions*. Little, Brown, 1901.

J. Morrison, 1902

The Sun itself and all the planets, so far as known, revolve on their axes in the same direction and the satellites revolve about their primaries in the same direction as the planet's axial rotation. The planets Uranus and Neptune form an apparent exception to this; their satellites have a retrograde motion around their primaries and the planets themselves probably have a retrograde motion on their axes, but this is by no means inconsistent with the hypothesis, for the direction of the axial rotation of the planet resulting from the segment set free from the central contracting mass, depends on the manner in which the matter is distributed in the segment, that is to say, on the position of its center of gravity with regard to its geometric center.

Moreover, as we shall presently show, if the Sun's mass were expanded until the surface would reach each planet in succession, the period of axial rotation in each position would be exactly equal to the periodic time of the corresponding planet, and so also would the time of rotation of the primary planets expanded in like manner, be equal to the times of revolution of their satellites, thus if the Sun, for instance, were expanded until its surface reached the orbit of Mercury, it would then revolve in 88 days instead of 25 as at present; if expanded until it reached the orbit of Venus, it would revolve in 224 days, and so

Morrison, J. "The source and maintenance of solar energy." *Popular Astronomy* 10 (1902): 409-419.

George William Hooper, 1903

This text uses “primary planet” but not “secondary planet”:

ART. I. *Gravitation.*—In the realm of Science, there exists a Force or Law that pervades and influences all Nature, and from the power of which, nothing, not even an atom, is free.

It holds together the component parts of each and every individual world, and in the world's revolving prevents both its inhabitants and its vegetation from being whirled off its surface into space. It exists in each and every central sun, and circles round each sun its associated system of planets. It rolls each satellite around its primary planet, and regulates the comet's mysterious flight into the depths of space, while the pendulation of even the remotest star is accomplished by this same force. Our own rocking world obeys the same mysterious power, that seems to grasp the entire material creation as with the grasp of the Infinite.

It exists in, and influences every atom, whose combinations

Hooper, William George. *Aether and gravitation*. Chapman and Hall, ltd., 1903.

Nathaniel Southgate Shaler, 1904

> In that detached portion of the parent nebula the process of concentration was repeated, with the result that satellites, or as we may term them, secondary planets, were formed substantially as the greater spheres were set off from the sun. [p. 104]

Shaler, Nathaniel Southgate. *General description of the moon*. Gov't. print. off., 1904.

Henry Pattillo, 1909

p. 25:

A. Yes; the very proper time. The *planets* are a number of globes, that revolve round the Sun, as the Earth does; some less than the Earth, some vastly larger, some nearer to him, others much farther from him, some primary, others secondary; and the Sun, Planets and Comets compose the SOLAR SYSTEM.

p. 26:

Q. 70. What is the distinction of primary and secondary, among the planets?

A. The Earth is a primary planet; the Moon a secondary, called a satellite, guard or attendant; and so of the rest.

III. The Earth is the third planet from the Sun, and revolves round him, as you have seen, in 365 1-4 days, at

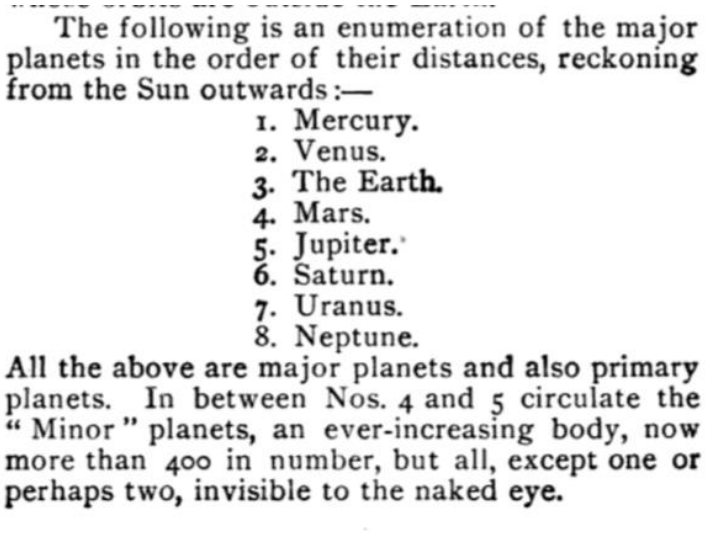
p. 27:

the rate of 60,000 miles each hour, and at the distance of 96,000,000 of miles from him; while her secondary or satellite, the Moon, attends her through the whole of her annual course, but partakes not of her daily motion round her axis: instead of which, the Moon has an orbit of about 1,400,000 miles around the Earth, from change to change; and consequently travels so much more than the Earth every month. The diameter of the Moon is about 2200 miles,

