uired. The claim is, in fact, unclear.
lescribing the property is an obser-
ate that can only be defined
it is trivial to claim that the first in-
the property could not have been
e theorist lacks the words to for-
prediction in advance. If, on the
he can specify the property in
ie is verbally capable of predicting
instantiated under such and such
ie well-foundedness of his predic-
on the richness of his background
i enough knowledge both of
l the physiology of taste, a theorist
ly predict that, say, sucrose would
The doctrine of emergence thus
contingent limitations in our
a given time.

AW

. *See* spectroscopy.

ee healing.

complex reaction to a stimulus
despread, involuntary, bodily
orrelated feelings; a cognitive ap-
lesirability of the stimulus; a ten-
specific ways towards the object
rded as approach or avoidance
l a disturbed condition of mind
Emotion as a category of ex-
cally classified into discrete types
fear, etc. Traditionally, emotions
as conscious feelings, knowable
experience. René Descartes
cluded emotions among 'the pas-
il'; they originated in *sensation
rdinate to the will. British *em-
hat emotions originated in sensa-
1632–1704) stated that emotions
mple ideas about the causes and
asure and pain. Psychological
by became an integral principle
f *associationists from D. Hume
Bain (1818–1903). The laws of
plained how connections were
he stimulus and the idea or feel-
so that motivation and emotion
. W. M. Wundt (1832–1920)
ener (1867–1927) defined emo-
ents of feelings. C. R. Darwin's
ession of the Emotions in Man
72) stimulated the development
l theories and detailed the
*evolutionary genesis and *adaptive value of the emotional expressions. Influenced by Darwin, W. James (1842–1910) and C. G. Lange (1834–1900) argued independently that emotions consisted of the experience of the sum of the visceral sensations engendered by stimuli: the individual felt sad because he cried, afraid because he ran. The James–Lange theory was largely accepted until 1929 when W. B. Cannon (1871–1945) demonstrated that emotions were specifically generated within the limbic system of the *brain. While modern theories of emotion are typically couched in physiological terms, psychological hedonism and associationism re-emerged in *behaviourism: J. B. Watson (1878–1958) argued that emotional reactions were differentiated through conditioning and E. C. Tolman (1886–1959) defined emotions as drives towards particular behavioural results.

See also passions.

SLM

empirical regularities. *See* explanation.

empiricism. An ensemble of theories of *explanation, definition and justification to the effect that our concepts or knowledge are derived from or to be explicated (or justified) in terms of *sense-experience* (or introspection). Initially a reaction to Platonic and *Cartesian doctrines of 'innate ideas' and 'natural intuition' [*rationalism], it is especially associated with the great line of British philosophers from Francis Bacon (1561–1626) through T. Hobbes (1588–1679), J. Locke (1632–1704), G. Berkeley (1685–1753), D. Hume (1711–76), J. S. Mill (1806–73) to Bertrand Russell (1872–1970), but is characteristic of *positivism generally – particularly the forms espoused by Ernst Mach (1838–1916) and, as logical empiricism, the Vienna Circle.

The analysis of *prima facie* synthetic *a priori* propositions (especially those of mathematics) and concepts has always posed problems for empiricism. While most empiricists, exempting logical constants and analytical (or definitionally true) propositions from the principles of empirical definition or confirmation, have been willing to cede mathematics analytical status, Mill claimed that propositions such as '7 + 5 = 12' were neither analytic nor *a priori*, but *inductively established empirical generalizations. Hume's treatment of the apparently synthetic *a priori* concept of causality has commanded wider assent. Accepting that to say 'A causes B' entails their necessary connection, Hume 'traced' the source of our idea of that necessary connection to our repeated experience of their constant conjunctions, thus dishing natural necessity along with the synthetic *a priori*. A further difficulty relates to the epistemic status of empiricism itself – is it analytic, and therefore 'trifling' (Locke), as L. Wittgenstein (1889–1951) was prepared to accept; or merely empirical, as W. James (1842–1910) conceded, and thereby subject to inductive doubt?

In its canonical Humean form, empiricism readily leads to scepticism about the existence of (a) objects independently of perception and (b), as just noted, necessary connections in *Nature. Typically, (a) has been 'remedied' by *phenomenalism and (b) by a Humean subjective–successionist analysis of the causal modality – at the prices of solipsism and the problem of induction ('the scandal of philosophy') respectively. Consistent with these remedies, empiricists have tended to conceive scientific knowledge as growing by induction from a steadily accumulating base of logically independent facts; and as consisting in a deductive hierarchy of propositions rooted in those facts. The credibility of such a monistic and deductivist account of science has been fatally undermined by, on the one hand, a growing awareness of the actuality of scientific discontinuity and change and, on the other, criticism of the pivotal Humean theory of causal *laws and the undifferentiated *ontology of experience it presupposes.

