Stillman Drake was born in 1910 in California, and received his A.B. from the University of California in 1932. His interest in the history and biography of science centers in seventeenth-century physics and astronomy. Beginning with the Dialogue Concerning the Two World Systems, published in 1953, he has translated into English virtually all the scientific works of Galileo. Mr. Drake is a member of the History of Science Society and the History of Science Dinner Club of the University of California. He is now employed by Blyth & Co., Inc. in San Francisco.

DISCOVERIES AND OPINIONS OF GALILEO

Including
The Starry Messenger (1610)
Letter to the Grand Duchess Christina (1615)
And Excerpts from
Letters on Sunspots (1613)
The Assayer (1623)

Translated
with an Introduction and Notes
by Stillman Drake

DOUBLEDAY ANCHOR BOOKS
DOUBLEDAY & COMPANY, INC., GARDEN CITY, NEW YORK
in favor to our error we conceive a prejudice against something that truth hereafter may reveal to be not contrary in any way to the sacred books of either the Old or the New Testament."

Well, the passage of time has revealed to everyone the truths that I previously set forth; and, together with the truth of the facts, there has come to light the great difference in attitude between those who simply and dispassionately refused to admit the discoveries to be true, and those who combined with their incredulity some reckless passion of their own. Men who were well grounded in astronomical and physical science were persuaded as soon as they received my first message. There were others who denied them or remained in doubt only because of their novel and unexpected character, and because they had not yet had the opportunity to see for themselves. These men have by degrees come to be satisfied. But some, besides allegiance to their original error, possess I know not what fanciful interest in remaining hostile not so much toward the things in question as toward their discoverer. No longer being able to deny them, these men now take refuge in obstinate silence, but being more than ever exasperated by that which has pacified and quieted other men, they divert their thoughts to other fancies and seek new ways to damage me.

I should pay no more attention to them than to those who previously contradicted me—at whom I always laugh, being assured of the eventual outcome—were it not that in their new calumnies and persecutions I perceive that they do not stop at proving themselves more learned than I am (a claim which I scarcely contest), but go so far as to cast against me imputations of crimes which must be, and are, more abhorrent to me than death itself. I cannot remain satisfied merely to know that the injustice of this is recognized by those who are acquainted with these men and with me, as perhaps it is not known to others.

1 De Genesi ad literam, end of bk. ii. (Citations of theological works are taken from Galileo’s marginal notes, without verification.)

Persisting in their original resolve to destroy me and everything mine by any means they can think of, these men are aware of my views in astronomy and philosophy. They know that as to the arrangement of the parts of the universe, I hold the sun to be situated motionless in the center of the revolution of the celestial orbs while the earth rotates on its axis and revolves about the sun. They know also that I support this position not only by refuting the arguments of Ptolemy and Aristotle, but by producing many counter-arguments; in particular, some which relate to physical effects whose causes can perhaps be assigned in no other way. In addition there are astronomical arguments derived from many things in my new celestial discoveries that plainly confute the Ptolemaic system while admiringly agreeing with and confirming the contrary hypothesis. Possibly because they are disturbed by the known truth of other propositions of mine which differ from those commonly held, and therefore mistrusting their defense so long as they confine themselves to the field of philosophy, these men have resolved to fabricate a shield for their fallacies out of the mantle of pretended religion and the authority of the Bible. These they apply, with little judgment, to the refutation of arguments that they do not understand and have not even listened to.

First they have endeavored to spread the opinion that such propositions in general are contrary to the Bible and are consequently damnable and heretical. They know that it is human nature to take up causes whereby a man may oppress his neighbor, no matter how unjustly, rather than those from which a man may receive some just encouragement. Hence they have had no trouble in finding men who would preach the damnable and heresy of the new doctrine from their very pulpits with unwonted confidence, thus doing impious and inconsiderate injury not only to that doctrine and its followers but to all mathematics and mathematicians in general. Next, becoming bolder, and hoping (though vainly) that this seed which first took root in their hypocritical minds would send out branches and ascend to heaven, they began scattering rumors among the people.
that before long this doctrine would be condemned by the
supreme authority. They know, too, that official condemnation
would not only suppress the two propositions which
I have mentioned, but would render damnable all other as-
tronomical and physical statements and observations that
have any necessary relation or connection with these.
In order to facilitate their designs, they seek so far as
possible (at least among the common people) to make this
opinion seem new and to belong to me alone. They pretend
to know that its author, or rather its restorer and con-
firmers, was Nicholas Copernicus; and that he was not only
a Catholic, but a priest and a canon. He was in fact so
esteemed by the church that when the Lateran Council
under Leo X took up the correction of the church calendar,
Copernicus was called to Rome from the most remote
parts of Germany to undertake its reform. At that time the
calendar was defective because the true measures of the
year and the lunar month were not exactly known. The
Bishop of Culm,² then superintendent of this matter, as-
signed Copernicus to seek more light and greater certainty
concerning the celestial motions by means of constant study
and labor. With Herculean toil he set his admirable mind
to this task, and he made such great progress in this science
and brought our knowledge of the heavenly motions to such
precision that he became celebrated as an astronomer.
Since that time not only has the calendar been regulated
by his teachings, but tables of all the motions of the planets
have been calculated as well.

