

Several books on science that are aimed at a popular, or nonspecialist, audience have appeared on best-seller lists in recent years. These titles include Stephen Hawking's *A Brief History of Time*, Roger Penrose's *The Emperor's New Mind*, and Carl Sagan's *Cosmos*. How does the language in these books, and in articles that appear in popular, general circulation magazines and newspapers such as *Scientific American*, *Natural History*, *The Washington Post*, or *The New York Times*, differ from that in articles that appear in journals, such as *The Journal of Geophysical Research*, aimed at the scientist's own peers? As a prelude to the discussion of that topic, a distinction must be made between the formal language and the popular language of scientific discourse.

The formal language of scientific discourse, which may be defined as the language scientists use in presenting ideas to others in the same discipline, attempts to present scientific concepts in a way that is emotionally neutral and devoid of conflicting connotations. The formal language shuns the polysemous word play of everyday usage and aspires to mathematical symbolization. The problem of finding an appropriate language for scientific discourse was recognized during the English Renaissance.

Brian Vickery has pointed out that Bacon, in his essay "On the Idols of the Marketplace" recognized that language could be misleading. There is an inherent danger of confusion when *res* and *verba*, subject matter and linguistic representation, are confused. Vickery cites examples such as "Fortune," "Element of Fire," and "Prime Mover." These are things that have no real existence and are only anthropomorphizations of concepts such as chance, or fire, or causality. Another source of confusion is the use of abstract terms such as "humid." Abstract terms, such as "humid," and "natural selection," are forms of generalization that do not correspond to particular experiences; they are a reduction of multiple observations to a general term. As such "they cannot be reduced to any common meaning." This observation is the forerunner of John Wilkins' protest against the polysemous propensities of language.[\[1\]](#)

Bacon advocates, in the *Paraseceve ad Historiam Naturalem et Experimentalem* (*Preparative towards a Natural and Experimental History*), which was appended to his *Novum Organum*, a reform of the language of science:

And for all that concerns ornaments of speech, similitudes, treasury of eloquence, and such like emptinesses, let it be utterly dismissed. Also let all those things which are admitted be themselves set down briefly and concisely, so that they may be nothing less than words.^[2]

Bacon promptly introduces two similes in the following sentence. Bacon, however, is not writing a scientific paper but an argument about the style of scientific papers. The style that Bacon is advocating is one that rests heavily on denotation and the absence of metaphor. The presence of connotative meanings and the presence of metaphor in scientific discourse would tend to give it that polysemous quality that works against precision of expression. Limiting the possibilities of meaning should limit the possibilities of error and misunderstanding. The ideal would be to have one word or symbol that relates to one thing, rather than having one word that is fraught with multiple meanings. John Wilkins, in his *An Essay Toward a Real Character and a Philosophical Language*, tried to carry out a reform of scientific language by advocating that there should be "a *Real universal Character*, that should not signifie *words* but *things* and *notions*, and consequently might be legible by any Nation in their own Tongue; which is the principal design of this Treatise."^[3]

Wilkins objects to both Latin and English on the grounds of the polysemous qualities of their words. He calls words with multiple meanings "Equivocals," because they "are of several significations and therefore must needs render speech doubtful and obscure." He cites, among other examples, the Latin "*Malus*," which "signifies both an *Apple-tree*, and *Evil*, and *the Mast of a ship*," and the English "*Bill*," which means "a *Weapon*, a Bird's *Beak*, and a written *Scroul*."⁴ What Wilkins proposes as a substitute is a form of writing that will be more directly representational of the notions that it is supposed to express. This language does not escape the curse of polysemy. As Vickers points out, Wilkins uses one symbol to

stand for "How," "More," and "Less," and another symbol to stand for "So," "Most," and "Least." Presumably the meaning of these symbols would be derived from the context, but if a symbol can stand for "More" and "Less" at the same time, the meaning of the text in which it is embedded can only remain obscure at best.

Wilkins is advocating the use of symbols in logical argument. This kind of symbolization is used in mathematical logic. In this kind of symbolization the symbol \sim stands for "not," or "it is not so that...," while the symbol \exists is "the *existential quantifier*" and the symbol \forall is "the *universal quantifier*." This enables a proposition such as Fermat's last theorem to be stated in the form: $w, x, y,$ and $z,$ there is no equation of the form x incremented by one and raised to a power equal to or greater than three plus another number $y,$ which is also incremented by one and raised to the same power as $w,$ that is equal to a third number z that fulfills the same conditions as the first two." The statement can, by substitution, be generalized into the expression [\[5\]](#) One difference between the first two statements is not that one is more precise than the other, but that one is less wordy than the other. The symbols in which the first form is expressed are singular in their meaning, whereas the words of the ordinary language statement can have multiple meanings. Further, the symbolic expression fulfills Wilkins' desideratum that the real characters be understandable across national boundaries. The model of formal scientific prose advocated by Bacon, Wilkins, and other writers of the English Renaissance is denotative, nonemotional, nonmetaphorical, and nonconnotative. As a prelude to our discussion of the language of popular scientific discourse, it would be well to look at an example of the language used in a formal paper that will be published in a scientific journal.

