ISAAC NEWTON
(1642–1727)

background:

English civil war

- began 1642
- culminated in execution of Charles I
- Oliver Cromwell
- issues included:
  - political—king vs Parliament
  - religious—puritans vs Anglicans

  1660 — monarchy restored, Charles II assumed throne

  1689 — "Glorious Revolution"

  - In 1689, England was ruled by James II, brother and successor of Charles II. James II
    * was Catholic
    * tried to rule without Parliament
    * was thrown out; William of Orange was brought in from Netherlands, under strict understanding of limited role of monarchy, supremacy of Parliament
  - Newton himself supported Protestant, Parliamentary position

brief chronology

- 1661 — Cambridge
- 1664 — scholarship
- 1665 — "annus mirabilis"
- 1667 — fellow of Trinity College
- 1669 — Lucasian Professor
- 1688 — *Principia*
- 1696 — Master of the Mint
- 1704 — *Optics*

Newton

(Note: Page references are to Westfall's full-scale biography, not the abridged version we are using.)

- certainly one of the greatest physicists who ever lived

  > The more I have studied him, the more Newton has receded from me. It has been my privilege at various times to know a number of brilliant men, ... whom I acknowledge without hesitation to be my intellectual superiors. I have never, however, met one against whom I was unwilling to measure myself, so that it seemed reasonable to say that I was half as able as the person in question, or a third or a fourth, but in every case a finite fraction. The end result of my study of Newton has served to convince me that with him there is no measure. He has become for me wholly other, one of the tiny handful of supreme geniuses who have shaped the categories of the human intellect, a man not finally reducible too the criteria by which we comprehend our fellow beings ..., (Westfall, p ix)

- enormous range of contributions:
  - optics, theoretical and experimental
  - laws of motion
  - universal gravitation—linked terrestrial physics and astronomy
  - mathematics (calculus)
- was born to a moderately well-off, but not rich, family
  - good in school
  - interested in gadgets:

    > A windmill was built north of Grantham while he [Newton] was there. Although water wheels were common in the area, windmills were not, and the inhabitants of Grantham used to walk out to watch its construction for diversion. Only the schoolboy Newton inspected it so closely that he could build a model of it, ... one which worked when he set it on the roof. He went the original one better. He equipped his model with a treadmill run by a mouse which was urged on either by tugs on a string tied to its tail or by corn placed above it to the front.
    >
    > He made a little vehicle for himself, a four-wheeled cart run by a crank which he turned as he sat in it. He made a lantern of "crimpled paper" to light his way to school on dark winter mornings ... The lantern had other possibilities; attached to the tail of a kite at night, it "wonderfully affrighted all the neighboring

> inhabitants for some time, and caus'd not a little discourse on market days, among the country people, when over their mugs of ale." By good fortune, Grantham was not burned to the ground. Similar stories of mechanical models are told of Robert Hooke's boyhood. In both cases, manual skill served them well in constructing equipment for experiments. Far more important, however, is the testimony of such stories to the pervasive image of the machine in the seventeenth-century mind. Already that image had reshaped the conception of nature. (Westfall p 60ff; p 62ff)

- 1661—entered Cambridge University
- By 1664, he was reading seriously in physics and mathematics; these subjects were *not* in the curriculum; but the presence of Isaac Barrow, a capable mathematician, gave Newton at least some support. To get a sense of what he was reading, consider the following passage, written down later by Newton—according to a friend of Newton (De Moivre),

  > Got Euclid to fit himself for understanding the ground of Trigonometry. Read only the titles of the propositions, which he found so easy to understand that he wondered how any body would amuse themselves to write any demonstrations of them. Began to change his mind when he read that Parallelograms upon the same base and between the same Parallels are equal, and that other proposition that in a right angled Triangle the square of the Hypothenuse is equal to the squares of the two other sides. Began to read Euclid with more attention than he had done before and went through it.
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  > . . . Took Descartes's *Geometry* in hand, tho he had been told it would be very difficult, read some ten pages in it, then stopt, began again, went a little farther than the first time, stopt again, went went back again to the beginning, read on till by degrees he made himself master of the whole, to that degree that he understood Decartes's Geometry better than he had done Euclid.
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  > Read Euclid again & then Decartes's Geometry a second time . . . (quoted in Palter, p 72ff)