Pattillo, Henry. *Pattillo's Geographical Catechism*. No. 1. The University Press, 1909.

George Frederick Chambers, 1909

> The planets are divided into “primary” and “secondary.” By a “primary” planet we mean one which directly circulates round the Sun ; by a “secondary” planet we mean one which in the first instance circulates round a primary planet, and therefore only in a secondary sense circulates round the Sun. The planets are also “major” or “minor” ; this, however, is only a distinction of size.
>
> The secondary planets are usually termed “satellites,” or, very often, in popular language, “moons,” because they owe allegiance to their respective primaries just as our Moon—*the* Moon—does to the Earth. But the use of the term “moon” is inconvenient, and it is better to stick to “satellite.” [pp. 7-8]



The following is an enumeration of the major planets in the order of their distances, reckoning from the Sun outwards:—

1. Mercury.
2. Venus.
3. The Earth.
4. Mars.
5. Jupiter.
6. Saturn.
7. Uranus.
8. Neptune.

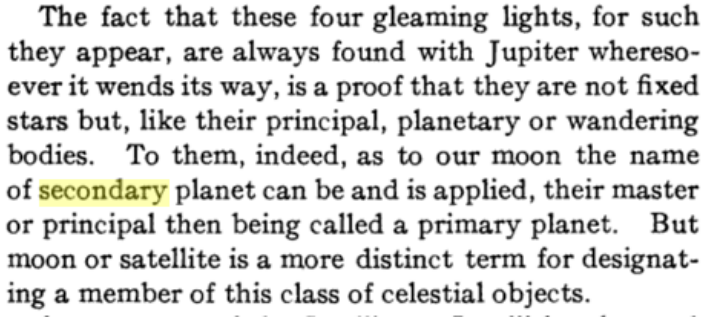
All the above are major planets and also primary planets. In between Nos. 4 and 5 circulate the "Minor" planets, an ever-increasing body, now more than 400 in number, but all, except one or perhaps two, invisible to the naked eye.

Chambers, George Frederick. *The story of the solar system*. University society, Incorporated, 1909.

George Vincent Leahy, 1910

> The satellites or secondary planets, over twenty in number, are all too feeble gravitationally to retain at their surface a proper atmosphere…True planets all of these are whatever be their distinguishing names. For they are solidified bodies shining by reflected light. Yet no one of them is enveloped in an atmosphere suited to the maintenance of life…the moon is typical of the entire group above enumerated.
>
> (…)
>
> The birth of the secondary planets, or satellites, they hypothesis of Laplace explains by the same chain of reasoning [as the primaries].

p. 63:



The fact that these four gleaming lights, for such they appear, are always found with Jupiter whereso-ever it wends its way, is a proof that they are not fixed stars but, like their principal, planetary or wandering bodies. To them, indeed, as to our moon the name of secondary planet can be and is applied, their master or principal then being called a primary planet. But moon or satellite is a more distinct term for designat-ing a member of this class of celestial objects.

Regarding habitability, p. 83:

Failures Under This Requirement. It is certainly to be accentuated that the vast majority of the components of the solar system fail to meet successfully this second test. Indeed none of them meet it except the eight greater or major planets. The satellites or secondary planets, over twenty in number, are all too

p. 84:

feeble gravitationally to retain at their surface a proper atmosphere. To them must also be added as similarly restricted the whole group of minor planets or asteroids, a force of five hundred diminutive bodies occupying the zone between Mars and Jupiter.

