

Daedalus or Science and the Future

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Introduction

I have slightly expanded certain parts of this paper since reading it. It has therefore probably lost any unity which it may once have possessed. It will be criticized for its undue and unpleasant emphasis on certain topics. This is necessary if people are to be induced to think about them, and it is the whole business of a university teacher to induce people to think.

relentlessly, and successfully pursuing them. The other picture is of three Europeans in India looking at a great new star in the milky way. These were apparently all of the guests at a large dance who were interested in such matters. Amongst those who were at all competent to form views as to the origin of this cosmoclastic explosion, the most popular theory attributed it to a collision between two stars, or a star and a nebula. There seem, however, to be at least two possible alternatives to this hypothesis. Perhaps it was the last judgment of some inhabited world, perhaps a too successful experiment in induced radio-activity on the part of some of the dwellers there. And perhaps also these two hypotheses are identical, and what we were watching that evening was the detonation of a world on which too many men came out to look at the stars when they should have been dancing. These two scenes suggest, very briefly, a part of the case against science. Has mankind released from the womb of matter a Demogorgon which is already beginning to turn against him, and may at any moment hurl him into the bottomless void? Or is Samuel Butler's even more horrible vision correct, in which man becomes a mere parasite of machinery, an appendage to the reproductive system of huge and complicated engines which will successively usurp his activities, and end by

organizations includes the fostering of research in its official programme. Indeed as far as biological research is concerned labour may prove a better master than capitalism, and there can be little doubt that it would be equally friendly to physical and chemical research if these came to lead immediately to shortened hours rather than to unemployment. In particular there is perhaps reason to think that that form of sentimentalism which hampers medical research in this country by legislation would be less likely to flourish in a robust and selfish labour party of the Australian type than in parties whose members enjoy the leisure which seems necessary to the development of such emotional luxuries. It is of course possible that civilisation may collapse throughout the world as it has done in parts of Russia, and science with it, but such an event would in all probability, only postpone the problem for a few thousand years. And even in Russia we must not forget that first-rate scientific research is still being carried on. The possibility has been suggested -I do not know how seriously -that the progress of science may cease through lack of new problems for investigation. Mr. Chesterton in *The Napoleon of Notting Hill*, a book written fifteen years or so ago, prophesied that hansom-cabs would still be in existence a hundred years hence owing to a cessation of invention. Within six

opposed to those of the gospels a loophole has been left for moral progress such as hardly exists in other religions. This is no doubt an argument for Christianity as against other religions, but not as against none at all, or as against a religion which will frankly admit that its mythology and morals are provisional. That is the only sort of religion that would satisfy the scientific mind, and it is very doubtful whether it could properly be called a religion at all. No doubt many people hope that such a religion may develop from christianity. The human intellect is feeble, and there are times when it does not assert the infinity of its claims. But even then:

“Though in black jest it bows and nods
* * * * *

"I know it is roaring at the gods
Waiting the last eclipse."

The scientific worker of the future will more and more resemble the lonely figure of Daedalus as he becomes conscious of his ghastly mission, and proud of it.

in physics and chemistry. Now these are commercial problems, and I believe that the centre of scientific interest lies in biology. A generation hence it may be elsewhere, and the views expressed in this paper will appear as modest, conservative, and unimaginative as do many of those of Mr. Wells today. I will only touch very briefly on the future of physics, as the subject is inevitably technical. At present physical theory is in a state of profound suspense. This is primarily due to Einstein -the greatest Jew since Jesus. I have no doubt that Einstein's name will still be remembered and revered when Lloyd George, Foch, and William Hohenzollem share with Charlie Chaplin that ineluctable oblivion which awaits the uncreative mind. I trust that I may be excused if I trespass from the strict subject of my theme to add my quota to the rather numerous misstatements of Einstein's views which have appeared during the last few years. Ever since the time of Berkeley it has been customary for the majority of metaphysicians to proclaim the ideality of Time, of Space, or of both. But they soon made it clear that in spite of this, time would continue to wait for no man, and space to separate lovers. The only practical consequence that they generally drew was that very their own ethical and political views were somehow inherent in the structure of the universe. The

“te cernere finis
“Principium, vector, dux, semita,
terminus idem”.

