Shakespeare, Newton and Beethoven or patterns of creativity

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PREFACING a somewhat derogatory criticism of Milton, T. S. Eliot once stated that 'the only jury of judgement' that he would accept on his views was that 'of the ablest poetical practitioners of his time'. Ten years later, perhaps in a more mellow mood, he added: 'the scholar and the practitioner, in the field of literary criticism, should supplement each others' work. The criticism of the practitioner will be all the better, certainly, if he is not wholly destitute of scholarship; and the criticism of the scholar will be all the better if he has some experience of the difficulties of writing verse.' By the same criterion, anyone who is emboldened to ask if there are discernible differences in the patterns of creativity among the practitioners in the arts and the practitioners in the sciences, must be a practitioner, as well as a scholar, in the arts as well as in the sciences. It will not suffice to be a practitioner in the arts only, or in the sciences only. Certainly, a wanderer, often lonely, in some of the by-lanes of the physical sciences, has simply not the circumference of comprehension to address himself to a question which encompasses the arts and the sciences. I, therefore, begin by asking your forbearance.

Allowing, as we must, for the innumerable individual differences in tastes, temperaments, and comprehension, we ask: Can we in fact discern any major differences in the patterns of creativity among the practitioners in the arts and the practitioners in the sciences? The way I propose to approach this question is to examine, first, the creative patterns of Shakespeare, Newton and Beethoven, who, by common consent, have, each in his own way, scaled the very summits of human achievement. I shall then seek to determine whether, from the likenesses and the differences in the patterns at these rarified heights, we can draw any larger conclusions which may be valid at lower levels.

I begin with Shakespeare.

Shakespeare's education was simple, as Elizabethan education was. While it sufficed and stood him in good stead, Shakespeare was never persuaded by scholarship as such. He clearly expressed his attitude in

> Small have continual plodders ever won
> Save base authority from others' books.

or

> Oh, this learning, what a thing it is!

Even so, when Shakespeare arrived in London in 1587, at the age of twenty-three, he had none of the advantages of a London background that Lodge and Kyd had, or the advantages of years at Oxford or Cambridge that Peele, Lyly, Greene, Marlowe and Nashe had. There can be little doubt that Shakespeare was acutely aware of his shortcomings and his handicaps. He overcame them by reading and absorbing whatever came his way. The publication of the revised second edition of Holinshed's *Chronicles of England, Scotland and Ireland*, was particularly timely: it provided Shakespeare with the inspiration for his chronicle plays yet to come.

By 1592, Shakespeare had written his three parts of *Henry VI* and his early comedies, *The Comedy of Errors*, *Love's Labour's Lost* and *Two Gentlemen of Verona*. His success with these plays produced Robert Greene's vicious attack on him in that year. Greene was six years older than Shakespeare, and he was among the most prominent figures in the literary life of London at that time. As it happened, Greene's attack was posthumous, as he had died somewhat earlier as the result of a fatal banquet, it is said, 'of Rhenish wine and pickled herrings'. It was therefore 'a time bomb which Greene left'. His attack in part read:

> For there is an upstart crow, beautified by our feathers, that with his 'Tiger's heart wrapped in a player's hide', supposes he is as well able to bombast out a blank verse as the best of you, and being an absolute Johannes Factotum, is in his own conceit the only Shake-scene in a country.

Greene's attack brings out very clearly that Shakespeare was considered an outsider and an intruder: he had no university background and he did not belong to the aristocratic court circles.

In spite of his early successes, life for Shakespeare, as a player and a playwright, was fraught with uncertainties with the recurring years of the plague and the periodic closing of the theaters in London. But in 1590, Shakespeare found a patron, a friend, and love.

Shakespeare's patron was the young Earl of Southampton who came of age in 1591. The intensity

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of Shakespeare's emotional experience in the four years that followed was decisive for the development of his art and for the opportunities that opened up for him. Shakespeare's genius matured and flowered with an unexampled outburst of creative activity. Besides the plays already mentioned, he wrote *The Merchant of Venice*, *The Taming of the Shrew* and *Richard III*. The two splendid narrative poems, *Venus and Adonis* and *The Rape of Lucrece*, dedicated to the Earl of Southampton, belong to this same period.

During 1592–95, Shakespeare wrote his sonnets as a part of his services for Southampton's patronage. The sonnets are the most autobiographical ever written. They throw a flood of light on Shakespeare's attitude to himself and his art; and they also reveal the extent of his dependence on Southampton's friendship and patronage.

The course of the friendship between Southampton and Shakespeare was by no means smooth. There was the difference in their ages; there was the disparity in their stations, as the aristocratic patron and a player poet; and besides, there was the complication of Shakespeare's mistress—the dark lady of the sonnets—turning her attention away from Shakespeare to the responsive Earl. Shakespeare poured his feelings with poignant sincerity into the sonnets:

When, in disgrace with fortune and men's eyes,
I all alone beweep my outcast state,
And trouble deaf heaven with my bootless cries,
And look upon myself and curse my fate: (29)

Against that time, if ever that time come,
When I shall see thee frown on my defects,
When as thy love hat cast his utmost sum,
Called to that audit by advised respects;
Against that time when thou shalt strangely pass,
And scarcely greet me with that sun, thine eye,
When love, converted from the thing it was,
Shall reasons find for that settled gravity:
Against that time do I ensconce me here
Within the knowledge of mine own desert,
And this my hand against myself uprear,
To guard the lawful reasons on thy part:
To leave poor me thou hast the strength of laws,
Since why to love I can allege no cause. (49)

Their relationship, at least as perceived by Shakespeare, was so fragile that he even considers the possibility of death:

No longer mourn for me when I am dead
Than you shall hear the surly sullen bell
Give warning to the world that I am fled
From this vile world with vilest worms to dwell. (71)

And Shakespeare feels that his life cannot last longer than Southampton's love and that it will come to an end with it.

But do thy worst to steal thyself away,
For term of life thou art assured mine;
And life no longer than thy love will stay,
For it depends upon that love of thine.
Then need I not to fear the worst of wrongs,
When in the least of them my life hath end;
I see a better state to me belongs
Than that which on thy humour doth depend.
Thou canst not vex me with inconstant mind,
Since that my life on thy revolt doth lie.
O, what a happy title do I find,
Happy to have thy love, happy to die!
But what's so blessed-fair that fears no blo
Thou mayst be false, and yet I know it no

In spite of the uncertainty which pervade sonnet sequence, Shakespeare's prophetic cc his own poetry occasionally erupts. Thus, in sonnet 55, we have the outpouring:

Not marble, nor the gilded monuments
Of princes, shall outlive this powerful rhyme;
But you shall shine more bright in these cont
Than unswept stone, besmeared with sluttish t
When wasteful war shall statues overturn,
And broils root out the work of masonry,
Nor Mars's sword nor war's quick fire shall
The living record of your memory.