True planets all of these are whatever be their distinguishing names. For they are solidified bodies shining by reflected light. Yet no one of them is enveloped in an atmosphere suited to the maintenance of life. The absence of all trace of atmosphere from the surface of the moon has long been a well-established fact of observational astronomy. And the moon is typical of the entire group above enumerated.

Leahy, George Vincent. *Astronomical essays*. Washington Press, 1910.

George Frederick Chambers, 1911

> The planets are divided into ‘primary’ and ‘secondary.’ By a ‘primary’ planet we mean one which directly circulates round the Sun ; by a ‘secondary’ planet we mean one which in the first instance circulates round a primary planet, and therefore only in a secondary sense circulates round the Sun….The secondary planets are usually termed ‘satellites,’ or, very often, in popular language, ‘moons,’ because they own allegiance to their respective primaries just as our Moon—the Moon—does to the Earth. But the use of the term ‘moon’ is inconvenient, and it is better to stick to ‘satellite.'

Chambers, George Frederick. *The story of the solar system simply told for general readers*. New York: D. Appleton & Company, 1911.

Philip E. B. Jourdain, 1914

> If that is so, this force must act towards the center of the earth in the place where the moon is: if this is so, this power —whatever it may be—may, consequently,

> be the same as that which makes the planets tend towards the sun and as that which makes the satellites of Jupiter gravitate to Jupiter. Now it is demonstrated by all the inductions deduced from Kepler's laws that all these secondary planets gravitate the more towards the center of their orbits as they are nearer and the less so as they are farther off, that is to say, reciprocally as the squares of their distances. [pp. 209-210]

Jourdain, Philip EB. "The Principles of Mechanics with Newton: From 1666 to 1679." *The Monist* 24, no. 2 (1914): 188-224.

Vincent Francis, 1917

> Not including the moon, there are twenty six secondary planets or satellites so far discovered in the solar system, Mars being attended by two, Jupiter by nine, Saturn by ten, Uranus by four, and Neptune by one. [p. 446-447]

Francis, Vincent. "Is our earth the only life supporting body in the universe?." *Popular Astronomy* 25 (1917): 441.