The prospect will appear most hopeful. But it is only hopeful if mankind can adjust its morality to its powers. If we can succeed in this, then science holds in her hands one at least of the keys to the thorny and arduous path of moral progress, then:

”Per cruciamina leti
“Via panditur ardua justis,
“Et ad astra doloribus itur ”.

That is possibly a correct large-scale view, but it is only for short periods that one can take views of history sufficiently broad to render the fate of one's own generation irrelevant. The scientific worker is brought up with the moral values of his neighbours. He is perhaps fortunate if he does not realize that it is his destiny to turn good into evil. The moral and physical (though not the intellectual) virtues are means between two extremes. They are essentially quantitative. It follows that an alteration in the scale of human power will render actions

educated men, just as materialism did after Newton's day. We may not call ourselves materialists, but we do interpret the activities of the moon, the Thames, influenza, and aeroplanes in terms of matter. Our ancestors did not, nor, in all probability, will our descendants. The materialism (whether conscious or sub-conscious does not very much matter) of the last few generations has led to various results of practical importance, such as sanitation, Marxian socialism, and the right of an accused person to give evidence on his or her own behalf. The reign of Kantian idealism as the basal working hypothesis, first of physics, and then of everyday life, will in all probability last for some centuries. At the end of that time a similar step in advance will be taken. Einstein showed that experience cannot be interpreted in terms of space and time. This was a well-known fact, but so long as space and time did not break down in their own special sphere, that of explaining the facts of motion, physicists continued to believe in them, or at any rate, what was much more important, to think in terms of them for practical purposes. A time will however come (as I believe) when physiology will invade and destroy mathematical physics, as the latter have destroyed geometry. The basic metaphysical working hypothesis of science and practical life will, I think, be something like

world-war has at least this satisfactory element. In the late war the most rabid nationalists were to be found well behind the front line. In the next war no one will be behind the front line. It will be brought home to all whom it may concern that war is a very dirty business. No doubt there is a fair chance that the possibility of human organization on a planetary scale may be rendered impossible by such a war. If so man-kind will probably have to wait for a couple of thousand years for another opportunity. But to the student of geology such a period is negligible. It took man 250,000 years to transcend the hunting pack. It will not take him so long to transcend the nation. I think then that the tendency of applied science is to magnify injustices until they become too intolerable to be borne, and the average man whom all the prophets and poets could not move, turns at last and extinguishes the evil at its source. Marx' theory of industrial evolution is a particular example of this tendency, though it does not in the least follow that his somewhat artificial solution of the problem will be adopted. It is probable that biological progress will prove to be as incompatible with certain of our social evils as industrial progress has proved to be with war or certain systems of private ownership. To take a concrete example it is clear that the second biological invention considered by my future essayist would be

as Poincare (the other Poincare) suggested we shall be forced to conceive of all change as occurring in a series of clicks, and all space as consisting of discrete points. However this may be it is safe to say that a better knowledge of the properties of radiation will permit us to produce it in a more satisfactory manner future than is at present possible. Almost all our present sources of light are hot bodies, 95% of whose radiation is invisible. To light a lamp as a source of light is about as wasteful of energy as to burn down one's house to roast pork. It is a fairly safe prophecy that in 50 years light will cost about a fiftieth of its present price, and there will be no more night in our cities. The alternation of day and night is a check on the freedom of human activity which must go the way of other spatial and temporal checks. In the long run I think that all that applied physics can do for us is to abolish these checks. It enables us to possess more, travel more, and communicate more. I shall not attempt to predict in detail the future developments of transport and communication. They are only limited by the velocity of light. We are working towards a condition when any two persons on earth will be able to be completely present to one another in not more than 1/24 of a second. We shall never reach it, but that is the limit which we shall approach indefinitely. Developments in this direction are

profoundly than I have suggested. And though personally I am Victorian enough in my sympathies to hope that after all family life, for example, may be spared, I can only reiterate that not one of the practical advances which I have predicted is not already foreshadowed by recent scientific work. If a chemist or physicist living at the end of the seventeenth century had been asked to predict the future application of his science he would doubtless have made many laughable errors in the best Laputan style, but he would have been certain that it would somehow be applied, and his faith would have been justified. We must regard science then from three points of view. First it is the free activity of man's divine faculties of reason and imagination. Secondly it is the answer of the few to the demands of the many for wealth, comfort and victory, for gifts which it will grant only in exchange for peace, security and stagnation. Finally it is man's gradual conquest, first of space and time, then of matter as such, then of his own body and those of other living beings, and finally the subjugation of the dark and evil elements in his own soul. None of these conquests will ever be complete, but all, I believe will be progressive. The question of what he will do with these powers is essentially a question for religion and aesthetic. It may be