What is formal scientific prose like? What qualities does it possess? An analysis of the following piece, taken from the introduction to a paper to be published in *The Journal of Geophysical Research* can serve as a model of scientific prose.

The analysis of Satellite Laser Ranging (g) data requires precise dynamic modeling of a rapidly moving near-Earth

orbiting target. Through the application of the theory of motion for an orbiting object, SLR sites can be located in a common reference frame through the accurate determination of the satellite ephemerides. The principal model needed for the computation of a satellite's trajectory is that of the gravitational field which accurately reflects the inhomogeneous distribution of the Earth's mass, and the temporal changes in the field due to tidal and climatological sources. Depending on the orbit of interest and the area-to-mass ratio of the satellite, non-gravitational forces arising from the effects of atmospheric drag and solar radiation are also important. Ground tracking systems provide an accurate means of sensing the perturbed motion of satellites. Historically, global tracking networks have had limited geographic distribution with central Asia, Africa and the polar regions being systematically under represented [sic]. However, by modeling these measurements [sic] although they are geographically restricted, the broad features of the gravity field are determined. When combined with satellite altimetry and surface gravimetry, the gravity field is sensed over an extensive spatial bandwidth. Using all these measurements has yielded comprehensive models of the Earth's gravity field in the form of spherical harmonic coefficients. These solutions describe the complex shape of the geoid as well as the resulting variation in the gravitational potential at altitude which perturbs the orbits of near-Earth artificial satellites.[\[6\]](#)

There are several things that are noticeable here. One is the presence of a large number of words of Latin and Greek origin (e.g., satellite, dynamic, ephemerides). Another is the presence of a word such as "inhomogeneous," apparently used to make a distinction between the "homogeneous," the "heterogenous" and that which is merely "inhomogeneous." The most obvious characteristic of this piece of prose is the high percentage of verb phrases that use the auxiliary copula. A computer analysis, using a grammar checker, would mark all of these sentences as being in the passive voice. This is not the case, since some lack the indirect object that also characterizes the passive. In some cases, e.g., sentence 1, the indirect object does exist and is thematized by being put first in the sentence. However, by modeling these

measurements although they are geographically restricted, the broad features of the gravity field are determined. The sentence could be rewritten as sentence 2. However, the broad features of the gravity field are determined by modeling these measurements, although they are geographically restricted. It could even be put into the active voice by writing sentence 3. The model of these geographically restricted measurements determines the broad features of the gravity field. The difference among these sentences illustrates the difference between the formal and the popular scientific discourses that are explored in depth below. In sentence 1 the process of modeling is thematized in the position ordinarily occupied by the subject ("features") and the meaning conveyed is that the process is continuing and ongoing. Further, the process determines the results of the study, but the process is not an entity that has a personalized existence. The gerund "modeling" should, as the indirect object, be put into the role of patient, the one who suffers the action to be performed, but it seems to be an instrument, i.e., it is the means by which something is done (determined). In sentence 2 the subject occupies its normal place and is thematized as could be expected in standard practice. In this sentence the role of "modeling" is more clearly that of the instrument by which "the broad features" are "determined." Both versions of this sentence are in the passive voice and both maintain a dispassionate distance from conveying any imagistic impressions.

The 3rd sentence, which approaches the deep structure of the sentence, is in the active voice. Here "modeling" has dropped its gerundive form and become a noun. It is no longer an indirect object, but is the subject and it appears to have the role of agent. This means that the model determines the features of the gravity field. The modeling is no longer a process but a thing which does. It has become personalized and anthropomorphized. Now it is subject to the objection that the arbitrary nature of the model determines the features of the gravity field. Further, the word "model" may have different connotations that carry different images depending on the reader. A further objection is that the model is a mathematical construct, an image of reality, so how can it

"determine" the reality of an actually existing object. The shift from the active voice of the deep structure into the passive and convoluted phrasing of sentence 1 avoids these issues. It does not suggest ship in a bottle, or a girl in a swimsuit, or some other ludicrous "model" determining the features of a gravity field.

This style of writing avoids the problem of attributing agency to something that is impersonal, or which exists as a mental construct, but it is awkward and boring. The exact nature of the thing being discussed is lost in the attempt to disambiguate the sentence. The problem of presenting scientific information is how to present it clearly and in an understandable manner. It is this level that popular books and articles on science aim at.