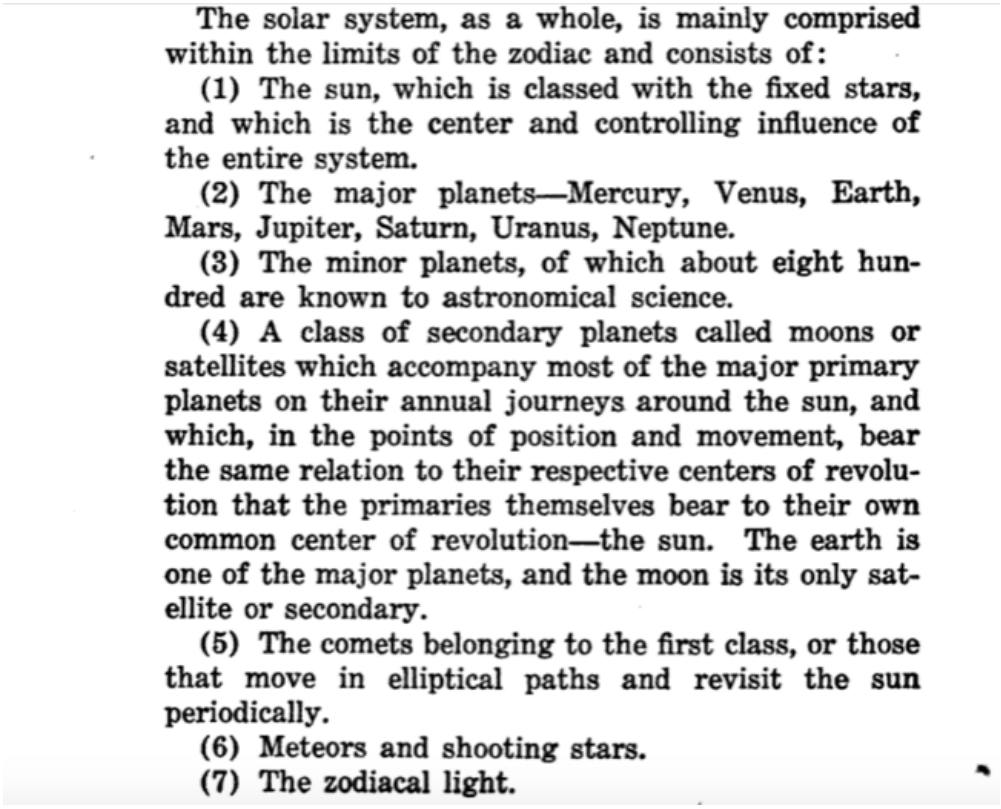
Albert B. Reagan, 1919

> And as the writer has suggested in previous publications may not these changes both in climate and in the readjusting and rebuilding of the earth's crust be due to results brought about by our solar system having reached one or the other terminus of the great elipse [sic] around which it is whirling with its company of planets, meteors, planetoids, secondary planets, and comets, much as our extreme yearly seasons are caused by similar positions of the earth with reference to the path it travels around the sun and to the inclination of its axis.

Reagan, Albert B. "Probable Eocene Glacial Deposits in the Fort Apache Region, Arizona." In *Proceedings of the Indiana Academy of Science*, vol. 29, pp. 355-358. 1919.

John Young Brown, 1922

Page 4:



The solar system, as a whole, is mainly comprised within the limits of the zodiac and consists of:

(1) The sun, which is classed with the fixed stars, and which is the center and controlling influence of the entire system.

(2) The major planets—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

(3) The minor planets, of which about eight hundred are known to astronomical science.

(4) A class of secondary planets called moons or satellites which accompany most of the major primary planets on their annual journeys around the sun, and which, in the points of position and movement, bear the same relation to their respective centers of revolution that the primaries themselves bear to their own common center of revolution—the sun. The earth is one of the major planets, and the moon is its only satellite or secondary.

(5) The comets belonging to the first class, or those that move in elliptical paths and revisit the sun periodically.

(6) Meteors and shooting stars.

(7) The zodiacal light.

Brown, John Young. *To the Moon and Back in Ninety Days: A Thrilling Narrative of Blended Science and Adventure*. Lunar Publishing Company, 1922.

Orbital States Are Changeable

Examples showing that scientists recognized that planets could (and did) change dynamical states from primary to secondary, from secondary to primary, from primary to rogue (free floating), etc. Thus, a taxonomy based on their current dynamical state could be recognized from an early date as merely descriptivist and not ontogenetic, which may have been part of the reason they did not base the planet concept on current dynamical state.

Bernard Le Bovier de Fontenelle, 1686:

> The comets are merely planets, belonging to another system. Their orbit was towards the extremity of their vortex…These planets, beginning at the upper part to form their circle, did not foresee that it would extend beyond the limit of their

> vortex…therefore, to continue their circular journey, they were obliged to enter the extremities of the next vortex, which we will suppose is ours.

Comment on this passage: At that time, scientists did not know how large or small the comets are. de Fontenelle thought they are much larger than they really are, and he thought they were populated worlds. Most scientists in his era thought all the planets were populated worlds because they were working from a teleological basis and needed that theory to explain why planets were created, since they do not orbit or serve the world on the Earth. He was working from the vortex theory that Descartes' proposed to explain planetary circular motions. It was a popular theory before Newton finally explained orbits via gravity. De Fontenelle discusses here how a planet escapes the vortex of its home star then enters the vortex of another star, passing the orbits of other planets, thus becoming what we call a comet. Although much of that is now known to be incorrect, it shows that scientists of that era believed that planets can change orbits, which we still believe today.

[p. 94:]

> If a smaller planet comes within the vortex of a larger one, it is irresistibly carried round the larger one, and altogether the large, and the small planet, and the vortex that encloses them, perform their revolution round the sun. Thus at the commencement of creation we obliged the moon to follow us because she came within the influence of our vortex, and was by that means subjugated to our will. Jupiter, he planet we were speaking of, was more fortunate, or more powerful than the earth. Four little planets were in the neighborhood, and he became master of them all ; and we, who are a planet of some importance, would probably have felt his power if we had been near him. He is a thousand times larger than the earth ; and would easily have drawn us into his cortex, and made us one of his moons ; instead of this we have a planet attend on us : so true is it that the situation into which we are thrown decides the fate of our lives.