which may be briefly stated as follows: “*No human society will ever succeed in producing a stable organization in which the majority of the population is employed otherwise than in agriculture, animal-rearing, hunting of fishing.*” It took some thousands of years to produce the stable agricultural society which forms the basis of European life and whose morals we are too apt to regard as eternal truths. It should take a shorter time to evolve a stable industrial society. The people that do so will inherit the earth. In sum, I believe that the progress of science will ultimately make industrial civilization as self-destructive as it is now making international injustice. As for the supplies of mechanical power, it is axiomatic that the exhaustion of our coal and oil-fields is a matter of centuries only. As it has often been assumed that their exhaustion would lead to the collapse of industrial civilization, I may perhaps be pardoned if I give some of the reasons which lead me to doubt this proposition. Water-power is not, I think, a probable substitute, on account of its small quantity, seasonal fluctuation, and sporadic distribution. It may perhaps, however, shift the centre of industrial gravity to well-watered mountainous tracts such as the Himalayan foothills, British Columbia, and Armenia. Ultimately we shall have to tap those intermittent but inexhaustible

few of the possible fields of scientific advance. If I have convinced anyone present that science has still a good deal up her sleeve, and that of a sufficiently startling character, I shall be amply repaid. If anything I have said appears to be of a gratuitously disgusting nature, I would reply that certain phenomena of normal life do seem to many to be of that nature, and that these phenomena are of the utmost scientific and practical importance. I have tried to show why I believe that the biologist is the most romantic figure on earth at the present day. At first sight he seems to be just a poor little scrubby underpaid man, groping blindly amid the mazes of the ultra-microscopic, engaging in bitter and lifelong quarrels over the nephridia of flatworms, waking perhaps one morning to find that someone whose name he has never heard has demolished by a few crucial experiments the work which he had hoped would render him immortal. There is real tragedy in his life, but he knows that he has a responsibility which he dare not disclaim, and he is urged on, apart from all utilitarian considerations, by something or some-one which he feels to be higher than himself. The conservative has but little to fear from the man whose reason is the servant of his passions, but let him beware of him in whom reason has become the greatest and most terrible of the passions. These are the wreckers of outworn empires

explosion motors working dynamos which produce electrical energy once more, or more probably in oxidation cells. Liquid hydrogen is weight for weight the most efficient known method of storing energy, as it gives about three times as much heat per pound as petrol. On the other hand it is very light, and bulk for bulk has only one-third of the efficiency of petrol. This will not, however, detract from its use in aeroplanes, where weight is more important than bulk. These huge reservoirs of liquefied gases will enable wind energy to be stored, so that it can be expended for industry, transportation, heating, and lighting, as desired. The initial costs will be very considerable, but the running expenses less than those of our present system. Among its more obvious advantages will be the fact that energy will be as cheap in one part of the country as another, so that industry will be greatly decentralized; and that no smoke or ash will be produced. It is on some such lines as these, I think, that the problem will be solved. It is essentially a practical problem, and the exhaustion of our coalfields will furnish the necessary stimulus for its solution. Even now perhaps Italy might achieve economic independence by the expenditure of a few million pounds upon research on the lines indicated. I may add in parenthesis that, on thermodynamical grounds which I can hardly summarize

deal with the former he can often keep the patient alive long enough to be able to do so himself. And here he has to rely largely on a knowledge of physiology. I do not say that a physiologist will discover how to prevent cancer. Pasteur started life as a crystallographer. But whoever does so is likely at least to make use of physiological data on a large scale. The abolition of disease will make death a physiological event like sleep. A generation that has lived together will die together. I suspect that man's desire for a future life is largely due to two causes, a feeling that most lives are incomplete, and a desire to meet friends from whom we have parted prematurely. A gentle decline into the grave at the end of a completed life's work will largely do away with the first, and our contemporaries will rarely leave us sorrowing for long. Old age is perhaps harder on women than on men. They live longer, but their life is too often marred by the sudden change which generally over- takes them between forty and fifty, and sometimes leaves them a prey to disease, though it may improve their health. This change seems to be due to a sudden failure of a definite chemical substance produced by the ovary. When we can isolate and synthesize this body we shall be able to prolong a woman's youth, and allow her to age as gradually as the average man. Psychology is hardly a science yet. Like biology it