Examples of prose from books and articles on scientific issues that were, in their day, aimed at general audiences, show the problem of writing about science for the lay reader. These examples, culled from Lamarck, Darwin, and a recent article in *The New York Times*, show how confusion can arise from the very nature of language itself.

Gillian Beer, in her book *Darwin's Plots*, has said that language "puts man at the center of signification."^[7] It does this by positing, especially in the active voice, the subject as agent. Agents perform actions, and as such the acting subject is personalized and represented as a real being. The tendency then is to visualize any subject that acts as an extension of ourselves. The presence of an abstract entity, such as "Nature," in the subject position and in the agent role means that "Nature" is personalized and allegorized so that what is in actuality a series of mathematical, chemical, or biological constructs and theorems is posited as doing rather than being. The problem becomes most acute when trying to convey ideas, such as evolution, in biology.

In the case of Lamarck, for instance, it has been supposed on the basis of a paragraph in his *Recherches sur l'organisation des corps vivans* that he imagines birds as wishing to grow legs. Lamarck had said:

One may perceive that the bird of the shore, which does not at all like to swim, and which however, needs to draw near to the water to find its prey, will be continually exposed to

sinking in the mud. Wishing [*voulant*] to avoid immersing its body in the liquid, [it] acquires the habit of stretching and elongating its legs. The result of this for the generations of these birds that continue to live in this manner is that the individuals will find themselves elevated as on stilts, on long naked legs.[8]

The act of wishing commonly involves the formation of a thought and its expression in verbal form. This is true of conscious wishing. Loren Eiseley, however, has pointed out, correctly I believe, that what Lamarck and his contemporary Erasmus Darwin, Charles's grandfather, actually believed in was "unconscious striving." [9] The error in perception, traceable from Cuvier's *Eloge* on Lamarck, that he, Lamarck, actually believed in the influence of will on the organism, comes as much from Lamarck's careless linguistic habits as it does from any actual statement made by him. [10] A more notable biologist, one that has been more influential than Lamarck, is Charles Darwin. His *Origin of Species* may not appear to be a popular book, but it did sell out on the day of its first publication, and the audience that Darwin addressed was not that of his peers in science, but the educated layperson. Beer has said that "it is clear that in *The Origin* Darwin was writing not only to the confraternity of scientists but with the assumption that his work would be readable by any educated reader." [11] Given these circumstances it would appear to qualify for citation as an example of popular scientific discourse. Gillian Beer has described Darwin's language as multivocal and as "expressive rather than rigorous." His style "is not an austere Cartesian style" and "there are few lean sentences in *The Origin of the Species*." [12] *An illustration of how Darwin constructed his sentences can be seen in the following:*

In the case of the mistletoe, which draws its nourishment from certain trees, which has seed that must be transported by certain birds, and which has flowers with separate sexes absolutely requiring the agency of certain insects to bring pollen from one flower to the other, it is equally preposterous to account for the structure of this parasite, with its relations to several distinct organic beings by the effects of external conditions, or of habit, or of the volition of the plant itself.

[13]

The first thing noticeable about this sentence is its length. It is more than eighty words long. It starts off with a series of prepositional phrases that are immediately qualified by two subordinate clauses. The main clause does not come until "it is equally preposterous...." The sentence ends with a series of nine prepositional phrases. (These are (1) for the structure, (2) of this parasite, (3) with its relations, (4) to several distinct organic beings, (5) by the effects, (6) of external conditions, (7) of habit, (8) of the volition, (9) of the plant.) The grammatical subject of the sentence is the "it" in the main clause, but this "it" is not thematized; it is far down in the order of the sentence. The thematized portion is "In the case of the mistletoe." The thematization makes the mistletoe appear to be more active than it is. It is here that the play of imagery, which inheres in linguistic structure operates. The verb phrase "draws its nourishment" has connotations, because of similar phrasing, that suggest the mistletoe is in some sense active in obtaining its nourishment, and the image might suggest, despite Darwin's explicit statement, volition.

How is this misreading possible? The verb phrase is similar to "drawing water," as from a well. The connotation then is that somehow the mistletoe actively seeks out and obtains water from the host. Since I am conscious of my own desire for nourishment, I then attribute a similar consciousness to the parasite. This does not necessarily mean that this is what Darwin intended, or even what he said, nor is it even to assert that anyone has ever read this passage in this way. It is merely to assert that if language is as anthropocentric as Beer states, that it is difficult to find a way to remove even the most outlandish connotations and images from our reading, and hence from our response to a given work. Unconsciously, an attribution of volition to mistletoe can be formed.