Meantime, Marlowe appears as a dangerc Southampton's patronage. To offset Shakespe *and Adonis*, Marlowe began writing his *Leander*. Shakespeare expresses his uneasine rivalry while conceding Marlowe's superior

O, how I faint when I of you do write,
Knowing a better spirit doth use your name,
And in the praise thereof spends all his migh
To make me tongue-tied speaking of your fan
But since your worth, wide as the ocean is,
The humble, as the proudest sail doth bear,
My saucy bark, inferior far to his.
On your broad main doth willfully appear.
Your shallowest help will hold me up afloat,
Whilst he upon your soundless depth doth rid
Or, being wrecked, I am a worthless boat,
He of tall building and of goodly pride.
Then if he thrive and I be cast away
The worst was this: my love was my decay

Marlowe died in 1593 in an unhappy bı Shakespeare clearly had in mind when Touchstone, in *As You Like It*, say:

When a man's verses cannot be understood, nor a wit seconded with the forward child Understandi a man more dead than a great reckoning in a lit

In the same play, Shakespeare also paid M unusual tribute of addressing him as 'Dead and quoting his line:

Who ever loved that loved not at first sight?

And before long, the unhappy episode with the 'dark lady' also ended:

> I am perjured most
> For all my vows are oaths to misuse thee,
> And all my honest faith in thee is lost. (152)

With the last sonnet of the Southampton sequence, Shakespeare emerges triumphant:

> No, let me be obsequious in they heart,
> And take thou my oblation, poor but free,
> Which is not mixed with seconds, knows no art
> But mutual render, only me for thee. (125)

Yes! 'poor but free', 'not mixed with seconds' and 'only me for thee'.

In 1594, the Earl of Southampton gave Shakespeare some such amount as £100 to acquire a share in Lord Chamberlain's company when it was formed. With the future thus assured, Shakespeare's natural spirits rose and his genius matured. *A Midsummer Night's Dream*, which he wrote in that year, was the first of his great masterpieces. Soon *Romeo and Juliet*, *As You Like it* and *Much Ado About Nothing* followed. Then Shakespeare turned again to his chronicle plays: *King John*, the two parts of *Henry IV* and *Henry V*. The one hero in all these chronicle plays is England; and in them Shakespeare gives lasting expression to 'to the very age and body of the time'.

Many consider the two parts of *Henry IV* as the twin summits of Shakespeare's achievement in his chronicle plays. They are certainly superlative plays made more memorable by the character of Falstaff. It has been said that 'in a totally different way, Falstaff is to English literature what his contemporary Don Quixote has been to the Spanish'.

The great 'middle period' of Shakespeare begins with *A Midsummer Night's Dream* and ends with *Hamlet* (1600–1601).

In *Hamlet* Shakespeare gives expression to his thoughts on the theater and also his reaction to the rising rivalry with Ben Jonson and the Blackfriar's theater with their appeal to wit and fashion. Thus, in his instruction to the players (in the play within the play), we find Hamlet saying:

> For anything so overdone is from the purpose of playing, whose end, both at the first and now, was and is to hold, as 'twere, the mirror up to nature, to show virtue her own feature, scorn her own image, and the very age and body of the time his form and pressure.

Shakespeare is here asserting that 'the very age and body of the time' can be expressed in drama—as, indeed, he had expressed his own age in his chronicle plays.

There is perhaps a hint of admonition to Ben Jonson and the 'reformers' in

> O it offends me to the soul to hear a robustious periwig-pated fellow tear a passion to tatters, to very rags, to split the ears of the groundlings, who for the most part, are capable of nothing but inexplicable dumb-shows and noise:
>
> O there be players that I have seen play and heard others praise . . . have so strutted and bellowed that I have thought some of nature's journeymen had made men, and not made them well, they imitated humanity so abominably.
>
> . . .
>
> O reform it altogether.

The plays that followed *Hamlet*—*All's Well That Ends Well* and *Measure for Measure*—provide indications that, at this time, Shakespeare's 'nerves were on edge': he appears disillusioned with men and things—perhaps, a proper frame of mind to embark on his great tragedies. As A. L. Rowse, the distinguished Elizabethan and Shakespearian scholar, has written, the great tragedies 'show evidences of strain and exhaustion'; he continues:

> As in all significant work, we have a convergence of factors, on the one side literary, on the other personal . . . If Shakespeare were to compare with his rival Ben Jonson he must do so now in tragedy. With the tragedies he was to make the grandest efforts, extend his powers to his fullest capacity and thus fulfill his destiny as a writer . . . There is cumulative evidence that so far from not caring about his fame and achievement as a writer, his ambition was the highest. The argument has come full circle: here is a personal consideration.

When Shakespeare's work was complete, Ben Jonson was able to compare him only with the great tragedians: Aeschylus, Sophocles and Euripides.

The year 1604–08 saw in succession the plays *Othello*, *King Lear*, *Macbeth*, *Antony and Cleopatra* and *Coriolanus*. It staggers one's imagination to realize that these great plays, so utterly different from one another, could have been written, in succession, with such unfaltering inspiration.

Here is Hazlitt's summing up of the tragedies:

> *Macbeth* and *Lear*, *Othello* and *Hamlet*, are usually reckoned Shakespeare's four principal tragedies. *Lear* stands first for the profound intensity of the passion; *Macbeth* for the wildness of the imagination and the rapidity of action; *Othello* for the progressive interest and powerful alternations of feeling; *Hamlet* for the refined development of thought and sentiment. If the force of genius shown in each of these works is astonishing, their variety is not less so. They are like different creations of the same mind, not one of which has the slightest reference to the rest. This distinctness and originality is indeed the necessary consequences of truth and nature.

Hazlitt does not include *Antony and Cleopatra* among the great tragedies. But nowadays it is considered by many as equally great. As T. S. Eliot in a remarkably sensitive analysis of *Antony and Cleopatra* has said:

> This is a play for mature actors and for a mature audience, for neither on the stage nor in the audience can immature people enter into the feelings of these middle-aged

lovers... The peculiar triumph of *Antony and Cleopatra* is in the fusion of the heroic and the sordid, in the same characters in one vision of life. Marlowe could have made them seem equally majestic. Dryden in his later play on the subject almost does so. But only Shakespeare could have made them at once majestic and human in their weakness; and without the human weaknesses we should not have the greatness and the terror of tragedy. And the reason is that Shakespeare had learned to say things in poetry which no one else could have said in prose.

It has sometimes been suggested that the plays which ollowed the great tragedies—*Timon of Athens*, *Pericles*, *rince of Tyre* and *Cymbeline*—all show signs of nervous atigue. As A. L. Rowse has remarked: 'there seems to e a hiatus here, a pause, if not something more, during hese years'. But a contrary view has been expressed y T. S. Eliot:

> The last plays are more difficult. Our astonishment in reading and hearing *Antony and Cleopatra* might often in many places be expressed by the words, 'I should never have thought that that would be said in poetry'. Our moments of astonishment in the later plays could better be expressed by the words, 'I should never have thought that that could be said at all'. For in the last plays, and I mean especially *Cymbeline*, *The Winter's Tale*, *Pericles* and *The Tempest*, Shakespeare has abandoned the realism of ordinary existence in order to reveal to us a further world of emotion...