Edmund Halley, ca. 1692

> Since this was written, a Discovery I have made in the Celestial Motions, seems to render a farther account of the Use of the Cavity of the Earth, *viz.* To diminish the Specifick Gravity thereof in respect of the Moon : for I think I can demonstrate that the Opposition of the Ether to the Motions of the Planets in long time becomes sensible: and consequently the greater Body must receive a less Opposition than the smaller, unless the Specifick Gravity of the smaller do proportionably exceed that of the greater, in which case only they can move together; so that the Cavity I assign in the Earth, may well serve to adjust its wight to that of the Moon. For otherwise the Earth would leave the Moon behind it, and she become another Primary Planet. But this I design to explain by a Discourse apart more at large.

Edmund Halley, *Phil. Trans.* 17, 577-578 (ca. 1692).

David Gregory and Edmund Halley, 1715

> There may also be another Effect or Use of a Comet. Namely, if a Comet passes near a Planet … it will so attract it that its Orb will be chang'd. . . whence the Planet's Period will also be chang'd. But the Comet may also by its Attraction so disturb the Satellite, as to make it leave its Primary Planet and itself become a Primary Planet about the Sun…

Gregory, David, and Edmond Halley. *The elements of astronomy, physical and geometrical*. Vol. 1. J. Nicholson and sold, 1715.

Isaac Newton, 1724/5

A conversation with Isaac Newton from 1724/5 recorded by Newton's nephew, Mr. Conduit:

> He then repeated to me, by way of discourse…as water and other matter, had gathered themselves, by degree, into a body, and attracted more matter from the planets, and at last made a secondary planet (viz: one of those that go round another planet), and then, by gathering to them, and attracting more matter, became a primary planet; and then, by increasing still, became a comet,….He said he took all the planets to be composed of the same matter with this earth, viz: earth, water and stones &c., but variously concocted.

Chittenden, M.A. (1848). "Life of Sir Isaac Newton." In: Newton, Isaac. *The Mathematical Principles of Natural Philosophy.* Transl. by Andrew Motte. New York: Daniel Adee, 1848.

Later Uses of 'Primary Planet'

After about the 1920s we no longer found sources that use the terminology "secondary planet" (or they were very few), nor that teach moons as planets, until the view of moons-as-planets revived specifically among planetary scientists ca. the 1960s. However, we did find continued use of "primary planet" throughout the interim and into the modern era. Starting after ca. the 1920s "primary planet" was used as the opposite to "satellite/moon" rather than as the opposite to "secondary planet." Some examples follow.

W. G. Colgrove, 1927

Two cases of saying "their primary" but not explicitly "primary planet":

> from the surface of Saturn. The thickness of the rings is small, less than 50 miles. In all probability they are composed of swarms of meteoric bodies revolving around their primary in individual orbits and in different periods, yet in each ring the particles are so nearly alike that they have become associated in the three distinct groups. During the past six years, on account of their inclination of about 27° to the plane of their orbit and about 28° to the plane of the ecliptic, these rings have been apparently opening out. In 1928 they will reach their widest, and then they will begin to close again, each process taking about seven years.

(…)

> about 22 hrs. 37 min. The farthest, Phoebe, is more than 8,000,000 miles away; is of the seventeenth magnitude; has a diameter of only 200 miles and revolves backwards in a period of 546 dys. The five nearest revolve in the same plane as their primary; the next two, Titan and Hyperion, are quite near this plane, but the others, excepting Phoebe, are inclined from 10 to 20 deg. These ten moons together have only six times the volume of ours, while all the light available from as many as shine at one time on Saturn is less than .01 of what we receive from our full moon.

Colgrove, W. G. "The Planet Saturn." *Journal of the Royal Astronomical Society of Canada* 21 (1927): 241.

William H. Pickering, 1928

Looking for a planet beyond Neptune by studying orbital perturbations:

> We must point out here that this [presumed] object is in no sense a satellite of Neptune, revolving about it in a period of 165 years, but a true primary planet.

