Problems of Cartesian physics:

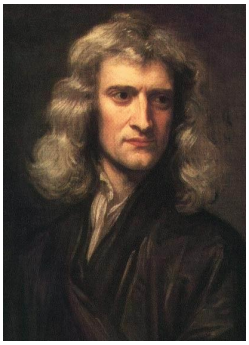
The vortices would have to be thick fluids like hot tar to move the planets.

But such fluids could not stay in motion for long.

The parts of the vortices would have to simultaneously move with different speeds in order to account for the observed motions of the planets.

The orbits of comets are unaccountable.

It is extraordinary that the planets and moons should all orbit in the same direction and in nearly the same plane.



Newton's reflections:

A body once set in motion may stay in motion forever

if placed in a vacuum

But Descartes did not believe that a vacuum exists.

A body surrounded by bodies will lose its motion to them.

Motion is in fact constantly on the wane because not all collisions are perfectly elastic.

Accounting for the motions of the planets therefore requires:

- That they occupy largely empty space
  (So vortices and collisions cannot be responsible)

- That there be some "force" responsible for deflecting them from a straight line
  And for generating new motion to replace that lost in collisions

Consequences

Two of the dogmas of Cartesian physics

- no empty space
- no forces or qualities in bodies

must be rejected if we are to account for planetary motions

Indeed, we may have to go so far as to reject a dogma of all past philosophy:

- a body can only act where it is, not where it is not
- all action requires contact of agent and patient

What could justify such a radical revision to all accepted principles?

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Experience.

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Experience.

The foundation for Newton's revolution:

A new appeal to the old tenets of Bacon's "bottom up" scientific method

Show that we must accept empty space, forces, and action at a distance because experience proves that these things must exist

Reject all forms of a priori theorizing that would suggest otherwise.

Implications for philosophy

There is no call for a Cartesian, “foundationalist” epistemology built on absolutely certain first principles.

We can do with a new, empiricist epistemology that better fits the Newtonian program in natural science.

Some Newtonian claims and their foundations

Bodies have other qualities than those that arise from how they fill space

> notably hardness, impenetrability, inertial mass, and gravitational attraction

Why?

Because those qualities that are not subject to intensification or remission and that are found to be possessed by all bodies whatsoever are to be accounted the primary and real qualities of bodies.

> Experience gets to decide what qualities are real, not a priori theorizing.

Some Newtonian claims and their foundations, cont.'d

Space exists independently of body; it can be empty and serves as an ultimate reference frame for motion,

> which can be "real" or "apparent" depending on whether it occurs with reference to places in absolute space or with reference to other bodies

Why?

> Because bodies are observed to have other qualities than just those having to do with extension, so there must be a difference.
>
> And because the alternative, a plenum, is inconsistent with the observed fact of planetary motion

Some Newtonian claims and their foundations, cont.'d

Change occurs as a consequence of certain attractive and repulsive forces that operate on bodies, often from a distance.

Why?

> Because the effects of these forces are observed, not only in the motions of the heavenly bodies, but in terrestrial phenomena having to do both with attraction (gravitation, magnetism, cohesion) and with repulsion (solidity, magnetic resistance)

But how can a force act over empty space or a body exert a force in a place it does not itself occupy?