In any event, Shakespeare's last three plays—*The Vinter's Tale*, *The Tempest* and *Henry VIII*—are more ccessible—at least, Shakespeare's natural poise is more vident. Thus, *Winter's Tale* is a most beautiful and oving play. Hazlitt describes it as 'one of the best cting of our author's plays' while the well-known hakespearian scholar Q. writes: '*Winter's Tale* is beyond riticism and even beyond praise'.

In his penultimate play, Shakespeare, ever searching or something new, deals with a profound theme which ontinues to be vexatious down to this day: in his reation of Caliban, he concretely states for us a central ssue of the present age. But the mood of the *The empest* is one of farewell:

> Our revels are now ended. These our actors,
> As I foretold you, were all spirits, and
> Are melted into air, into thin air:
> And like the baseless fabric of this vision,
> The cloud-capped towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherit, shall dissolve,
> And, like this insubstantial pageant faded,
> Leave not a rack behind.

And finally, in his last play, Shakespeare returns to is chronicle of the English story, which he began with *lenry VI* and *Richard III* and completes the cycle with *lenry VIII* and the birth of Elizabeth. The concluding peech by the Archbishop of Canterbury opening with ie incantation:

> This royal infant—Heaven still move about her—
> Though in her cradle, yet now promises
> Upon this land a thousand thousand blessings,

is a form of prophesy of what the Elizabethan age was to be. It gave Shakespeare the splendid opportunity to pay his tribute to the Queen, he had not eulogized at her death in 1603, and to sum up the Elizabethan age now only an imprint on time. As A. L. Rowse concludes his biography of Shakespeare:

> And this too was Shakespeare's end. But like a splendid coiled snake, glittering and richly iridescent—emblem alike of wisdom and immortality—his work lay about him rounded and complete.

Ben Jonson's tribute, included with the first folio, has been prophetic:

> He was not of an age, but of all time!

Let me conclude by quoting two contemporary writers.

Virginia Woolf, after a vain effort imagining how Shakespeare 'coined his words', writes in her diary:

> Indeed, I could say that Shakespeare surpasses literature altogether, if I knew what it meant.

And T. S. Eliot sums up Shakespeare as follows:

> The standard set by Shakespeare is that of continuous development from first to last, a development in which the choice both of theme and of dramatic and verse technique in each play seems to be determined increasingly by Shakespeare's state of feeling by the particular stage of his emotional maturity at the time... We may say confidently that the full meaning of any one of his plays is not in itself alone, but in that play in the order in which it was written, in its relation to all of Shakespeare's other plays, earlier and later: we must know all of Shakespeare's work in order to know any of it. No other dramatist of the time approaches anywhere near to this perfection of pattern...

It seems to me to correspond to some law of nature that the work of a man like Shakespeare, whose development in the course of his career was so amazing, that it should reach, as in *Hamlet*, the point at which it can touch the imagination and feeling of the maximum number of people to the greatest possible depth and that, thereafter, like a comet which has approached the earth and then continued away on its course, he should gradually recede from view until he tends to disappear into his private mystery.

II

I now turn to Beethoven with more qualms: I am even more painfully aware of my shortcomings to discourse on him.

When Beethoven came to Vienna in 1792, at the age of twenty-two, his attitude must have been one of caution; his studies with Haydn, Schenk, Albrechtsberger and Salieri were, we may assume, primarily for finding

out if there were things he could learn from them. He clearly absorbed what they had to teach him without distorting his own musical ideas. In any event, once he found that he could over-power everyone in Vienna by the sheer virtuosity of his improvizations on the pianoforte, he became impatient and, sometimes, even defiant. Thus, Haydn's unfavourable opinion of the third of his three trios, Opus 1, only confirmed Beethoven's own opinion that it was the best of the three and that Haydn's contrary view was due to jealousy and malice.

At this time, Beethoven desired great fame; and he seems to have been convinced that his sheer strength was sufficient to protect him against all misfortune. This attitude is clearly expressed in his letter to von Zmeskall:

> The devil take you! I do not know anything about your whole system of ethics. Power is the morality of men who stand out from the rest and it is also mine.

This supreme confidence in himself, derived from this morality of power, was soon destined to be tried most sorely.

The first signs of his deafness appeared, already, when Beethoven was twenty-eight years. His initial reaction was, one of rage at what he considered as the senselessness of the affliction. As he wrote to Karl Amenda three years later (1801):

> Your Beethoven is most unhappy and at strife with nature and Creator. I have often cursed the latter for exposing his creatures to the merest accident, so that often the most beautiful buds are broken or destroyed thereby. Only think that my noblest faculty, my hearing, has greatly deteriorated.

But his fortitude was unshaken, for he continued:

> I am resolved to rise superior to every obstacle . . . I am sure my fortune will not desert me. With whom need I be afraid of measuring my strength . . . I will take Fate by the throat.

We obtain proper appreciation of the state of Beethoven's mind at this time from his famous Heiligenstadt testament written in 1802 but discovered among his papers only after his death. The Heiligenstadt testament is so transparently sincere that it should really be read in its entirety, but the following extract must suffice:

> But how humiliated I have felt if somebody standing beside me heard the sound of a flute in the distance and I heard nothing, or if somebody heard a shepherd sing and again I heard nothing—Such experiences almost made me despair, and I was on the point of putting an end to my life—The only thing that held me back was my art. For indeed it seemed impossible to leave this world before I had produced all the works that I felt urged to compose.

Beethoven's confession that he contemplated suicide and that it was the power of his unfulfilled art that saved him finds an echo in what he wrote twenty years later:

> I live only for my art and to fulfill my duties as a man.

It is clear that Beethoven's growing deafness shattered his earlier ethics of the morality of power. But like a phoenix it rose only to sustain the realization of his creative powers. Thus, by the time (1807) he came to writing his third Rasoumowsky quartet, his resignation to his affliction appears to be complete, for we find him writing in the margin:

> Let your deafness no longer be secret even for art . . .

And the work on the grand scale in which his conflict with fate is taken for granted and ignored is his seventh symphony.

This 'middle period' of intense creativeness lasted for some ten years. By his early forties, Beethoven had composed his eight symphonies, his five piano concertos, his one violin concerto, his twenty-five piano sonatas, his eleven quartets, his seven overtures, his one opera, and his one mass. At the age of forty-two with this magnificent pile of compositions behind him, Beethoven practically stopped composing for the next seven years. The fruits of his meditation—so they must have been—came after this period of quiescence in a manner that is perhaps without parallel in musical history.

From the first symphony written in 1801 to the eighth symphony written in 1812, it is essentially the same Beethoven: it is, in fact, the Beethoven of the common understanding. But the Beethoven of the ninth symphony, of the mass in D, of the last four piano sonatas, and, most of all, the last five quartets is an altogether different Beethoven. Beethoven's own pupil, Czerny, did not understand his music of this last period, and he tried to explain it away as due to Beethoven's deafness:

> Beethoven's third style dates from the time when he became gradually completely deaf . . . Thence comes the dissimilarity of the style of his last three sonatas . . . Thence many harmonic roughnesses . . .