form. When they can express themselves we get a Butler or a Norman Douglas. Not until our poets are once more drawn from the educated classes (I speak as a scientist), will they appeal to the average man by showing him the beauty in his own life as Homer and Virgil appealed to the street urchins who scrawled their verses on the walls of Pompeii. And if we must educate our poets and artists in science, we must educate our masters, labour and capital, in art. Personally I believe that we may have good hopes of both. The capitalist's idea of art in industry at present tends to limit itself to painting green and white stripes on the front of his factories in certain cases. This is a primitive type of decoration, but it has, I think, the root of the matter in it. Before long someone may discover that frescoes inside a factory increase the average efficiency of the worker 1.03% and art will become a commercial proposition once more. Even now it is being discovered that artistic advertising often pays. Similarly I do not doubt that labour will come to find that it cannot live by bread (or shall we say bread and beer) alone. But it can hardly be expected to make this discovery until it is assured of its supply of bread and beer. Applied chemistry has introduced into human life no radical novelty of the importance of the heat-engine or the telegraph. It has vastly increased the production of various types of

laws. The problem of politics is to find institutions suitable to it. In the future perhaps it may be possible by selective breeding to change character as quickly as institutions. I can foresee the election placards of 300 years hence, if such quaint political methods survive, which is perhaps improbable, "Vote for Smith and more musicians ", "Vote for O'Leary and more girls ", or perhaps finally, "Vote for Macpherson and a prehensile tail for your great-grandchildren ". We can already alter animal species to an enormous extent, and it seems only a question of time before we shall be able to apply the same principles to our own. I suggest then that biology will probably be applied on lines roughly resembling the above. There are perhaps equally great possibilities in the way of the direct improvement of the individual, as we come to know more of the physiological obstacles to the development of different faculties. But at present we can only guess at the nature of these obstacles, and the line of attack suggested in the myth is the one which seems most obvious to a Darwinian. We already know however that many of our spiritual faculties can only be manifested if certain glands, notably the thyroid and sex-glands, are functioning properly, and that very minute changes in such glands affect the character greatly. As our knowledge of this subject increases we may be able, for

on a quite special relationship to the human organism which depends in the most intimate way on the constitution of the latter, and has not in general been at all fully explained in terms of physics and chemistry. For example fires can be made of coal or peat instead of wood, but no other chemical substance has the same effect as water or alcohol. So unless a chemical substance has new physiological properties its production will merely serve to improve or make possible some appliance whose use lies within the sphere of applied physics. Within historical time two and only two substances of the second class have come into universal use in Europe, namely caffeine and nicotine, which were introduced into this country in the sixteenth and seventeenth centuries. There are others of immense importance, such as chloroform and quinine, but their use is not universal. But coffee, tea, and tobacco, with alcohol, are as much a part of normal life as food and water. There is no reason to suppose that the list of such substances is exhausted. During the war Embden **1** the professor of physiology in Frankfurt University discovered that a dose of about 7 grams of acid sodium phosphate increases a man's capacity for prolonged muscular work by about 20%, and probably aids in prolonged mental work. It can be taken over very lengthy periods. A group of coal-miners took it

of the Khalif, both of which appeared in 1960. As we know ectogenesis is now universal, and in this country less than 30 per cent of children are now born of woman. The effect on human psychology and social life of the separation of sexual love and reproduction which was begun in the 19th century and completed in the 20th is by no means wholly satisfactory. The old family life had certainly a good deal to commend it, and although nowadays we bring on lactation in women by injection of placentin as a routine, and thus conserve much of what was best in the former instinctive cycle, we must admit that in certain respects our great grandparents had the advantage of us. On the other hand it is generally admitted that the effects of selection have more than counterbalanced these evils. The small proportion of men and women who are selected as ancestors for the next generation are so undoubtedly superior to the average that the advance in each generation in any single respect, from the increased out-put of first-class music to the decreased convictions for theft, is very startling. Had it not been for ectogenesis there can be little doubt that civilization would have collapsed within a measurable time owing to the greater fertility of the less desirable members of the population in almost all countries. It is perhaps fortunate that the process of