Pickering, William H. "The next planet beyond Neptune." *Popular Astronomy* 36 (1928): 143.

Elmer S. Hall, 1930

In 1930, Hall copyrighted a book, *The mechanics of primary planet rotation, with table of rotations, periods and axial inclinations.* Green Bay, Wisc.: Carl Herrmann co., 1930.

Unable to obtain a copy of this book

Forest Ray Moulton, 1935

p. 241:

> The mass of a planet which has a satellite can be computed by the formulat of Art. 177 frm the distance of the satellite from the center of its primary and the period of revolution about…

p. 284:

> The sun would rob a planet of a satellite if the satellite were too remote from its primary.

Moulton, Forest Ray, Astronomy (New York: McMillan, 1935)

Clyde Fisher and Marian Lockwood, 1940

> This text specifically says (or at least implies) that moons are not planets because they do not orbit the Sun directly – they only "resemble" small planets. This clearly shows that the folk taxonomy has been embraced.
>
> The Moon is the only heavenly body that revolves around the Earth; and because of this relationship it is known as a satellite, one of the bodies that resemble small planets but revolve around planets instead of around the Sun. In our entire solar system only twenty-eight satellites or moons are knonw. Our Moon is the largest satellite in comparison with the size of its primary planet.

Fisher, Clyde, and Marian Lockwood, Astronomy (New York: Wiley, 1940)

Hugh Oscar Peebles, 1960

> Calculations made by E. A. Roche on the assumption of a liquid satellite of equal density with its primary planet showed that the satellite could not withstand tidal disruption if it were at a distance less than 2.44 times the planet's radius (the "Roche limit").

Peebles, Hugh Oscar. "Atronomical Applications of the Law of Universal Gravitation and of the Theory of Relativity." Master's Thesis, University of Texas, Austin (1960).

V. S. Safronov, 1962

> Hoyle allowed for such a great velocity of rotation under the influence of Littleton's idea of the rotational instability of the primary planets and the separation of satellites from them.

Safronov, V. S. "On the Problem of the Rotation of Planets." *Problems of Cosmogeny* 8 (1962): 177.

Vsevolod Vasil′evich Sharonov, 1964

This paper only uses “planet” and “satellite” except in this one location where it compares the orbital elements of a satellite to the “primary”.

A satellite's orbit may be specified by the same elements as a planet's. However, in some cases it is preferable to refer these elements to the plane of the primary's orbit, rather than to the ecliptic. Or it may be desired to give the inclination relative to the equatorial plane of the primary planet. Both are given in Table 3.

Table 3 shows that while most satellites have direct motion quite a few retrograde, viz. 11 of the 31 satellites now known, or 35%. Of these 11, the five satellites of Uranus form a regular system with orbital planes close to their primary's equatorial plane, that is, perpendicular to the plane of the ecliptic.

Sharonov, Vsevolod Vasil′evich. "The nature of the planets." *Jerusalem: Israel Program for Scientific Translations (IPST), 1964* (1964).

Fred Lawrence Whipple, 1968

about half that of the Moon. The systems of Jupiter and Saturn are really miniature solar systems in every respect except that the primary planets do not send out light by themselves but shine by reflected sunlight only. The great planets are more massive when compared to their largest satellites than is the Sun when compared to Jupiter or Saturn.

The similarity with the whole solar system is even more striking

in the system of Saturn because this planet not only controls nine satellites, equal to the number of known planets about the Sun, but also possesses a family of miniature asteroids, which comprise the great rings (Fig. 11). These rings are so close to Saturn itself that

(…)

The mass of a satellite is difficult to determine because it is generally so small compared with the mass of the primary planet. The effect of the Earth on the Moon's motion is easily measured, but the Moon is so small in mass that it affects the Earth's motion only slightly. The center of the Earth moves about their common center of

Whipple, Fred Lawrence. *Earth, moon, and planets*. Harvard University Press, 1968.

Melvin Pollard, 1969

> It would be exceedingly dangerous to carry this speculation further than the known facts warrant, but it looks as if the evolution of human life itself may have depended ultimately upon the extremely rare occurrence of a primary planet not only located at the "proper" distance from its sun but controlling a satellite massive enough to raise tides on the primary.