By all accounts, Beethoven's last quartets are a Mount Everest of an achievement. Here is a sample of what has been said about them:

They are peerless.

The are beyond description or analysis in words.

The last quartets are unique, unique for Beethoven, unique in all music.

But this much may certainly be said: Nobody can say what the quartet really mean; we can only be sure that they express ideas nowhere else to be found. Wordsworth's description of Newton's mind 'as voyaging through strange seas of thought alone' applies equally to Beethoven's mind of this last period.

Beethoven's last complete work, the quartet No. 16 in F major, provides a noble ending to his great sequence. Of this quartet, J. W. N. Sullivan has written:

> It is the work of a man who is fundamentally at peace. It is the peace of a man who has known conflicts, but whose conflicts are now reminiscent. This quality is most apparent

in the last movement with its motto, '*Muss es sein? Es muss sein!*' (Must it be? It must be!)

Reviewing the life and work of Beethoven, Sullivan sums him up as follows:

> One of the most significant facts, for the understanding of Beethoven, is that his work shows an organic development up until the very end . . . The greatest music Beethoven ever wrote is to be found in the last string quartets, and the music of every decade before the final period was greater than its predecessor.

It is striking how close this summing of Beethoven is to T. S. Eliot's summing of Shakespeare which I quoted earlier. The way Shakespeare and Beethoven overcame the crises of their early years, the continual growth of their minds, the organic unity of their works spanning their entire lives, their great masterpieces towards the end, and even the moods of farewell in *The Tempest* and in the sixteenth quartet, all these are indeed most striking.

III

I now turn to Newton.

Isaac Newton, a posthumous child, born with no father on Christmas Day 1642, was, as Maynard Keynes has aptly written, 'the last wonder child to whom the Magi could do sincere and appropriate homage'.

One of the most remarkable aspects of Newton's most remarkable life is the explosive outburst of his genius. He was not an infant prodigy; and it is probable that when he went to Cambridge in 1661, he knew little more than elementary arithmetic. And it must be remembered that the new outlook on scientific thought that we associate with the names of Galileo, Kepler and Descartes had hardly yet penetrated the walls of Oxford and Cambridge. Nevertheless, by 1664, when Newton was in his twenty-third year, his genius seems to have flowered. Thus, Newton recalled in his old age that he had 'found the method of Infinite Series at such time (1664–65)'. Newton, in fact, wrote out his notes as a connected essay entitled, 'On Analysis of Equations with an Infinite Number of Terms' and allowed Barrow to send it to Collins, stipulating, however, that he remain anonymous. This stipulation was withdrawn later; but we encounter here the first indication of a trait which was later to become an obsession with Newton.

By the summer of 1665, when Cambridge was evacuated on account of the plague and Newton had gone to Woolsthorpe, his genius was fully in flower. It manifested itself in a manner unsurpassed in the history of scientific thought. But it was not until many years later that the world was to know what happened during the two years that Newton was at Woolsthorpe.

For here at Woolsthorpe, Newton at the age of twenty-three made three of the greatest discoveries in science: the Differential Calculus, the Composition of Light, and the Laws of Gravitation. Writing towards the end of his life, Newton recalled his discovery of the laws of gravitation thus:

> In the same year (1666) I began to think of gravity extending to the orb of the moon . . . I deduced that the forces which keep the planets in their orbs must be reciprocally as the squares of their distances from the centers about which they revolve; and thereby compared the force requisite to keep the moon in her orb with the force of gravity at the surface of the earth, and found them answer pretty well. All this was in the two plague years 1665 and 1666, for in those days I was in the prime of my age for invention, and minded mathematics and philosophy more than at any time since.

Notice, first, his statement that 'in those days . . . I minded mathematics and philosophy [meaning science] more than at any time since'. Notice also the curious words 'answer pretty well' to the agreement he had found with respect to the acceleration experienced by the moon in its orbit and as deduced—on the basis of his inverse-square law—from the acceleration experienced by bodies on the earth, that is, the falling apple. Newton does not appear to have felt any urgency to verify if his prediction 'answers' more than 'pretty well'. Indeed, he does not seem to have experienced any special delight in having discovered so fundamental a law of nature. In actual fact, he dismissed the entire matter from his mind for a decade and more.

Newton returned to Cambridge early in 1667; and in 1669 he was appointed to the Lucasian Chair of Mathematics in succession to Barrow who had relinquished the Chair on Newton's behalf.

Soon after his return to Cambridge, Newton appears to have completed to his satisfaction his experimental investigations on the composition of light and constructed his first reflecting telescope to avoid the chromatic aberrations of the then extant refracting telescopes. But he did not publish any of these results of his investigations for several years.

The news of Newton having constructed a telescope on a new principle soon spread and Newton was urged to exhibit it at the Royal Society. It is known that Newton sent at least two telescopes to the Royal Society and that the second of them was exhibited in 1671.

Newton was elected to the Royal Society in January 1672. Stimulated perhaps by this recognition, Newton acceded to the request by Oldenburg, then the Secretary of the Royal Society, to communicate to the Society an account of his discoveries and in particular the principles underlying the construction of his telescope. In two successive letters, Newton replied to Oldenburg as follows:

> I shall endeavour to testify my gratitude by communicating what my poor and solitary endeavours can effect towards the promoting your philosophical designs (6 January 1672).

In the next letter he suggests communicating an account of his optical discoveries rather than a description of his telescope. He writes:

> An account of a philosophical discovery . . . which I doubt not but will prove much more grateful than the communication of that instrument, being in my judgement the oddest, if not the most considerable detection, which has hitherto been made in the operation of nature (18 January 1672).

I should like to draw your attention especially to the words, 'the oddest, if not the most considerable detection'. This is the first and the only time that Newton expresses a trace of enthusiasm with respect to any of his discoveries. But what followed the publication of Newton's account of his experiments on the composition of light was nothing short of a disaster. A vigorous controversy ensued, and Newton appears to have been irritated beyond endurance by the inability of his critics even to comprehend what it was he had experimentally demonstrated. This lack of comprehension is apparent, for example, from Huygens—even Huygens—arguing that there 'would still remain the great difficulty of explaining by mechanical principles, in what consists the diversity of colours, even supposing that Newton's decomposition of white light into the colours of the spectrum is correct'.

At first Newton tried to persuade by clarifying his method:

> For the best and safest method of philosophizing seems to be, first to enquire diligently into the properties of things, and of establishing those properties by experiments, and then to proceed more slowly to hypotheses for the explanation of them. For hypotheses should be subservient only in explaining the properties of things, but not assumed in determining them; unless so far as they may furnish experiments . . .

(Parenthetically, we may notice that Newton is, here, enunciating what he was to formulate later in his famous aphorism:

Hypotheses non fingo—I frame no hypotheses.)