mean we may expect that mankind will ultimately have at its disposal a vast array of substances like wine, coffee, and tobacco, whose intelligent use can add to the amenity of life and promote the expression of man's higher faculties. But before that day comes chemistry will be applied to the production of still more important group of physiologically active substances, namely foods. The facts about food are rather curious. Everyone knows that food is ultimately produced by plants, though we may get it at second or third hand if we eat animals or their products. But the average plant turns most of its sugar not into starch which is digestible, but into cellulose which is not, but forms its woody skeleton. The hoofed animals have dealt with this problem in their own way, by turning their bellies into vast hives of bacteria that attack cellulose, and on whose by-products they live. We have got to do the same, but outside our bodies. It may be done on chemical lines. Irvine has obtained a 95% yield of sugar from cellulose, but at a prohibitive cost. Or we may use micro-organisms, but in any case within the next century sugar and starch will be about as cheap as saw-dust. Many of our foodstuffs, including the proteins, we shall probably build up from simpler sources such as coal and atmospheric nitrogen. I should be inclined to allow 120 years, but not much more, before a completely

escaped into the sea and multiplied with enormous rapidity. Indeed for two months the surface of the tropical Atlantic set to a jelly, with disastrous results to the weather of Europe. When certain of the plankton organisms developed ferments capable of digesting it the increase of the fish population of the seas was so great as to make fish the universal good that it is now, and to render even England self-supporting in respect of food. So great was the prosperity in England that in that year the coal-miner's union entered its first horse for the Derby (a horse-race which still took place annually at that time). It was of course as the result of its invasion by *Porphyrococcus* that the sea assumed the intense purple colour which seems so natural to us, but which so distressed the more aesthetically minded of our great grandparents who witnessed the change. It is certainly I curious to us to read of the sea as having been green or blue. I need not detail the work of Ferguson and Rahmatullah who in 1957 produced the lichen which has bound the drifting sand of the world's deserts (for it was merely a continuation of that of Selkovski), nor yet the story of how the agricultural countries dealt with their unemployment by huge socialistic windpower schemes. It was in 1951 that Dupont and Schwarz produced the first ectogenetic child. As early as 1901 Heape had transferred

I should have liked had time allowed to have added my quota to the speculations which have been made with regard to interplanetary communication. Whether this is possible I can form no conjecture; that it will be attempted I have no doubt whatever. With regard to the application of biology to human life, the average prophet appears to content himself with considerable if rather rudimentary progress in medicine and surgery, some improvements in domestic plants and animals, and possibly the introduction of a little eugenics. The eugenic official, a compound, It would appear, of the policeman, the priest and the procurer, is to hale us off at suitable intervals to the local temple of Venus Genetrix with a partner chosen, one gathers, by something of the nature of a glorified medical board. To this prophecy I should reply that it proceeds from a type of mind as lacking in originality as in knowledge of human nature. Marriage "by numbers ", so to speak, was a comparatively novel idea when proposed by Plato 2,300 years ago, but it has already actually been practised in various places, notably among the subjects of the Jesuits in Paraguay. It is moreover likely, as we shall see, that the ends proposed by the eugenicist will be attained in a very different manner. But before we proceed to prophecy I should like to turn back to the past and examine very briefly the half

countries managed to carry a good deal of legislation. They appear to have managed to prevent the transmission of a good deal of syphilis, insanity, and the like, and they certainly succeeded in producing the most violent opposition and hatred amongst the classes whom they somewhat gratuitously regarded as undesirable parents. (There was even a rebellion in Nebraska). However, they undoubtedly prepared public opinion for what was to come, and so far served a useful purpose. Far more important was the progress in medicine which practically abolished infectious diseases in those countries which were prepared to tolerate the requisite amount of state interference in private life, and finally, after the league's ordinance of 1958, all over the world; though owing to Hindu opposition, parts of India were still quite unhealthy up to 1980 or so. But from a wider point of view the most important biological work in the first third of the century was in experimental zoology and botany. When we consider that in 1912 Morgan had located several Mendelian factors in the nucleus of *Drosophila*, and modified its sex-ratio, while Marmorek had taught a harmless bacillus to kill guinea-pigs, and finally in 1913 Brachet had grown rabbit embryos in serum for some days, it is remarkable how little the scientific workers of that time, and a fortiori the general public, seem to have