Pollard, Melvin. "Cambrian Fossils and Origin of Earth-Moon System: Discussion." *Geological Society of America Bulletin* 80, no. 4 (1969): 729-732.

Donald C. Fraser et al., 1971

> When in the vicinity of a planet, the TV is used to measure the direction to one or more of the planetary satellites. By imaging the satellite in the TV coordinate system, one gains information about the position of the spacecraft relative to the satellite, and by considering the position of the satellite relative to its primary, one obtains information on the spacecraft's position relative to the primary planet.

Fraser, Donald C., Malchow, Harvey L., Farrington, Patricia, and Sackett, Lester L., "guidance and navigation requirements for unmanned flyby and swingby missions to the outer planets," Volume IV, High Thrust Missions – Part 2, Final Technical Report on Phase C of Contract NAS-2-5043, Charles Stark Draper Laboratory, Massachusetts Institute of Technology, Cambridge, MA, 1971.

Ian Halliday, 1972

> If enough heat is applied to a satellite by the tidal effects of a massive primary planet, or by internal radioactivity, to partially melt the satellite then these reserves of gravitational and chemical energy also become available for further heating.

Halliday, Ian. "Advances in Astronomy: Satellites of the Outer Planets." *Journal of the Royal Astronomical Society of Canada*66 (1972): 314.

Recent Variant Uses of "Primary"

Other recent uses of "primary" that often show up in searches: Telescope Exoplanet literature refers to stars as the primary, or if there are multiple exopolanets in a a system the "primary planet" is the largest creating the primary signal. In binary star systems the larger star is the primary.

Modern Variant Uses of "Secondary Planet"

A. A text in the 1970s that comes very close to saying moons are secondary planets:

> Thus Clairaut articulates the importance of the verifiability of the consequences of universal gravitation. Now the most important consequence of universal gravitation is that of perturbation in a system of three or more bodies. This problem may be studied either in the case of the perturbation of the solar orbit of one primary planet by a neighbouring primary, or in that of the solar perturbation of the orbit of a secondary planet round a primary.
>
> …The first of these demonstrations is a brief repetition of the argument that the truth of Kepler's third law for all the primary planets shows an inverse-square attraction focussed in the sun. Buffon seems unconcerned with the limits of this law's applicability, for he asserts that we may consider all the primary planets 'apart and.., as unable to perturb one another' and that we may pay ' attention only to their motion round the sun'. 33
>
> Ignoring Clairaut's demonstration that an added term of inverse-fourth power would have no easily discernible effect on the primary planets, though it would affect the secondary ones, Buffon simply argues from precedent that whenever two bodies orbit one another, an inverse-square law must be assigned.

Chandler, Philip. "Clairaut's critique of Newtonian attraction: Some insights into his philosophy of science." *Annals of Science* 32, no. 4 (1975): 369-378.

B. A text in 1990 that uses “secondary planet” for the Moon but only because the barycenter is significantly offset from Earth’s center.

> Another problem concerned the far side of the Moon. It is not really correct to say simply that the Moon moves round the Earth; more accurately, the Earth and the Moon move together round their common centre of gravity, which is know as the barycentre. True, the barycentre lies well inside Earth’s globe, bevause the Earth is 81 times as massive as the Moon, but the distinction is important to mathematicians, and may provide extra support for the idea that the Moon should be ranked as a secondary planet than as a satellite.

Moore, Patrick. *Mission to the planets: the illustrated story of man's exploration of the solar system*. WW Norton & Company, 1990.

C. A text in 1991 that revived the general use of “secondary planets” in the historic meaning:

> Let us give here only the most interesting properties of the solar system (Klimishin, 1980):
> 1. The orbits of the planets lie practically in the plane of the solar equator and are close to circular.
> 2. Most of the secondary planets move in almost circular orbits in the plane of their equator.
> 3. The principal planets (Saturn, Jupiter, Uranus, and, according to the latest data, Neptune) have ring systems in their equatorial planes.
> 4. All the planets move about the sun in the same direction, coinciding with that of the proper rotation of the sun.