It is also possible that Darwin could fall into the trap of personalizing either species, or abstract entities such as "Nature," or "natural selection." Does this in fact ever happen? Darwin acknowledges that he uses the term "struggle for existence" in "a large and metaphorical sense" (33). Darwin addresses the question of personifying natural selection in

Chapter 4 of the *Origin*:

Several writers has misapprehended or objected to the term Natural Selection. Some have even imagined that natural selection induces variability.... No one objects to agriculturists speaking of the potent effects of man's selection; and in this case the individual differences given by nature, which man for some object selects, must of necessity first occur. Others have objected that the term selection implies conscious choice in the animals which become modified.... In the literal sense of the word, no doubt, natural selection is a false term; but who ever objected to chemists speaking of the elective affinities of the various elements...? It has been said that I speak of natural selection as an active power of Deity; but who objects to an author speaking of the attraction of gravity as ruling the movements of the planets. Every one knows what is meant and is implied by such metaphorical expression; and they are almost necessary for brevity. So again it is difficult to avoid personifying the word Nature, only the aggregate action and product of many natural laws, and by laws the sequence of events as ascertained by us. (40)

Darwin recognizes the metaphorical nature of his terminology, but he claims that since everyone knows it is only a metaphor it is quite proper to use it. Darwin is not always careful to make clear that he is using a metaphor, nor is it only when he is speaking of nature or natural selection that he personifies natural phenomenon. Several sentences exemplify this: Many cultivated plants display the utmost vigour, and yet rarely or never seed! (10)

Many laws regulate variation, some few of which can be dimly seen, and will hereafter be briefly discussed. (11)

Nevertheless, as our varieties certainly do occasionally revert in some of their characters to ancestral forms, it seems to me not improbable that if we could succeed in naturalising, or were to cultivate, during many generations, the several races, for instance, of the cabbage, in very poor soil (in which case, however, some effect would have to attributed to the *definite* action of the poor soil), that they would, to a large extent, or even wholly, revert to the wild aboriginal stock. (12)

Here we see that cattle absolutely determine the existence of the Scotch fir; but in several parts of the world insects

determine the existence of cattle. (36)

Though Nature grants long period so time for the work of natural selection, she does not grant an indefinite period....

(49) If we examine these sentences, we see that in sentence 4 "plants" is both subject and agent. The plants perform the action of display. In sentence 5 "laws" are spoken of as regulating variation. The scientist, by natural law, means something that is inherent in the structure of the universe, and which, because of its structure is inviolable. This can frequently be expressed in mathematical symbols. The common understanding of law, however, is that it is a type of performative utterance, i.e., a command to build a dam, establish a new government department, or perform some other action. It is this second, and most common understanding, of the term law that Darwin seems to be using. A natural philosopher who thought of natural law in this way was Gravesande:

A Law of Nature then is *the rule and Law, according to which God resolved that certain motions should always, that is, in all Cases, be performed.* Every Law does immediately depend upon the will of God.[\[14\]](#)

In sentence 5 we again observe the term "law" has the role of agent. Sentence 6 is longer than the other examples, exemplifying the absence of "lean" sentences in Darwin's prose. It is also an extremely tentative sentence. It opens with "Nevertheless," suggesting an adversative continuation of the preceding sentence. The "varieties... occasionally revert." "Occasionally" is indefinite, suggesting that it may be only a few times, perhaps once in a million, perhaps once in a hundred times. "Some" is also indefinite and precedes the plaintive "if we could succeed in naturalizing, or were to cultivate." The phrase "it seems to me" is another tentative statement. Darwin is not saying that this is a certain fact, but one that is possible, that can be subsumed under the category of seeming or appearing rather than being. Darwin has loaded the sentence with so many qualifications and limitations that he implies the extreme improbability of the cabbage ever reverting to its natural stock. In sentence 7 "cattle absolutely determine" whether or not Scotch fir exist in a given area. This is followed by his statement that in some

cases "insects determine the existence of cattle." Darwin does not mean that the existence of insects determine whether the life of cattle is comfortable, but that the existence of the insects makes it possible for the cattle to exist in a given environment. What the sentence *appears* to mean is that insects have the ability to make the judgment whether or not cattle should exist in a given place.

Sentence 8, which is not given in full, immediately personifies "Nature." It also engenders it as a female, a tradition of ancient lineage. This follows closely upon Darwin's comment on his use of personification and metaphor in his prose. In none of these quotations does Darwin observe the Baconian strictures on the avoidance of metaphor. His sentences are lengthy, metaphorical, and laden with personification of the various entities--"Nature," "Natural Selection," and "law"--that he deals with.