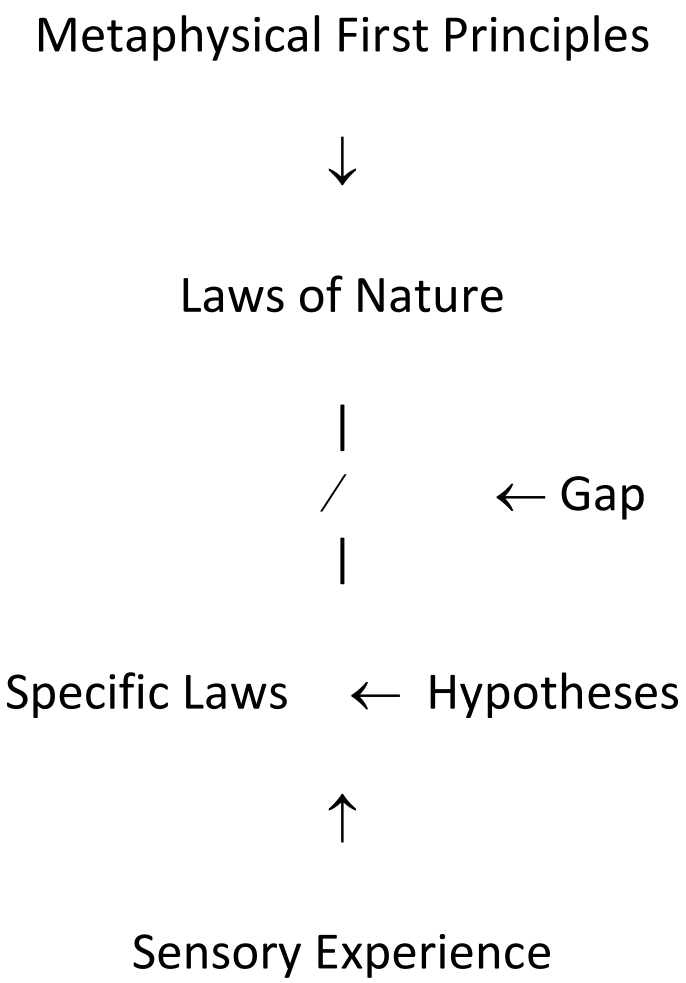
It is not the business of natural philosophy to answer these questions.

> When the facts are known by experience, it is pointless to ask what makes them possible.

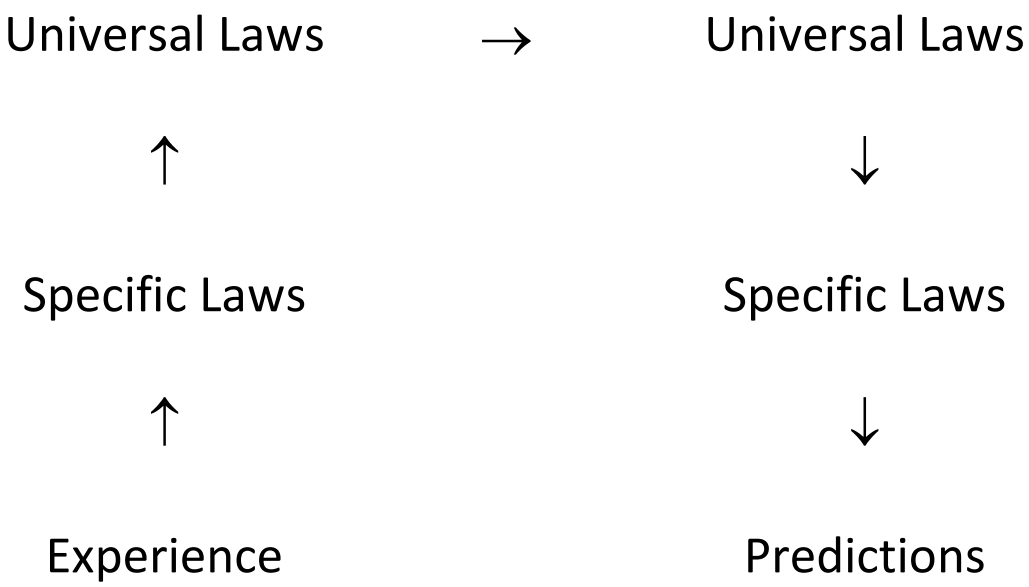
The causes of these forces are unknown, but their manner of operation can be described by mathematical laws, and it is the business of natural philosophy just to discover these laws of the operations of forces.

> Our fundamental purposes do not require that we do any more.

Descartes's Scientific Method



Newton's Scientific Method



Why the Newtonian view triumphed

It did a better job of accounting for the phenomena, esp. astronomical phenomena.

> The theory of gravitation accounts for a vast range of phenomena as instances of a single law.
>
> Descartes needed to appeal to a different kind of machine to explain each particular phenomenon

Problems

It was hard to accept that bodies can act on one another over a distance.

It was hard to accept that space might be a thing in its own right.

The success of the account of gravitational force was not in the end matched by similar successes accounting for the forces responsible for cohesion, impenetrability, electricity & magnetism, chemical reactions ("fermentation") and life.