Newton's failure to persuade resulted in the aversion he now formed to scientific publication, discussion and arguments. Thus, he wrote to Oldenburg:

> I have long since determined to concern myself no further about the promotion of philosophy (5 December 1672).

> I see I have made myself a slave to Philosophy, but if I get free of Mr. Linus' business I will resolutely bid adieu to it eternally, except what I do for my private satisfaction, or leave to come out after me. For I see, a man must either resolve to point out nothing new or to become a slave to defend it (18 November 1676).

This aversion to scientific publication, discussion, and argument was to find repeated expressions in later years. Here are two examples:

> For I see not what there is desirable in public esteem, were I able to acquire and maintain it. It would perhaps increase my acquaintance, the thing which I chiefly study to decline.

> I am grown of all men the most shy of setting pen to paper about anything that may lead into disputes (12 September 1682).

Soon after the publication of his optical discoveries, Newton receded into himself, and we do not know very much as to how he occupied himself during the following decade. But we do know that in 1679, Newton had proved for himself that under the influence of a central inverse-square attractive force an object will describe an elliptical orbit, with the center of attraction at one of its foci. But, again, he kept the result to himself.

At long last, in 1684, an incident, not of Newton's making, was to change the course of scientific history. In January of that year, at a meeting in London between Christopher Wren, Robert Hooke and Edmund Halley, the question arose as to the nature of the orbit a planet would describe under the influence of an inverse-square attractive gravitational force. Since none of them knew how the question could be resolved, Halley went to Cambridge in August of that year to inquire if Newton had any suggestions to offer. To Halley's inquiry, Newton replied at once that the orbit would be an ellipse, and that he had established this result for himself some seven years earlier. Halley was overjoyed and wished to see Newton's proof. On Newton finding that he had mislaid the piece of paper on which he had written out the proof, he promised to rework it and send it to him shortly.

The reworking of this old problem seems to have aroused Newton's interest in the whole area. By October, he had worked out enough problems to serve as a basis for nine lectures which he gave during the Michaelmas term under the title *De Motu Corporum in gyrum.*

Halley, on receiving Newton's promised proof at about this time and hearing also of Newton's lectures, went to Cambridge once again, this time to persuade Newton to publish his lectures.

By now Newton's mathematical genius seems to have been fully aroused, and Newton appears to have been caught in its grip. Newton now entered upon a period of the most intense mathematical activity. Against his will and against his preferences, Newton seems to have been propelled inexorably forward, by the pressure of his own genius, till, at last, he had accomplished the greatest intellectual feat of his life, the greatest intellectual feat in all of science.

Let us pause for a moment to take full measure of the magnitude of this feat. By Newton's own account, he began writing the *Principia* towards the end of December 1684, and he sent the completed manuscript

of all three Books of the *Principia* to the Royal Society in May 1686, that is, in seventeen months. He had solved two of the propositions in the first Book in 1679, and he had also proved eight of the propositions in the second Book in June and July 1685. There are ninety-eight propositions in the first Book; fifty-three in the second; and forty-two in the third. By far the larger proportion of them was, therefore, enunciated and proved during the seventeen consecutive months that Newton was at work on the three Books. It is this rapidity of execution, besides the monumental scale of the whole work, that makes this achievement incomparable. If the problems enunciated in the *Principia* were the results of a lifetime of thought and work, Newton's position in science would still be unique. But that all these problems should have been enunciated, solved, and arranged in logical sequence in seventeen months is beyond human comprehension. It can be accepted only because it is a fact: it just happens to be so!

It is only when we observe the scale of Newton's achievement that comparisons, which have sometimes been made with other men of science, appear altogether inappropriate both with respect to Newton and with respect to the others. In fact, only in juxtaposition with Shakespeare and Beethoven is the consideration of Newton appropriate.

Now, a few remarks concerning the style of the *Principia*. Quite unlike his early communications on his optical discoveries, the *Principia* is written in a style of glacial remoteness which makes no concessions to his readers. As Whewell aptly wrote:

> ... As we read the *Principia* we feel as when we are in an ancient armoury where the weapons are of gigantic size; and as we look at them, we marvel what manner of men they were who could use as weapons what we can scarcely lift as a burden ...

It is, however, clear that the rigid and the lamellated style of the *Principia* is deliberate. For after the publication of the *Principia*, Newton is reported to have told Rev. Dr. Derham:

> To avoid being baited by little smatterers in mathematics, I designedly made the *Principia* abstruse; but yet so as to be understood by able mathematicians who, I imagine, by comprehending my demonstrations would concur with my theory.

Although Newton was only forty-two years of age when he finished writing the *Principia* and was, quite literally, at the height of his mathematical powers and was to remain in full possession of his faculties for another forty years, he never again seriously concerned himself with a scientific investigation. He turned to an utterly different way of living. And in time he became one of the principal sights of London for all visiting intellectuals; *the* Sir Isaac Newton of popular tradition.

No account of Newton's life, however brief, can omit some indication of the manner of man he was. The subject is a complex and a controversial one. But this much can fairly be said: Newton seems to have been remarkably insensitive: impervious to the arts, tactless, and with no real understanding of others.

Newton's most remarkable gift was probably his powers of concentration. As Keynes wrote:

> His peculiar gift was the power of holding continuously in his mind a purely mental problem until he had seen straight through it. I fancy his pre-eminence is due to his muscles of intuition being the strongest and most enduring with which a man has ever been gifted ... I believe that Newton could hold a problem in his mind for hours and days and weeks until it surrendered to him its secret.

Besides, as De Morgan has said, he was:

> ... So happy in his conjectures as to seem to know more than he could possibly have any means of proving.

But the central paradox of Newton's life is that he deliberately and systematically ignored his supreme mathematical genius and through most of his life neglected the one activity for which he was gifted beyond any man. This paradox can be resolved only if we realize that Newton simply did not consider science and mathematics as of any great importance: or, as Keyness has said:

> ... It seems easier to understand ... this strange spirit, who was tempted by the Devil to believe, at the time when within these walls (of Trinity College) he was solving so much, that he could reach *all* the secrets of God and Nature by the pure power of mind—Copernicus ad Faustus in one.

And finally, I cannot desist repeating Newton's oft-quoted evaluation of himself.

> I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

In view of Newton's insensitiveness to others, doubts have sometimes been raised about the sincerity of this statement. I do not believe that such doubts are warranted: only someone, like Newton, who can view knowledge from his height, can have the vision of an 'ocean of undiscovered truth'. As an ancient proverb of India says, 'Only the wise can plumb the wells of wisdom'.

IV

From the accounts of the creative patterns of Shakespeare, Beethoven and Newton, though very brief and very inadequate, two facts emerge with startling clarity: the remarkable similarity in the creative patterns of Shakespeare and Beethoven, on the one hand, and their

stark contrast with that of Newton, on the other. Are the similarity and the contrast accidental? Or, are they manifestations of a general phenomenon which in the case of these giants only happens to be very sharply etched?

Consider in juxtaposition the following statements that have been made concerning the creativity of mathematicians and of poets.