The fact that Darwin's sentences can be read in this way does not mean that the readings given are the correct readings, or that they are what Darwin intended. The assertion that is made is that these are possible readings and that their existence within the Darwinian text is the result of the inherent tendency to anthropomorphize and personify abstract entities. The metaphoricalness and figurativeness of popular scientific discourse is an attempt to render complex processes comprehensible to the lay audience. This can be further illustrated by an examination of a recent (February 11, 1992) article from *The New York Times* science section. The article, by Natalie Angier, is entitled "When Proteins Come to Life, 'Chaperones' Show the Way."

The anthropomorphic tendency begins with the first paragraph: When a new protein slides off the tiny molecular assembly line within the cell, it is nothing more than a droopy string of amino acids, not yet fit for its designated profession.^[15] The first clause of this sentence uses the image of an assembly line within the cell. This may suggest something like the assembly line in Chaplin's *Modern Times*, or some other image, but it is a far cry from the actual process that goes on within the cell. The protein at this part may be regarded as a manufactured object, such as a car or a lamp, but it is immediately personalized and transformed from an

object when Angier describes it as "not yet fit for its designated profession." Here the protein becomes something with a purpose, "its designated profession," as a person might be described as "a lawyer" or "a teacher." Angier continues in this vein in the next paragraph: Only upon being coiled and pleated and braided into its proper three-dimensional conformation will a protein burst to life, seizing up oxygen if it is hemoglobin, shearing apart sugars if it is an enzyme or lashing cells together if it is a stout twine of collagen. (C1) The polysyndeton of the first part of the sentence ("coiled and pleated and braided") slows the progress of the sentence and suggests within itself a patient, plodding process that prepares the protein for its role. The agent of the coiling, pleating, and braiding, is not mentioned here. Again, however, the molecular action is described in human terms, as if the molecule were paying a visit to a hair stylist. Activity is ascribed to the protein. It "bursts to life," suggesting a state of previous quiescence. It "seizes oxygen," "shears sugars," or "lashes cells." These suggest human activities such as carrying, dressmaking (or hair cutting), raft building, and so on. The images suggest a person within the cell who is carrying on these activities. Molecular and cellular chemistry, however, is not something that is carried out on assembly lines or aimed at giving proteins professions. It is largely, on the atomic level, an exchange of electrons, a joining based on valences and other processes.[\[16\]](#)

The article continues by describing the processing of shaping proteins into the proper three-dimensional structure. The belief that was current among researchers until recently, according to Angier's article, was that polypeptides were properly shaped when they were manufactured. The current belief, however, is that another group of proteins exist whose purpose is to guide the proteins in attaining their shape. Angier has this to say about the new proteins: The detection of the handmaiden proteins, called chaperones, means that the traditional theory of spontaneous folding is mistaken, and that the forces inherent in a polypeptide's sequence of amino acids are not enough to sculpture and knead a protein into its correct, muscular form. (C1) The imagery again is anthropomorphic. "Handmaiden" suggests a master/servant (or

mistress/servant) relationship. The term "handmaiden" also assigns gender to the proteins. "Chaperones" suggests courtship rituals and the presence of a watchful *duenna*. The words "sculpture and knead" suggest chiseling marble, shaping clay, making bread, or energetic massage. The "muscular form" suggests a protein that looks like a bodybuilder. These are outlandish images, granted, but they exist within the connotative and allusive aspects of the words themselves, rather than in the delimited meaning of the sentences.

Angier, at another point, describes the cell as having a "birthing chamber." Before the protein can begin functioning it must immediately begin to fold into its three-dimensional shape. To that end, a series of chaperone midwives rush over and gently embrace the flat polypeptide at hundreds of key spots, shielding it against the hostile environment of the cell. (C1) The image of "chaperone midwives" seems contradictory. Usually a midwife is present if the chaperone has failed in her job. The chaperones, however, "embrace" the polypeptide, and here "embrace" has connotations not only of holding, but also of sexuality, to shield it from the cellular environment. The personalization of the protein continues and expands to include it within a series of social relationships: Chaperones do not dictate how a protein folds, they say [research scientists], but only help the protein realize its ambitions and steer it away from binding with bad company. (C8) The protein now has ambitions, something that suggests a mind within the protein, one that is capable of aspiration. Further, it is to be kept away from "bad company," a phrase that is redolent of teenage melodramas of the 1950's. The "bad company" personifies other molecules and casts them into the role of molecular Fagins. Angier's recognizes the problem of calling these proteins "chaperones" and explains that originally they were described as heat-shock proteins because they were first recognized in living cells that had been subjected to high temperatures. As it became evident that the proteins were not always related to heat-specific trauma, but were more general, their name was changed. Angier says: The proteins were rechristened chaperones to reflect their more general duties, although they are also called stress proteins or by any number