Despite this, few modern philosophers would want to deny the epistemic value of experience – the central insight of empiricism – or the ideas that at least some terms in a theory must be partially empirically defined or that law-like statements are ultimately to be judged by their instances under *experimentally produced and controlled conditions. Rather *realists, in particular, are concerned to focus on the question, historically neglected by empiricists, of the precise *ontological and social contexts in which epistemically significant experience occurs.

See also pragmatism.

RB

encapsulation. Encapsulation, or 'emboîtement', means that all future generations of an organism exist within that organism's *germ.

Before the 17th century, Aristotle's (384–322 BC) view prevailed. He maintained that *development begins when the male provides the active form to the passive female substance; the male alone determines the offspring's form. William Harvey (1578–1657) questioned this picture with his argument for *epigenesis and his suggestions that all animals originate from *eggs. Yet Harvey had no observational basis for believing that eggs exist in all organisms; his 'egg' was hypothetical and vaguely defined.

Harvey's epigenetic view gave way to preformationist ideas when Regnier de Graaf (1641–73) discovered what he believed were mammalian eggs. Actually, he had discovered what are now called the Graafian follicles. Yet his 'discovery' required a new theory of reproduction [*generation] in which male *fertilization of the female egg was thought to inaugurate development.

Denying that form could emerge gradually by epigenesis, naturalists maintained that form must literally pre-exist in the egg. If the next generation's form always pre-exists in the egg, then all future generations must also pre-exist within that egg. Ultimately, therefore, all human beings must have pre-existed in Eve's egg.

Thus argued the *ovists. After Antony van Leeuwenhoek's (1632–1723) observation of *spermatozoa, a group of animalculists argued the male germ actually holds the pre-existent future generations.

JM

endocrinology. *See* hormone.

endoplasmic reticulum. *See* protoplasm.

endoscopes. *See* diagnosis.

energetics. *See* energy; heat and thermodynamics; statistical mechanics.

energy. Three traditions contributed to the development of the concept of energy. Mediaeval students of *mechanics supposed that some quantity related to motion was conserved; G. W. Leibniz (1646–1716) stated that this quantity was mv^2 or **vis viva*, a measure of the height to which a moving body could raise a weight and the damage it could do upon impact. In impact *vis viva* was not lost, but transformed into the internal motion of the body's constituent particles. Leibniz thus adumbrated the principle of energy conservation and of the equivalence of potential and kinetic energy and heat. The principle of the conservation of *vis viva* was incorporated into mechanics during the 18th century, and in 1807 Thomas Young (1773–1829) coined 'energy' for *vis viva*, a suggestion not widely adopted.

A second tradition of 'correlation of forces' had its roots in 18th-century theories of a single universal fluid responsible for the phenomena of *heat, *light, *electricity and magnetism. Such a scheme did not prove useful; and at the end of the century physicists relied on several distinct *imponderable fluids that submitted more easily to quantification. But the discovery of the Voltaic *pile in 1800 brought to light many phenomena that pointed to the 'correlation' or equivalence of the forces or powers associated with these fluids. Internally the pile converted chemical *affinity to electricity; externally electrolysis reversed the transformation. The electric current generated heat and light; in 1820 H. C. Ørsted (1777–1851) demonstrated that it induced magnetic force, and in 1831 Faraday (1791–1867) inverted the induction. A close tie between radiant heat and light was shown by William Herschel (1738–1822) and Macedonio Melloni (1798–1854). Finally, a correlation between heat, chemical activity and muscular work was developed in studies of animal economy by Justus Liebig (1803–73) and Johannes Müller (1801–58). By 1840 several physicists had announced the equivalence of all forms of 'force'.

The third tradition came from engineering. The steam engine offered an every-day example of the equivalence of chemical affinity, heat and mechanical work. Sadi Carnot's (1796–1832) analysis of its effects (1824), based upon the concept of the imponderable fluid caloric, came into conflict with the results James Joule (1818–89) deduced from experiments on the efficiency of electric motors. The resolution of the conflict resulted in the two principles of thermodynamics, the conservation of energy and its dissipation [*heat and thermodynamics]. The science of thermodynamics or 'energetics', proclaimed in 1855 by William Thomson (1824–1907) and William Rankine (1820–72), revolutionized physics. A new vocabulary entered the discipline: 'energy' was reintroduced and its connection with mechanical work made clear; actual and potential energy were distinguished, 'work' and 'power' made precise, 'entropy' defined. The major branches of physics were restructured by Thomson, Rankine, Hermann von Helmholtz (1821–94) and James Clerk Maxwell (1831–79) to allow