G. H. Hardy, an outstanding English mathematician of this century, in his essay *A Mathematician's Apology*—an essay which has been described by C. P. Snow as 'the most beautiful statement of the creative mind ever written or ever likely to be written'—writes:

> No mathematician should ever allow himself to forget that mathematics, more than any other art or science, is a young man's game... Galois died at twenty-one, Abel at twenty-seven, Ramanujan at thirty-three, Riemann at forty. There have been men who have done great work a good deal later;... (but) I do not know an instance of a major mathematical advance initiated by a man past fifty... A mathematician may still be competent enough at sixty, but it is useless to expect him to have original ideas.

And with respect to Ramanujan's early death, Hardy has further written:

> The real tragedy about Ramanujan was not his early death. It is, of course, a disaster that any great man should die young; but a mathematician is comparatively old at thirty, and his death may be less of a catastrophe than it seems...

Place beside these statements of Hardy the following one of A. L. Rowse on the death of Christopher Marlowe at the age of twenty-nine:

> What would he not have achieved if he had lived!—his was the greatest of all losses to English Literature.

Or, of Desmond King-Hele's on the death of Shelley at the age of thirty:

> The rule that a poet is at his best after the age of 30 might have applied as well to him as to Shakespeare, Milton, Wordsworth, Byron, Tennyson and indeed almost every major English poet who lived to be over 30.

In a more negative vein, there is the statement attributed to Thomas Huxley that a man of science past sixty does more harm than good.

I do not doubt that these statements will be challenged or, at least, subjected to qualifications. But consider this.

In 1817, at the age of forty-seven, when the long period of meditation, during which Beethoven composed very little, was coming to an end, he said to Cipriani Potter with transparent sincerity, '*Now*, I know how to compose'. I do not believe that there has been any scientist, past forty, who could have said, '*Now*, I know how to do research'. And this to my mind is the center and the core of the difference: the apparent inability of a scientist to continually grow and mature.

V

If one should wish to establish with some degree of certainty that a contrast does exist in the patterns of creativity among the practitioners in the arts and the practitioners in the sciences, then one should undertake a survey of an extent and a depth which is far beyond my resources. At the same time it does not seem entirely proper that I leave the matter without some further examples. I shall consider four examples taken from science.

My first example is James Clerk Maxwell who is generally considered the greatest physicist of the nineteenth century. Maxwell's principal contributions to physics are his founding of the kinetic theory of gases and the dynamical theory of the electromagnetic field. The new physical concepts which Maxwell introduced in formulating his equations of the electromagnetic field—Maxwell's equations which every student of physics knows—have been described by Einstein as 'the most fruitful and profound that physics has experienced since the time of Newton'.

The four great memoirs which encompass Maxwell's contributions to the two areas were published during the five years 1860–65 when he was between the ages of thirty and thirty-five and was a professor at King's College, London. At the end of this period of intense activity, Maxwell resigned his professorship in London and retired to his country home in Glenlair in Scotland. (Maxwell's biographers never really 'explain' why Maxwell felt it necessary to take these actions.) In Glenlair, for the following six years, Maxwell seems to have lived in quietness, occupied, principally, with the planning of his two volume *Treatise on Electricity and Magnetism* (which was eventually completed and published in 1873). In 1871, Maxwell was persuaded to leave his retirement in Glenlair and return to academic life in Cambridge as the first Cavendish Professor of Experimental Physics. He died in 1878 at the age of forty-eight. Maxwell's eight years in Cambridge were devoted mostly to editing the scientific papers of Henry Cavendish, organizing and establishing the Cavendish Laboratory, and other diverse university matters. While Maxwell's early death was a tragedy, it must be admitted that his work did not rise again to the heights it had in his early thirties.

My second example is George Gabriel Stokes. Stokes was elected to the Lucasian Chair of Mathematics (in Cambridge) in 1849 when he was just past thirty. He held this Chair until his death in 1903—a Chair that was once held by Newton. Stokes is one of the great figures of nineteenth-century physics and mathematics.

His name continues to be associated with several current notions and concepts. Thus, we have the Navier-Stokes equations governing viscous flow in hydrodynamics; the Stokes law giving the asymptotic rate of fall of small spherical bodies in a viscous medium—a law which provides the basis for Millikan's 'oil-drop experiment' for determining the charge on the electron; the Stokes parameters for characterizing polarized radiation which are relevant to most current measurements in radioastronomy; the Stokes law of fluorescence, that the wavelength of the fluorescing light must exceed that of the exciting light; and the Stokes theorem which, in addition to being a very fundamental theorem, provides a key element for modern developments in the calculus of differential forms.

Now Stokes's scientific papers are collected in five medium-sized volumes. The first three volumes contain all the important concepts and notions that I have just enumerated and cover the ten-year period 1842–52; the remaining two volumes suffice to cover his entire scientific work of the following fifty years.

G. Evelyn Hutchinson (the distinguished zoologist at Yale University), whose father was a close associate of Stokes during his last years, makes the remarkable statement: 'Stokes, however, quite possibly, emulated his great predecessor (in the Lucasian Chair) consciously . . . What Newton did, Stokes deemed appropriate for him to do also'.

My third example is Einstein. The year 1905 was the *annus mirabilis* both for Einstein and for physics. It was in that year that Einstein, at the age of twenty-six, published three papers, each epoch-making in its own way: the first laid the foundations for his special theory of relativity with remarkable clarity, conciseness and coherence; the second provided a rational molecular basis (independently of Smoluchowski) for accounting for Brownian motion; and the third carried Planck's hypothesis of the quantum to its logical limit to formulate the concept of the light quantum. In the decade that followed, Einstein was constantly preoccupied with the resolution of the basic inconsistency between Newton's law of gravitation, with its postulate of instantaneous action at a distance, and his own special theory of relativity, with its postulate that no signal can be propagated with a velocity exceeding that of light. After many detours and false starts, Einstein finally arrived triumphantly at his general theory of relativity in 1915. As Hermann Weyl later expressed, Einstein's general theory of relativity is 'one of the great examples of the power of speculative thought'.

In the years following the founding of his general theory of relativity, Einstein made a number of important contributions to the further ramifications of his own general theory as well as to certain aspects of statistical physics. But already by 1925, Einstein was letting the newer developments in the quantum theory, initiated by Heisenberg, pass him by. Thus, Heisenberg records that at the Solvay Congress in 1927, Paul Ehrenfest, Einstein's friend, said to him, 'Einstein, I am ashamed of you: you are arguing against the new quantum theory just as your opponents argue about relativity theory'. Heisenberg adds sadly that this friendly admonition went unheeded. As Einstein's great admirer Cornelius Lanczos observes

> From 1925 on his interest in the current affairs of physics begins to slacken. He voluntarily abdicated his leadership as the foremost physicist of his time, and receded more and more into voluntary exile from his laboratory, a state into which only a few of his colleagues were willing to follow. During the last thirty years of his life he became more and more a recluse who lost touch with the contemporary developments of physics.