of unequivocal names. (C8) Angier implicitly recognizes that the name "chaperone" is evocative, that it conjures up pictures out of *Don Giovanni*, or Tirso de Molina. This evocative aspect is passed over without further comment. Further personalization occurs when the "chaperones" are called "indispensable nursemaids." One researcher, Dr. Mary-Jane Gething of the University of Texas, compares the process to a fairy tale: "It's like Snow White with her seven dwarves.... One dwarf has the hammer, another the chisel, and so forth." (C8) There is a recognition here that the process is only *like* the other process. This resemblance is placed on the level of analogy and is less immediate than the metaphorical insistence on identity. It was Samuel Butler's argument that knowledge inhered in cellular forms of life. In *Erewhon*, he, or rather one of his presumed representatives, asserted that a potato makes its needs for growth and nutrition known by certain actions:

The potato says these things by doing them, which is the best of languages. What is consciousness if this is not consciousness?[\[17\]](#)

Butler's argument is not usually accepted, but there is, in the first sentence of Angier's concluding paragraph, a kind of homage to Butler's argument: Scientists have yet to figure out how a chaperone knows where it is needed on a polypeptide and when to let go. (C8) To say that protein "knows" implies cognition and consciousness not just at the cellular level, but at the molecular, or even atomic level, and to implicitly posit consciousness as existing in entities at this level. It is possible that the universe itself has a kind of consciousness; that is a matter for philosophical and epistemological speculation. The suggestion that proteins "know" certain things is part of the anthropomorphization of the molecules; it also suggests the epistemological possibility that consciousness is wider or has different forms than might usually be thought. Angier concludes the article with an echo of a fairy tale: In that way, they may yet understand how the cell manages the alchemical trick hundreds if not thousands of times each hour, of spinning dull chemical straw into a splash of protein gold. (C8) The image is personalized but ambiguously gendered. Is Angier referring to the dwarf Rumpelstiltskin, or to the

princess, as the spinner? The image, however, remains personalized, and the molecular processes have been encapsulated in a human image that most people recall from early childhood reading. What emerges from these samples is that what I have called popular scientific discourse is highly metaphorical. Darwin recognizes the metaphor and the personification of referring to "Nature" and "Natural Selection" as real, existing entities, rather than as abstractions formed in the mind and then transformed into the printed words on the page. Angier admits that "chaperone" is an evocative term, without ever specifying what the term is supposed to evoke. Angier's article uses metaphors derived from human activities. These activities can be categorized as shown in Table 1.

Types of Human Activity Suggested in NY

Times Article	Human Activity	Phrase
	Sentence	
	manufacturing	"assembly line"
9	education	"designated
	profession" 9	
	hair dressing, or dress making	"coiled and pleated
	and braided" 10	
	carrying	"seizing up oxygen"
10	cutting	"shearing apart
	sugars" 10	
	joining objects	"lashing cells
	together" 10	
	artistic manufacture	"sculpture and knead"
11	sexuality	"midwives," "gently
	embrace the 12	
	social control	flat polypeptide"
13	social interaction	"do not dictate"
	ambitions," "binding 13	
	cognition, perception, and	"realize its
	knows" 16	
	consciousness	with bad company"
	manufacturing	"how a chaperone
		"spinning dull

Angier, of course, is not alone in this attribution of human activity to the nonhuman. Lamarck did it when he described the birds as "wishing" to avoid getting wet. Darwin did it, to a lesser and more arguable extent, when he described the mistletoe as "drawing" nourishment from trees, when he said "plants display the utmost vigor," when he referred to the "laws" that "regulate" variation, when he spoke of varieties reverting to their original stock, when he said "that cattle determine the existence of the Scotch fir," and when he personified Nature.

Gillian Beer has said that "Language is anthropomorphic by its nature and anthropocentric in its assumptions."[\[18\]](#) If this statement is true, then we should expect to find a high degree of personalization not only in Darwin, but also in other writers. The anthropomorphic element appears to be missing in what we have cited as an example of formal scientific discourse, but it is present in Lamarck, ("wishing"), Darwin, and Angier. The anthropocentric tendency of language, as Beer says, "puts man at the center of signification." Concretely, this means that it is difficult, if not impossible, to read a piece of prose that describes molecules as being lashed together without visualizing some scene in which a man ties a group of logs together to form a raft, or some other scene that comes out of our own real or imaginative experience. If we try to imagine a molecule, we imagine not a molecule as it really is but some ball and stick figure that was constructed during our high school chemistry class, or pictured in the latest issue of *The Scientific American*. Our response is always personal and idiosyncratic. It might not be going too far to claim that not only is language inherently anthropocentric, it is inherently personal and that we always substitute ourselves for the subject.