Having reduced his system into six books, he published
these at the instance of the Cardinal of Capua³ and the
Bishop of Culm. And since he had assumed his laborious
enterprise by order of the supreme pontiff, he dedicated
this book On the celestial revolutions to Pope Paul III.
When printed, the book was accepted by the holy Church,
and it has been read and studied by everyone without the

² Tiedmann Giese, to whom Copernicus referred in his
preface as “that scholar, my good friend.”

³ Nicholas Schoenberg, spoken of by Copernicus as “cele-
brated in all fields of scholarship.”

faintest hint of any objection ever being conceived against
its doctrines. Yet now that manifest experiences and nec-
essary proofs have shown them to be well grounded, per-
sons exist who would strip the author of his reward without
so much as looking at his book, and add the shame of
having him pronounced a heretic. All this they would do
merely to satisfy their personal displeasure conceived with-
out any cause against another man, who has no interest in
Copernicus beyond approving his teachings.

Now as to the false aspersions which they so unjustly
seek to cast upon me, I have thought it necessary to justify
myself in the eyes of all men, whose judgment in matters
of religion and of reputation I must hold in great esteem.
I shall therefore discourse of the particulars which these
men produce to make this opinion detested and to have it
condemned not merely as false but as heretical. To this end
they make a shield of their hypocritical zeal for religion.
They go about invoking the Bible, which they would have
minister to their deceitful purposes. Contrary to the sense
of the Bible and the intention of the holy Fathers, if I am
not mistaken, they would extend such authorities until even
in purely physical matters—where faith is not involved—
they would have us altogether abandon reason and the
evidence of our senses in favor of some biblical passage,
though under the surface meaning of its words this passage
may contain a different sense.

I hope to show that I proceed with much greater piety
than they do, when I argue not against condemning this
book, but against condemning it in the way they suggest—
that is, without understanding it, weighing it, or so much
as reading it. For Copernicus never discusses matters of
religion or faith, nor does he use arguments that depend
in any way upon the authority of sacred writings which he
might have interpreted erroneously. He stands always upon
physical conclusions pertaining to the celestial motions, and
deals with them by astronomical and geometrical demon-
strations, founded primarily upon sense experiences and
very exact observations. He did not ignore the Bible, but he
knew very well that if his doctrine were proved, then it
could not contradict the Scriptures when they were rightly understood. And thus at the end of his letter of dedication, addressing the pope, he said:

“If there should chance to be any exegetes ignorant of mathematics who pretend to skill in that discipline, and dare to condemn and censure this hypothesis of mine upon the authority of some scriptural passage twisted to their purpose, I value them not, but disdain their unconsidered judgment. For it is known that Lactantius—a poor mathematician though in other respects a worthy author—writes very childishly about the shape of the earth when he scoffs at those who affirm it to be a globe. Hence it should not seem strange to the ingenious if people of that sort should in turn deride me. But mathematics is written for mathematicians, by whom, if I am not deceived, these labors of mine will be recognized as contributing something to their domain, as also to that of the Church over which Your Holiness now reigns.”

Such are the people who labor to persuade us that an author like Copernicus may be condemned without being read, and who produce various authorities from the Bible, from theologians, and from Church Councils to make us believe that this is not only lawful but commendable. Since I hold these to be of supreme authority, I consider it rank temerity for anyone to contradict them—when employed according to the usage of the holy Church. Yet I do not believe it is wrong to speak out when there is reason to suspect that other men wish, for some personal motive, to produce and employ such authorities for purposes quite different from the sacred intention of the holy Church.

Therefore I declare (and my sincerity will make itself manifest) not only that I mean to submit myself freely and renounce any errors into which I may fall in this discourse through ignorance of matters pertaining to religion, but that I do not desire in these matters to engage in disputes with anyone, even on points that are disputable. My goal is this alone; that if, among errors that may abound in these con-

\* De Revolutionibus (Nuremberg, 1543), f. iii.
of such passages, together with the special reasons for which they were set down in these words. This doctrine is so widespread and so definite with all theologians that it would be superfluous to adduce evidence for it.