I should like to conclude with an example which in some ways appears counter to Hardy's general rule: the case of Lord Rayleigh, perhaps the greatest pillar of classical mathematical physics. Rayleigh's productivity was remarkably steady and uniform all through his fifty years of scientific publication. His scientific work is encompassed in a two-volume treatise on *The Theory of Sound* and the six large volumes of his *Scientific Papers*.

In a memorial address, delivered in Westminster Abbey in December 1921, J. J. Thomson evaluated Rayleigh's scientific contributions in the following terms:

> Among the 446 papers which fill these volumes (the six volumes of his *Scientific Papers*), there is not one that is trivial, there is not one which does not advance the subject with which it deals, there is not one which does not clear away difficulties; and among that great number there are scarcely any which time has shown to require correction . . . Lord Rayleigh took physics for his province and extended the boundary of every department of physics. The impression made by reading his papers is not only due to the beauty of the new results attained, but to the clearness and insight displayed, which gives one a new grasp of the subject . . .

This is a remarkable testimony; and anyone who has had occasion to use Rayleigh's *Scientific Papers* will testify to its accuracy.

But why was Rayleigh so different from Maxwell and Einstein? Perhaps the clue is to be found in what Thomson said in the same memorial address:

> There are some great men of science whose charm consists in having said the first word on a subject, in having introduced some new idea which has proved fruitful; there are others whose charm consists perhaps in having said the last word on the subject, and who have reduced the subject to logical consistency and clearness. I think by temperament Lord Rayleigh belonged to the second group.

And perhaps there is a clue also in Rayleigh's response

to his son (also a distinguished physicist) when he asked him to comment on Huxley's remark I quoted earlier, 'that a man of science past sixty does more harm than good'. Rayleigh was sixty-seven at that time, and his response was

> That may be, if he undertakes to criticize the work of younger men, but I do not see why it need be so if he sticks to the things he is conversant with.

Perhaps there is a moral here for all of us!

VI

I now pass on to some cognate matters.

First, may I say that I am frankly puzzled by the difference that appears to exist in the patterns of creativity among the practitioners in the arts and the practitioners in the sciences: for, in the arts as in the sciences, the quest is after the same elusive quality: beauty. But what is beauty?

In a deeply moving essay on 'The Meaning of Beauty in the Exact Sciences', Heisenberg gives a definition of beauty which I find most apposite. The definition, which Heisenberg says goes back to antiquity, is that 'beauty is the proper conformity of the parts to one another and to the whole'. On reflection, it does appear that this definition touches the essence of what we may describe as 'beautiful': it applies equally to *King Lear*, the *Missa Solemnis* and the *Principia*.

There is ample evidence that in science, beauty is often the source of delight. One can find many expressions of such delight scattered through the scientific literature. Let me quote a few examples.

Kepler:

> Mathematics is the archetype of the beautiful.

David Hilbert (in his memorial address for Hermann Minkowski):

> Our Science, which we loved above everything, had brought us together. It appeared to us as a flowering garden. In this garden there were well-worn paths where one might look around at leisure and enjoy oneself without effort, especially at the side of a congenial companion. But we also liked to seek out hidden trails and discovered many an unexpected view which was pleasing to our eyes; and when the one pointed it out to the other, and we admired it together, our joy was complete.

Hermann Weyl (as quoted by Freeman Dyson):

> My work always tried to unite the true with the beautiful; but when I had to choose one or the other, I usually chose the beautiful.

Heisenberg (in a discussion with Einstein):

> If nature leads us to mathematical forms of great simplicity and beauty—by forms I am referring to coherent systems of hypothesis, axioms, etc.—to forms that no one has previously encountered, we cannot help thinking that they are 'true', that they reveal a genuine feature of nature ... You must have felt this too: the almost frightening simplicity and wholeness of the relationships which nature suddenly spreads out before us and for which none of us was in the least prepared.

All these quotations express thoughts that may appear vague or too general. Let me try to be concrete and specific.

The discovery by Pythagoras, that vibrating strings, under equal tension, sound together harmoniously if their lengths are in simple numerical ratios, established for the first time a profound connection between the intelligible and the beautiful. I think we may agree with Heisenberg that this is 'one of the truly momentous discoveries in the history of mankind'.

Kepler was certainly under the influence of the Pythagorean concept of beauty when he compared the revolution of the planets about the sun with a vibrating string and spoke of the harmonious concord of the different planetary orbits as the music of the spheres. It is known that Kepler was profoundly grateful that it had been reserved for him to discover, through his laws of planetary motion, a connection of the highest beauty.

A more recent example of the reaction of a great scientist, to this aspect of beauty at the moment of revelation of a great truth, is provided by Heisenberg's description of the state of his feelings when he found the key that opened the door to all the subsequent developments in the quantum theory.

Towards the end of May 1925, Heisenberg, ill with hay fever, went to Heligoland to be away from flowers and fields. There by the sea, he made rapid progress in resolving the difficulties in the quantum theory as it was at that time. He writes:

> Within a few days more, it had become clear to me what precisely had to take the place of the Bohr–Sommerfeld quantum conditions in an atomic physics working with none but observable magnitudes. It also became obvious that with this additional assumption, I had introduced a crucial restriction into the theory. Then I noticed that there was no guarantee that ... the principle of the conservation of energy would apply ... Hence I concentrated on demonstrating that the conservation law held; and one evening I reached the point where I was ready to determine the individual terms in the energy table (Energy Matrix) ... When the first terms seemed to accord with the energy principle, I became rather excited, and I began to make countless arithmetical errors. As a result, it was almost three o'clock in the morning before the final result of my computations lay before me. The energy principle had held for all the terms, and I could no longer doubt the mathematical consistency and coherence of the kind of quantum mechanics to which my calculations pointed. At first, I was deeply alarmed. I had the feeling that, through the surface of atomic phenomena, I was looking at a strangely beautiful interior, and felt almost giddy at

> the thought that I now had to probe this wealth of mathematical structure nature had so generously spread out before me. I was far too excited to sleep, and so, as a new day dawned, I made for the southern tip of the island, where I had been longing to climb a rock jutting out into the sea. I now did so without too much trouble, and waited for the sun to rise.

May I allow myself at this point a personal reflection? In my entire scientific life, extending over forty-five years, the most shattering experience has been the realization that an exact solution of Einstein's equations of general relativity, discovered by the New Zealand mathematician, Roy Kerr, provides the *absolutely exact representation* of untold numbers of massive black holes that populate the universe. This 'shuddering before the beautiful', this incredible fact that a discovery motivated by a search after the beautiful in mathematics should find its exact replica in Nature, persuades me to say that beauty is that to which the human mind responds at its deepest and most profound. Indeed, everything I have tried to say in this connection has been stated more succinctly in the Latin mottos:

> *Simplex sigillum veri*—The simple is the seal of the true.

and

> *Pulchritudo splendor veritatis*—Beauty is the splendour of truth.

VII

But I must return to my question: why is there a difference in the patterns of creativity among the practitioners in the arts and the practitioners in the sciences? I shall not attempt to answer this question directly; but I shall make an assortment of remarks which may bear on the answer.