Beer also makes the point that "language always includes agency, and agency and intention are frequently impossible to distinguish in language."[\[19\]](#) In which, if any, of our texts are agency and intent combined? A tabulation of these elements can be made for the sentences we have discussed. Table 2 shows the phrases in each sentence that suggest agency and

whether or not those sentences also contain intentionality. In certain cases, such as sentence 1, the role may be ambiguous. In other cases, such as sentence 2, the element of intentionality appears unclear, or only tentative. Such cases have been noted and an explanatory footnote added.

Sentence	Intentionality	Agency and Intentionality Agent Role
1	Uncertain ²⁰	"by modeling these measurements"
2		N/A
3	Yes	"The model"
4	Possible	"plants display"
5	Yes	"laws regulate"
6	Yes	"varieties certainly do occasionally revert"
7	Yes ²¹	"we see" & "cattle absolutely determine"
8	Yes	"Nature grants"
9		N/A ²²
10	Yes ²³	"a protein burst to life"
11		N/A ²⁴
12	Yes ²⁵	"chaperone midwives"
13	Yes ²⁶	"Chaperones"
14		N/A ²⁷
15	Yes ²⁸	N/A
16	Yes ²⁹	"Scientists," "chaperone"
17	Yes ³⁰	"They," "cell"

In the samples taken from Darwin we have seen the truth of

Gillian Beer's observation:

In the first edition of *The Origin* both Nature and natural selection have grammatically the function of agents--and moreover, despite his later exasperation with the issue, Darwin does endow them in his language with conscious activity.[\[31\]](#)

This is true not only of the first edition, but also of subsequent editions. It is true also of Lamarck and Angier. To speak of the nonhuman is to render it into human terms, and because we have ambitions, intentions, goals, and desires, we project those onto the nonhuman world. The prose of formal scientific discourse achieves its effects by distancing itself from its objects of contemplation. The style is overwhelmingly passive and the objects contemplated function as either instruments or patients. They are either a means of discovery or the objects that endure observation and manipulation. In popular scientific discourse, however, we are in the realm of metaphor, connotation, and personification. Neither Lamarck nor Darwin were able to write about nature without lapsing into personifying and anthropomorphizing the objects of their contemplation. Lamarck's water bird that "wished" to avoid getting its feet wet is no different than Darwin's Nature with its "grants" of time. Nor are Angier's proteins and polypeptides that different from her predecessors' descriptions.

The anthropomorphism that we have seen to be inherent in language means that a scientific discourse that attempts to cross boundaries, to be popular, must be erroneous in its implicature. The naive reader does not perceive that by saying a bird wishes to avoid getting its feathers wet that Lamarck is referring not to a particular bird but to a set, or group, of birds. This reader also does not read the metaphor as metaphor but as a literal statement. The failure to perceive metaphor causes an interpretive failure and the belief that a scientist believes that animals strive, or that nature grants, or any number of other things. This failure means that in writing on topics such as evolution the popular idea is that evolution occurs because of the will of the animals involved. This is a popularized version of one interpretation of Lamarck. Gillian Beer has remarked, "Lamarck's account of evolutionary process is *still* the popular one."[\[32\]](#) This is precisely because of the intentionalist aspect of language.

Popular scientific discourse falls prey to the vices that Bacon and Wilkins inveighed against--metaphoricalness, polysemy, personification, and abstraction. These vices arise in part because of the need to communicate across a discourse barrier. The barrier is present because the formal symbolism of a discipline such as mathematics, biology, or physics, is not universally known. The writer, such as Angier, resorts to images and metaphor to convey a process in recognizable terms. In doing this, however, the writer attributes agency and intention to entities that exhibit neither. The result is that scientific discourse cannot be effectively and accurately communicated without resorting to the distancing and symbolism of formal scientific prose.

¹ Brian Vickers, Introduction, *English Science, Bacon to Newton*, Brian Vickers, ed. (Cambridge University Press: Cambridge, 1987) 8. The passages from Bacon and Wilkins are also cited from this volume.

² Vickers, 26.

³ Vickers, 184.

⁴ Vickers, 186.

⁵The examples and an extensive discussion can be found in Roger Penrose, *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics*, (Penguin: Hammondsworth, 1991) 58, 103.

⁶F.J. Lerch, R.S. Nerem, B.H. Putney, S.M. Klosko, G.B. Patel, R.G. Williamson, H.B. Iz, and J.C. Chan, "Improvements in the Accuracy of Goddard Earth Models (GEM)," to be published in a forthcoming issue of *The Journal of Geophysical Research*.

⁷ Gillian Beer, *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction*, (London: Ark, 1985) 53.