Rabinowitch, A. S. "Lobachevsky geometry and unsolved problems of solar cosmogony." *International journal of theoretical physics* 30, no. 4 (1991): 521-529.

D. A 2008 text uses “secondary planet” in the historic way.

> In dynamical astronomy, CR3BP is one of the most important models to investigate dynamical behaviour of the planets or their secondary planets in solar system.[1¡4]
>
> (…)
>
> CR3BP describes the motion law of an infinitesimal particle (small objects such as asteroid, secondary planet and satellite) under the gravitational attraction of two points like huge masses called primaries (P1; P2). The reaction of the infinitesimal particle on the primaries has been neglected, and these two primaries are in circular orbit around their centre of mass. The CR3BP will be researched in a rotating framework where both primaries lie on the x-axis for convenience. The sum of masses of the two primaries is assumed to be the mass unit, and the mass

> of the smaller one (P2) is Å, so another is (1 ¡ Å). The constant distance between P1 and P2 is the length unit, and the time unit is T=(2.), where T is the period of the primaries.

Wei-Tao, Lu, Zhang Hua, and Wang Shun-Jin. "Application of symplectic algebraic dynamics algorithm to circular restricted three-body problem." *Chinese Physics Letters* 25, no. 7 (2008): 2342.

E. In many modern texts, “secondary planet” is used in denote a *second* primary planet that is smaller than the *first* primary planet. This is especially true for exoplanetary studies.

F. “Secondary Planet” and “Primary Planet” became terms of art in mechanisms as components of planetary gear systems. The central gear is the sun gear. The Planet Gear may consist of larger and smaller parts connected to turn together, the secondary one turning the outer ring gear.

Planetary gears appear, perhaps for the first time, in a patent, “The horse-power for driving machinery”, Patent # US802A, 06/23/1838. It may be earlier in non-US patents?

G. “Secondary planet” became a term of art in fractal mathematics for a type of feature that appears in graphical plots.

E.g.:

Chun-mei, Wang, and Hu Chun-hua. "Research on fractal structure of generalized J set utilized compound complex map." *International Journal of Engineering and Applied Sciences* 2, no. 8. August 2015.

Appendix: Proctor’s Views on Asteroids 1880 & 1884

This is relevant to interpreting Proctor’s long discussion on taxonomy in his 1884 work, “A Zone of Worlds,” cited above.

A. Proctor, Richard Anthony. *Rough Ways Made Smooth: A Series of Familiar Essays on Scientific Subjects.* R. Worthington, 1880.

> The small planets which travel in hundreds between the paths of Mars and Jupiter have also been pressed into service [of determining the sun’s distance]. [p. 76]
>
> Professor Watson, of Ann Arbor, the discoverer of more than a score of the small planets which travel between the paths of Mars and Jupiter, had been searching for an *extra-Neptunian* planet, when the approach of the eclipse of July 1878, suggested the idea that he should return for a while from those dismal depths which lie beyond the path of

Neptune to seek for a new planet within the glowing region between the sun and the path of Mercury. [p. 47]

But on the other hand it seems extremely probably,—in fact, unless any one be disposed to question the veracity of the observers, it is certain,—that within the orbit of Mercury there are several small planets, of which two, and probably three, were seen during the eclipse of July 29, 1878…It is with large telescopes, then, and under favourable conditions of atmosphere, locality, and so forth, that the search for intra-Mercurial planets in transit must in future be conducted…I believe that a search carried out in April, May, and June, and in October, November, and December, with the express object of discovering *very* small planets in transit, could not fail to be quickly rewarded… [p. 56]

B. Proctor, Richard Anthony. *The Universe of Suns: And Other Science Gleanings*. R. Worthington, 1884.

The Ring of Small Planets

And as the attractions of these planets on each other are exceedingly small, it is practically impossible that the divergence of the system from a state of things with *must* have existed if ever a planet burst in the mid-region between Jupiter and Saturn, can be explained in this way. [p 176]

But while the nebular theory gives a sufficient explanation of the existence of a zone of small planets instead of a single planet… [p 177].

The Zone of Small Planets…it is with *this* theory that the characteristics of the zone of minor planets should be compared.…