First, I should like to consider how scientists and poets view one another. When one thinks of the attitude of the poets to science, one almost always thinks of Wordsworth and Keats and their oft-quoted lines:

> A fingering slave,
> One that would peep and botanize
> Upon his mother's grave?
>
> A reasoning self-sufficing thing,
> An intellectual All-in-all!
> Sweet is the lore which Nature brings;
> Our meddling intellect
> Misshapes the beauteous forms of things:
> We murder to dissect.
>
> (Wordsworth)

> Do not all charms fly
> At the mere touch of cold philosophy?
> There was an awful rainbow once in heaven:
> We know her woof, her texture; she is given
> In the dull catalogue of common things.
> Philosophy will clip an Angel's wings.
>
> (Keats)

These lines, perhaps, find an echo in a statement of Lowes Dickinson, 'When Science arrives, it expels Literature'.

It is to be expected that one should find scientists countering these views. Thus, Peter Medawar counters Lowes Dickinson by

> The case I shall find evidence for is that when literature arrives, it expels science . . . The way things are at present, it is simply no good pretending that science and literature represent complementary and mutually sustaining endeavours to reach a common goal. On the contrary, where they might be expected to cooperate, they compete.

It would not seem to me that one can go very far in these matters by pointing accusing fingers at one another. So, let me only say that the attitudes of Wordsworth and Keats are by no means typical. A scientist should rather consider the attitude of Shelley. Shelley is a scientist's poet. It is not an accident that the most discriminating literary criticism of Shelley's thought and work is by a distinguished scientist, Desmond King-Hele. As King-Hele has pointed out, 'Shelley's attitude to science emphasizes the surprising modern climate of thought in which he chose to live', and Shelley 'describes the mechanisms of Nature with a precision and a wealth of detail unparalleled in English poetry'. And here is A. N. Whitehead's testimony:

> Shelley's attitude to Science was at the opposite pole to that of Wordsworth. He loved it, and is never tired of expressing in poetry the thoughts which it suggests. It symbolizes to him joy, and peace, and illumination . . .

I should like to read two examples from Shelley's poetry which support what has been said about him. The first example is from his *Cloud* which 'fuses together a creative myth, a scientific monograph, and a gay picaresque tale of cloud adventure':

> I am the daughter of Earth and Water,
> And the nursling of the Sky;
> I pass through the pores of the ocean and shores;
> I change, but I cannot die.
> For after the rain when with never a stain
> The pavilion of Heaven is bare,
> And the winds and sunbeams with their convex gleams
> Build up the blue dome of air,
> I silently laugh at my own cenotaph,
> And out of the caverns of rain,
> Like a child from the womb, like a ghost from the tomb,
> I arise and unbuild it again.

The second example is from *Prometheus Unbound*, which has been described by Herbert Read as 'the

greatest expression ever given to humanity's desire for intellectual light and spiritual liberty':

> The lightning is his slave; heaven's utmost deep
> Gives up her stars, and like a flock of sheep
> They pass before his eye, are numbered, and roll on!
> The tempest is his steed, he strides the air;
> And the abyss shouts from her depth laid bare,
> Heaven, hast thou secrets? Man unveils me; I have none.

Let me turn to a slightly different aspect of the matter. What are we to make of the following confession of Charles Darwin:

> Up to the age of thirty, or beyond it, poetry of many kinds, such as the works of Milton, Gray, Byron, Wordsworth, Coleridge and Shelley, gave me great pleasure; and even as a school boy I took intense delight in Shakespeare, especially historical plays ... I have also said that formerly pictures gave me considerable, and music very great delight. But now for many years I cannot endure to read a line of poetry; I have tried lately to read Shakespeare, and found it so intolerably dull that it nauseated me. I have almost lost my taste for pictures or music ... My mind seems to have become a kind of machine for grinding general laws out of large collections of facts, but why this should have caused the atrophy of that part of the brain alone on which the higher tastes depend, I cannot conceive.

Or, consider this: Faraday discovered the laws of electromagnetic induction, and his discoveries led him to formulate concepts such as 'lines of force' and 'fields of force' which were foreign to the then prevailing modes of thought. They were in fact looked askance by many of his contemporaries. But of Faraday's ideas, Maxwell wrote with prophetic discernment:

> The way in which Faraday made use of his idea of lines of force in coordinating the phenomenon of magneto-electric induction shows him to have been in reality a mathematician of a very high order—one from whom the mathematicians of the future may derive valuable and fertile methods. We are probably ignorant even of the name of the science which will be developed out of the materials we are now collecting, when the great philosopher next after Faraday makes his appearance.

And yet when Gladstone, then the Chancellor of the Exchequer, interrupted Faraday in his description of his work on electricity by the impatient inquiry, 'But after all, what use is it?' Faraday's response was, 'Why, Sir, there is every probability that you will soon be able to tax it'. And Faraday's response has always been quoted most approvingly.

It seems to me that to Darwin's confession and to Faraday's response, what Shelley has said about the cultivation of the sciences in his *A Defence of Poetry* is apposite:

> The cultivation of those sciences which have enlarged the limits of the empire of man over the external world, has, for want of the poetical faculty, proportionally circumscribed those of the internal world; and man, having enslaved the elements, remains himself a slave.

Lest you think that Shelley is not sensitive to the role of technology in modern society, let me quote what he has said in that connection:

> Undoubtedly the promoters of utility, in this limited sense, have their appointed office in society. They follow the footsteps of poets, and copy the sketches of their creations into the book of common life. They make space, and give time.

Shelley's *A Defence of Poetry* from which I have just quoted is one of the most moving documents in all of English literature. W. B. Yeats has called it 'the profoundest essay on the foundation of poetry in the English language'. The essay should be read in its entirety; but allow me to read a selection:

> Poetry is the record of the best and happiest moments of the happiest and best minds.
>
> Poetry thus makes immortal all that is best and most beautiful in the world; it arrests the vanishing apparitions which haunt the interlunations of life ...
>
> Poetry is indeed something divine. It is at once the centre and circumference of knowledge; it is that which comprehends all science, and that to which all science must be referred. It is at the same time the root and blossom of all other systems of thought.
>
> Poets are the hierophants of an unapprehended inspiration; the mirrors of the gigantic shadows which futurity casts upon the present; the words which express what they understand not; the trumpets which sing to battle, and feel not what they inspire; the influence which is moved not, but moves. Poets are the unacknowledged legislators of the world.

On reading Shelley's *A Defence of Poetry*, the question insistently occurs why there is no similar *A Defence of Science* written by a scientist of equal endowment. Perhaps in raising this question I have, in part, suggested an answer to the one I have repeatedly asked during the lecture.

I began this lecture by asking your forbearance for addressing myself to matters which are largely outside the circumference of my comprehension. Allow me then to conclude by quoting from Shakespeare's epilogue to the second part of his *Henry IV*:

> First, my fear; then my curtsy; last my speech. My fear, is your displeasure, my curtsy, my duty, and my speech, to beg your pardon.