⁸Richard W. Burkhardt, Jr., "The Zoological Philosophy of J. B. Lamarck," *The Zoological Philosophy* by J. B. Lamarck, trans. Hugh Elliot, (The University of Chicago Press: Chicago, 1984) xxx.

⁹ Loren Eiseley, *Darwin's Century: Evolution and the Men who Discovered It*, (New York: Anchor Books, 1961) 46-50.

¹⁰See Georges Cuvier, "Biographical Memoir of M. de Lamarck," *The Zoological Philosophy* by J. B. Lamarck, trans. Hugh Elliot, (The University of Chicago Press: Chicago, 1984) 446. See also Pietro Corsi, *The Age of Lamarck: Evolutionary Theories in France 1790-1830*, trans. Jonathan Mandelbaum, (Berkeley: University of California Press, 1988) 198. Corsi discusses the difficulties of Lamarck's prose and the multiplicity of interpretations that surround his works.

¹¹Beer, 46

¹²Beer, 38, 39

¹³Charles Darwin, *The Origin of Species by Means of Natural Selection*, Great Books of the Western World, Gen. Ed. Robert Maynard Hutchins, (Chicago: Encyclopedia Britannica, 1952) 49, 6-7. All subsequent references to the *Origin* are from this edition and are cited by page number in the text.

¹⁴Charles Coulston Gillispie, *Genesis and Geology: A Study in the Relation of Scientific Thought, Natural Theology, and Social Opinion in Great Britain, 1790-1850*, (Cambridge: Harvard University Press, 1969), 13.

¹⁵Natalie Angier, "When Proteins Come to Life, 'Chaperones' Show the Way," *The New York Times*, February 11, 1992, C1. All further references are cited in the text.

¹⁶This sentence also exhibits the anthropomorphic tendency to describe nonhuman processes in human terms. It may be that there is no way to convey these things in a comprehensible way without resorting to metaphor, or without expressing them

in the formal language of chemistry, mathematics, physics, and the other sciences, i.e., without resorting to some sort of mathematical or formal symbolism.

¹⁷Samuel Butler, *Erewhon*, 1872 (1901), (London: Jonathan Cape; New York: E. P. Dutton & Co., 1923) 178, vol. 2 of *The Shrewsbury Edition of the Works of Samuel Butler*, eds. Henry Festing Jones and A. T. Bartholomew, 20 vols., 1923.

¹⁸Beer, 50.

¹⁹Beer, 53. ²⁰As noted above, the role of this phrase is ambiguous; it could also have the role of instrument.

²¹"We" is clearly the agent of "see." Darwin is referring to people here, so there is no question that this is a valid reading. The second part, "cattle determine," could be taken as assigning cattle the role of instruments, i.e., the means of determination. It could also be taken as indicating performance of the act of the determination. This part of the sentence is ambiguous in its role assignment.

²²There is no agent recognizable within this sentence, yet the phrase "designated profession" suggests intentionality on the part of something or someone.

²³The protein, in this sentence, has a dual role. It is a patient insofar as it suffers the coiling, pleating, and braiding. It is an agent with respect to its bursting into life and its "seizing, shearing, and lashing."

²⁴The phrase "forces inherent in a polypeptide's sequence" might be taken as containing an agent if the forces are thought of as actively doing something. If they are thought of as being a means of doing something, then they are instruments.

²⁵The phrase "gently embrace" suggests comfort and to some extent sexuality. The phrase "hostile environment" suggests either that the environment has an emotion of hatred, or that

the perceiver, the polypeptide, experiences an action as being directed against it personally. In either case, intentionality and human personality are attributed to lower level entities. A third possibility is that some outside observer has described the environment as hostile. In this case, which is the correct one, there is still the element of assignment of emotion to a nonhuman entity. In all three cases intentionality, or at least affect, is assigned to the nonhuman.

²⁶. "Chaperones" in this case may be taken as either an agent or as an instrument. The intentional aspect lies in the fact that the protein can "realize its ambitions." Ambitions imply a goal, consciousness, and direction of movement towards the goal. "Binding with bad company" suggests social interaction, e.g., male bonding.

²⁷. The action in this sentence is the rechristening, presumably performed by scientists. The element of intentionality is, of course, here, but we are looking for examples of other than human agency and human intentionality.

²⁸. Here the intentionality is expressed through the possession of instruments. The dwarves referred to are possessors rather than instruments or agents.

²⁹. Scientists are the agents of "figure out." "Chaperone" is the agent of "knows," "needed," and "let go."

³⁰. In this sentence I take "they may yet understand" as containing agency on the part of the "they" (scientists), and "cell" to be the agent who "manages." ³¹Beer, 68

³²Beer, 25.