Hence I think that I may reasonably conclude that whenever the Bible has occasion to speak of any physical conclusion (especially those which are very abstruse and hard to understand), the rule has been observed of avoiding confusion in the minds of the common people which would render them contumacious toward the higher mysteries. Now the Bible, merely to condescend to popular capacity, has not hesitated to obscure some very important pronouncements, attributing to God himself some qualities extremely remote from (and even contrary to) His essence. Who, then, would positively declare that this principle has been set aside, and the Bible has confined itself rigorously to the bare and restricted sense of its words, when speaking but casually of the earth, of water, of the sun, or of any other created thing? Especially in view of the fact that these things in no way concern the primary purpose of the sacred writings, which is the service of God and the salvation of souls—matters infinitely beyond the comprehension of the common people.

This being granted, I think that in discussions of physical problems we ought to begin not from the authority of scriptural passages, but from sense-experiences and necessary demonstrations; for the holy Bible and the phenomena of nature proceed alike from the divine Word, the former as the dictate of the Holy Ghost and the latter as the observant executrix of God’s commands. It is necessary for the Bible, in order to be accommodated to the understanding of every man, to speak many things which appear to differ from the absolute truth so far as the bare meaning of the words is concerned. But Nature, on the other hand, is inexorable and immutable; she never transgresses the laws imposed upon her, or cares a whit whether her abstruse reasons and methods of operation are understandable to men. For that reason it appears that nothing physical which sense-experience sets before our eyes, or which necessary demonstrations prove to us, ought to be called in question (much less condemned) upon the testimony of biblical passages which may have some different meaning beneath their words. For the Bible is not chained in every expression to conditions as strict as those which govern all physical effects; nor is God any less excellently revealed in Nature’s actions than in the sacred statements of the Bible. Perhaps this is what Tertullian meant by these words:

“We conclude that God is known first through Nature, and then again, more particularly, by doctrine; by Nature in His works, and by doctrine in His revealed word.”

From this I do not mean to infer that we need not have an extraordinary esteem for the passages of holy Scripture. On the contrary, having arrived at any certainties in physics, we ought to utilize these as the most appropriate aids in the true exposition of the Bible and in the investigation of those meanings which are necessarily contained therein, for these must be concordant with demonstrated truths. I should judge that the authority of the Bible was designed to persuade men of those articles and propositions which, surpassing all human reasoning, could not be made credible by science, or by any other means than through the very mouth of the Holy Spirit.

Yet even in those propositions which are not matters of faith, this authority ought to be preferred over that of all human writings which are supported only by bare assertions or probable arguments, and not set forth in a demonstrative way. This I hold to be necessary and proper to the same extent that divine wisdom surpasses all human judgment and conjecture.

But I do not feel obliged to believe that that same God who has endowed us with senses, reason, and intellect has intended to forgo their use and by some other means to give us knowledge which we can attain by them. He would not require us to deny sense and reason in physical matters which are set before our eyes and minds by direct experi-

5 Adversus Marcionem, ii, 18.
ence or necessary demonstrations. This must be especially true in those sciences of which but the faintest trace (and that consisting of conclusions) is to be found in the Bible. Of astronomy, for instance, so little is found that none of the planets except Venus are so much as mentioned, and this only once or twice under the name of "Lucifer." If the sacred scribes had had any intention of teaching people certain arrangements and motions of the heavenly bodies, or had they wished us to derive such knowledge from the Bible, then in my opinion they would not have spoken of these matters so sparingly in comparison with the infinite number of admirable conclusions which are demonstrated in that science. Far from pretending to teach us the constitution and motions of the heavens and the stars, with their shapes, magnitudes, and distances, the authors of the Bible intentionally forbore to speak of these things, though all were quite well known to them. Such is the opinion of the holiest and most learned Fathers, and in St. Augustine we find the following words:

"It is likewise commonly asked what we may believe about the form and shape of the heavens according to the Scriptures, for many contend much about these matters. But with superior prudence our authors have forbore to speak of this, as in no way furthering the student with respect to a blessed life—and, more important still, as taking up much of that time which should be spent in holy exercises. What is it to me whether heaven, like a sphere, surrounds the earth on all sides as a mass balanced in the center of the universe, or whether like a dish it merely covers and overcasts the earth? Belief in Scripture is urged rather for the reason we have often mentioned; that is, in order that no one, through ignorance of divine passages, finding anything in our Bibles or hearing anything cited from them of such a nature as may seem to oppose manifest conclusions, should be induced to suspect their truth when they teach, relate, and deliver more profitable matters. Hence let it be said briefly, touching the form of heaven, that our authors knew the truth but the Holy Spirit did not desire that men should learn things that are useful to no one for salvation." 6

The same disregard of these sacred authors toward beliefs about the phenomena of the celestial bodies is repeated to us by St. Augustine in his next chapter. On the question whether we are to believe that the heaven moves or stands still, he writes thus:

"Some of the brethren raise a question concerning the motion of heaven, whether it is fixed or moved. If it is moved, they say, how is it a firmament? If it stands still, how do these stars which are held fixed in it go round from east to west, the more northerly performing shorter circuits near the pole, so that heaven (if there is another pole unknown to us) may seem to revolve upon some axis, or (if there is no other pole) may be thought to move as a discus? To these men I reply that it would require many subtle and profound reasonings to find out which of these things is actually so; but to undertake this and discuss it is consistent neither with my leisure nor with the duty of those whom I desire to instruct in essential matters more directly conducing to their salvation and to the benefit of the holy Church." 7

From these things it follows as a necessary consequence that, since the Holy Ghost did not intend to teach us whether heaven moves or stands still, whether its shape is spherical or like a discus or extended in a plane, nor whether the earth is located at its center or off to one side, then so much the less was it intended to settle for us any other conclusion of the same kind. And the motion or rest of the earth and the sun is so closely linked with the things just named, that without a determination of the one, neither side can be taken in the other matters. Now if the Holy Spirit has purposely neglected to teach us propositions of this sort as irrelevant to the highest goal (that is, to our salvation), how can anyone affirm that it is obligatory to take sides on them, and that one belief is required by faith, while the other side is erroneous? Can an opinion be heretical and yet

6 De Genesi ad literam ii, 9. Galileo has noted also: "The same is to be read in Peter the Lombard, master of opinions."

7 Ibid., ii, 10.
have no concern with the salvation of souls? Can the Holy Ghost be asserted not to have intended teaching us something that does concern our salvation? I would say here something that was heard from an ecclesiastic of the most eminent degree: “That the intention of the Holy Ghost is to teach us how one goes to heaven, not how heaven goes.”

But let us again consider the degree to which necessary demonstrations and sense experiences ought to be respected in physical conclusions, and the authority they have enjoyed at the hands of holy and learned theologians. From among a hundred attestations I have selected the following:

“We must also take heed, in handling the doctrine of Moses, that we altogether avoid saying positively and confidently anything which contradicts manifest experiences and the reasoning of philosophy or the other sciences. For since every truth is in agreement with all other truth, the truth of Holy Writ cannot be contrary to the solid reasons and experiences of human knowledge.”

And in St. Augustine we read: “If anyone shall set the authority of Holy Writ against clear and manifest reason, he who does this knows not what he has undertaken; for he opposes to the truth not the meaning of the Bible, which is beyond his comprehension, but rather his own interpretation; not what is in the Bible, but what he has found in himself and imagines to be there.”

This granted, and it being true that two truths cannot contradict one another, it is the function of wise expositors to seek out the true senses of scriptural texts. These will unquestionably accord with the physical conclusions which manifest sense and necessary demonstrations have previously made certain to us. Now the Bible, as has been remarked, admits in many places expositions that are remote from the signification of the words for reasons we have already given. Moreover, we are unable to affirm that all interpreters of the Bible speak by divine inspiration, for if that were so there would exist no differences between them about the sense of a given passage. Hence I should think it would be the part of prudence not to permit anyone to usurp scriptural texts and force them in some way to maintain any physical conclusion to be true, when at some future time the senses and demonstrative or necessary reasons may show the contrary. Who indeed will set bounds to human ingenuity? Who will assert that everything in the universe capable of being perceived is already discovered and known? Let us rather confess quite truly that “Those truths which we know are very few in comparison with those which we do not know.”

We have it from the very mouth of the Holy Ghost that God delivered up the world to disputations, so that man cannot find out the work that God hath done from the beginning even to the end. In my opinion no one, in contradiction to that dictum, should close the road to free philosophizing about mundane and physical things, as if everything had already been discovered and revealed with certainty. Nor should it be considered rash not to be satisfied with those opinions which have become common. No one should be scorned in physical disputes for not holding to the opinions which happen to please other people best, especially concerning problems which have been debated among the greatest philosophers for thousands of years. One of these is the stability of the sun and mobility of the earth, a doctrine believed by Pythagoras and all his followers, by Heracleides of Pontus (who was one of them),

8 A marginal note by Galileo assigns this epigram to Cardinal Baronius (1538–1607). Baronius visited Padua with Cardinal Bellarmine in 1598, and Galileo probably met him at that time.

9 Pererius on Genesis, near the beginning.

10 In the seventh letter to Marcellinus.

11 Ecclesiastes 3:11.

12 Heracleides was born about 350 B.C. and is said to have attended lectures by Aristotle at Athens. He believed that the earth rotated on its axis, but not that it moved around the sun. He also discovered that Mercury and Venus revolve around the sun, and may have developed a system similar to that of Tycho.