- had read Galileo's Dialogue (but not the Discourse)
- and above all he had read Descartes'
  - *Principles of Philosophy*
  - *Geometry*
- and in the process, picked up
  - Decartes' mechanical philosophy

  - Descartes' very qualitative "laws of motion":
    * no change takes place in matter without an external cause
    * inertial principle: body continues in straight line at constant velocity unless a force acts
    * confused version of conservation of momentum ("conservation of motion")
    * necessity for analysis of circular motion

In 1665 (about the time he was to graduate), an epidemic of Plague hit; everyone left Cambridge and consequently Newton was at home much of the time (1665–1667) (age 23); in this period,

- developed calculus
- initial work on optics
- initial work on gravitation, laws of motion

In 1667, he became minor fellow of Trinity College, Cambridge and remained there, in increasingly higher positions (eventually he became Lucasian Professor) until late 1690s.

We should say a little about the organization of the English universities (discuss college system)

Moreover, at this time Cambridge had fallen on hard times:

> Cambridge was fast approaching the status of an intellectual wasteland. Consider the forty-one men who became fellows of Trinity in the three elections of 1664, 1667, and 1668. One of the forty-one was Newton, of course. Of the others, Robert Uvedale became a prominent educator and horticulturist; he pursued his career entirely outside Cambridge though he held on to his fellowship for fifteen years. Edward Pelling, who resigned his fellowship after one year, went on to become an Anglican polemicist of heroic proportions, though his writings are, I believe, virtually unknown today. Samuel Scattergood, who held his fellowship for sixteen years, published many sermons; Henry Dove, George Seignior and William Baldwin all published a small number. John Batteley gained some prominence as an antiquarian ... John Allen, a fellow for thirty years, mostly in absentia, published one sermon ... Newton aside, they do not form an imposing group of intellectuals by any standard. Nor were they more impressive as tutors. Four chose the role of pupil monger, in the pejorative phrase of the day. Of the other thirty-seven, only ten ever tutored a pupil, and those ten tutored a total of sixteen. Newton with three and Wickins with two accounted for five of the seventeen. The average tenure of the forty-one was seventeen and a half years; eleven

> stayed more than twenty years; and four ... [made] the college their permanent abode. ... None of the four ever published a word. All survived to become senior fellows of the college and to reap its ripest rewards.
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> After his creation as Master of Arts, Newton lived in Trinity for twenty-eight years. Those years coincided roughly with the most disastrous period in the history both of the college and of the university. Whatever his initial expectations may have been, he did not find a congenial circle of fellow scholars. A philosopher in search of truth, he found himself among placemen in search of a place. This fundamental fact colored the scene in which virtually the whole of his creative life was set. (Westfall, pp 190ff)

Newton developed into an intensely ingrown sort of person, with an immense ability to concentrate single-mindedly on a problem. Not surprisingly, stories grew up about his eccentric behavior. The following account is from the recollections of Humphrey Newton, who for a time acted as Newton's secretary:

> so intent, so serious upon his Studies, that he eat very sparingly, nay, oftimes he has forget to eat at all, so that going into his Chamber, I have found his Mess untouch'd, of which when I have reminded him, [he] would reply, Have I; & then making to the Table, would eat a bit or two standing ... At some seldom Times when he design'd to dine in the Hall, would turn to the left hand, & go out into the street, where making a stop, when he found his Mistake, would hastily turn back, & then sometimes instead of going into the Hall, would return to his Chamber again .... When he has sometimes taken a Turn or two [in the garden], has made a sudden stand, turn'd himself about, run up the stairs, like another Alchimedes [*sic*], with an *eureka*, fall to write on his Desk standing, without giving himself the Leasure to draw a Chair to sit down in. (quoted in Westfall, p 406)

Here are a few more passages from Westfall:

> During five years, Humphrey saw Newton laugh only once. He had loaned an acquaintance a copy of Euclid. The acquaintance asked what use its study would be to him. "Upon which Sir Isaac was very merry." (Westfall, p 192)
>
> Once at work on a problem, he would forget his meals. His cat grew very fat on the food he left standing on his tray. (No peculiarity of Newton's amazed his contemporaries more consistently; clearly food was not something they trifled with.) He would forget to sleep, and Wickins would find him the next morning, satisfied with having discovered some proposition and wholly unconcerned with the night's sleep he had lost. "He sate up so often in the year 1664 to observe a comet that appeared

> then," he told Conduitt, "that he found himself much disordered and learned from thence to go to bed betimes." Part of the story is true; he entered his observations of the comet into the "Quaestiones." The rest of it is patently false .... Newton never learned to go to bed betimes once a problem seized him. Even when he was an old man, the servants had to call him to dinner half an hour before it was ready, and when he came down, if he chanced to see a book or a paper, he would let his dinner stand for hours. (Westfall pp 103ff)

Nor in this work was he much troubled by other duties—even as Lucasian Professor (starting in 1669), he was required to lecture only weekly; and even then, Westfall tells us,

> In Restoration Cambridge, performance tended to diverge, often wildly, from statutory requirement. As far as the students were concerned, the fresh burden of lectures imposed on them was only another item on a list now universally ignored. ... Barrow had complained of the neglect of his lectures when he was Professor of Greek. ... Edmund Castell, the first Adams professor of Arabic, met the same indifference. Without further ado, he posted a sign on his door, "Tomorrow the Professor of Arabic goes into the wilderness," and converted the position into a sinecure. ... While we have no information about Newton's early experience, we do know what Humphrey Newton found upon his arrival fifteen years later. When Newton lectured, he recalled, "so few went to hear Him, & fewer yet understood him, that oftimes he did in a manner, for want of Hearers, read to the Walls." He usually lectured for half an hour, though he returned in less than a quarter of an hour when he had no audience. (Westfall, p 209)

Certainly Newton had plenty of time for his own work! It was thought a little odd, certainly, for a college fellow or university professor to spend his time on research, but after all, Cambridge was a tolerant sort of place; the remarkable thing is that Newton accomplished what he did in so completely uninspiring an atmosphere.

So far we have a picture of a highly capable individual, a bit odd to be sure, very much caught up in developing Descartes' mechanical philosophy and trying to turn it into mechanical science.

But at this point a cog seems to slip out of place; for starting around 1670, Newton suddenly began to turn his attention elsewhere, to alchemy and theology; he never abandoned physics and mathematics, but for about 10 years, his chief attention was elsewhere.

ALCHEMY—chiefly the notion that somehow it must be possible to turn base metals into gold. But it seems that Newton was not concerned with that aspect. His interest was serious—a substantial portion of his library was devoted to alchemical

works; and his unpublished papers have accounts of extremely detailed chemical experiments.

It appears that Newton's chief interest in alchemy was a search for an "active principle" that he came to think must underlie the mechanical philosophy. In a sense, therefore, Newton was going back to the "magical" tradition we saw in Kepler and the Neoplatonists. He may have been trying to discover an "organic" active principle that somehow underlay the mechanism of Descartes

There were theological implications as well—Newton came to see in the mechanical philosophy a tendency towards atheism:

> Even in the privacy of his study, he [Newton] worked himself into a passionate fury against the philosopher [Descartes] who, scarcely five years earlier, had introduced him to a new world of thought. The gravamen of the charge was atheism. By his separation of body and spirit, Descartes denied the dependence of the material world on God. The ultimate case of atheism, Newton asserted, is "this notion of bodies having, as it were, a complete, absolute and independent reality in themselves ..." (Westfall, p 302)

Thus, Newton was in a sense combining

- the mathematical approach of Kepler, Galileo
- the mechanical philosophy of Descartes
- a mystical "active principle," somehow related to God, which underlay mechanism

It is in this context that we must understand his work on gravitational forces, which in 1689 led to the publication of his *Mathematical Principles of Natural Philosophy.*

REFERENCES

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