Charles Bradlaugh and Annie Besant in the place of Triptolemus and Noah, but one may remark that it is impossible to keep religion out of any discussion of the practices which they popularized. The second point is perhaps harder to express. The chemical or physical inventor is always a Prometheus. There is no great invention, from fire to flying, which has not been hailed as an insult to some god. But if every physical and chemical invention is a blasphemy, every biological invention is a perversion. There is hardly one which, on first being brought to the notice of an observer from any nation which had not previously heard of their existence, would not appear to him as indecent and unnatural. Consider so simple and time-honoured a process as the milking of a cow. The milk which should have been an intimate and almost sacramental bond between mother and child is elicited by the deft fingers of a milk-maid, and drunk, cooked, or even allowed to rot into cheese. We have only to imagine ourselves as drinking any of its other secretions, in order to realise the radical indecency of our relation to the cow. **2** No less disgusting a priori is the process of corruption which yields our wine and beer. But in actual fact the processes of milking and of the making and drinking beer appear to us profoundly natural; they have even tended to develop a

that the progress of medicine has had almost, if not quite, as deep an effect on society in Western Europe as the industrial revolution. Apart from the important social consequences which have flowed from the partial substitution of the doctor for the priest, its net result has been that whereas four hundred years ago most people died in childhood, they now live on an average, (apart from the late war), until forty-five. Bad as our urban conditions often are, there is not a slum in the country which has a third of the infantile death-rate of the royal family in the middle ages. Largely as a result of this religion has come to lay less and less stress on a good death, and more and more on a good life, and its whole outlook has gradually changed in consequence. Death has receded so far into the back-ground of our normal thoughts that when we came into somewhat close contact with it during the war most of us failed completely to take it seriously. Similarly institutions which were based on short lives have almost wholly collapsed. For example the English land system postulated that the land-owner should die aged about forty, and be succeeded by his eldest son, aged about twenty. The son had spent most of his life on the estate, and had few interests outside it. He managed it at least as well as anyone else could have done. Nowadays the father dodders on till about eighty, and is

there. Save for his valuable invention of glue, little else is known of Daedalus. But it is most significant that, although he was responsible for the death of Zeus' son Minos he was neither smitten by a thunderbolt, chained to a rock, nor pursued by furies. Still less did any of the rather numerous visitors to Hades discover him either in Elysium or Tartarus. We can hardly imagine him as a member of the throng of shades who besieged Charon's ferry like sheep at a gap. He was the first to demonstrate that the scientific worker is not concerned with gods. The unconscious mind of the early Greeks, who focussed in this amazing figure the dim traditions of Minoan science, was presumably aware of this fact. The most monstrous and un-natural action in all human legend was unpunished in this world or the next. Even the death of Icarus must have weighed lightly with a man who had already been banished from Athens for the murder of his nephew. But if he escaped the vengeance of the gods he has been exposed to the universal and age-long reprobation of a humanity to whom biological inventions are abhorrent, with one very significant exception. Socrates was proud to claim him as an ancestor. The biological invention then tends to begin as a perversion and end as a ritual supported by unquestioned beliefs and prejudices. Even now surgical cleanliness is developing its rites and its

dogmas, which, it may be remarked, are accepted most religiously by women. With the above facts in your minds I would ask you to excuse what at first sight might appear improbable or indecent in any speculations which appear below, and to dismiss from your minds the belief that biology will consist merely in physical and chemical discoveries as applied to men, animals and plants. I say advisedly" will consist ", for we are at present almost completely ignorant of biology, a fact which often escapes the notice of biologists, and renders them too presumptuous in their estimates of the present position of their science, too modest in their claims for its future. If for example we take a typical case of applied biology such as the detection and destruction. of the cholera bacillus, we find a great deal of science involved, but the only purely biological principle is the very important but not very profound one that some bacteria kill some men. The really scientific parts of the process are the optical and chemical methods involved in the magnification, staining and killing of the bacilli. When on the other hand we come to immunization to typhoid we find certain purely biological principles involved which are neither simple nor at all completely understood. Actually biological theory consists of some ancient but not very easily stated truths about organisms in general,