Hal Clement
The Creation of Imaginary Beings

The unheard-of creature and the unhuman character have been part of the storyteller's ammunition since long before the invention of writing, it seems safe to claim. Angel and demon, ghost and vampire, dragon and *rukh,* Homer's Cyclopes and Mandeville's headless men are all part of the basic human heritage. Telling how to create such beings might almost be taken as an insult to normal human imagination.

In science fiction, however, we do try to maintain standards of realism (or at least believability) for a rather more knowledgeable and technically sophisticated audience than Homer faced. This is not to say that we have *higher* standards in these respects; Homer's gods and Sinbad's island-whale were as believable in their day as moon flight and atomic energy are now. Our standards are simply based on a better knowledge of the physical universe.

Also, there is no intended suggestion that the ghost and his nonmaterial kin either have vanished or should vanish from the inventory. It is perfectly possible for a competent, informed, educated materialist of the late twentieth century to enjoy the works of Sheridan le Fanu or Lyman Frank Baum, not only with the full knowledge that they are not true histories but also safely above the need to prove his open-mindedness by saying that such things *might* be possible. However, I am confining my remarks to the rather narrow limits of "hard" science fiction, where I am qualified to hold a professional opinion. It has been charged that in restricting ourselves to "scientific accuracy" my colleagues and I are narrowing the scope of usable story ideas available to us. My answer, mathematically rather horrible but defensible under literary standards, is that the square root of infinity is not really that much smaller than infinity as far as resource material goes. Our main point is that for many modern readers, a violation of the laws of thermodynamics by the author can spoil a story just as effectively as having Abraham Lincoln changing a set of spark plugs in a historical novel.

Therefore, if we travel to Mars in a story, the vehicle must operate either along physical laws we currently think we know, or at least on more or less convincing extrapolations of those laws. Furthermore, when we get there the Martians, not to mention their lapdogs, saddle horses, dinner steaks, and rheumatism, must not strike too jarring a set of notes against the background which author and reader are, it is to be hoped, visualizing together. It is permissible and even desirable to take the reader by surprise with some of these details, of course. However, his reaction to the surprise should be the urge to kick himself for failing to foresee the item, rather than resentment at the author's ringing in a new theme.

It follows that the "hard" science fiction writer must have at least an informed layman's grasp of biochemistry and ecology.

Even in this narrowed realm, there would seem to be two basic lines of procedure for the storyteller who needs nonhuman characters and other extraterrestrial life forms. The two are not mutually exclusive; they overlap heavily in many ways. Nevertheless they represent different directions of attack on the problem, one of which is more useful if the basic story is already well set up in the author's mind, while the other is of more use in creating and developing the story possibilities themselves.

In the first case, the qualities of the various life forms have to a considerable extent already been determined; they are demanded by the story events. Excellent recent examples occur in some of Keith Laumer's "Retief' novels, such as the wheeled metallic natives of Quopp in *Retief s War* and the even more peculiar Lumbagans in *Retief s Ransom.*

In other words, if the savages of Fomalhaut VII are going to kidnap the heroine by air, they must be able to fly with the weight of a human being. If the hero is going to escape from a welded-shut steel safe with the aid of his friend from Regulus IV, the friend must be able either to break or dissolve the steel, or perhaps get into and out of such spaces via the fourth dimension. These are part of the starting situation for the author, who must assume that the creations of his intellect do have the requisite powers. If he is really conscientious (or worries greatly about being laughed at by scientific purists) he will also have in the background an ecological system where these powers are of general use and which contains other creatures whose behavior and abilities fit into the same picture.

Flying must be easier on Fomalhaut VII than on Earth. Perhaps the air is denser, or the gravity weaker, or native muscle more efficient and powerful. Ordinary evolution will have been affected by the fact that flight by larger animals is possible, so there will be a much wider range of large flying organisms than we know on Earth. There will be carnivores, herbivores, and omnivores. There will be a wide range of attack and defense systems among these beings. In short, there will be more ecological niches available to large flyers, and it may be confidently expected that evolution will fill them.

Of course there will be limits, just as on Earth. Vertebrates have been flying for nearly two hundred million years, which for most of the forms involved means about the same number of generations; but we have no supersonic birds on this planet. Even the insects, which have been flying a good deal longer, haven't gotten anywhere near Mach 1; the eight-hundred-mile-per-hour deer-bot fly which appeared in the literature during the 1930s was very definitely a mistaken observation. It would seem that our biochemistry can't handle energy at the rates needed for supersonic flight. It is the evident existence of these limits which forces the author to assume a different set of conditions on the Fomalhaut planet.

Similarly, fourth-dimensional extrusion will have to be general on Regulus IV, and the local ecology will reflect the fact. There will be hide-and-seek techniques among predators and prey essentially incomprehensible to human beings, and therefore a tremendous challenge to the imagination and verbal skill of the writer.

If fourth-dimensional extrusion is not the answer chosen, then the ability to dissolve iron may have developed—which implies that free iron exists on the planet under circumstances that make the ability to dissolve it a useful one. Or . . .

There is, of course, a limit to the time any author can spend working out such details. Even I, a spare-time writer who seldom saddles himself with deadlines, spend some of that spare time writing the story itself. In any kind of story whatever, a certain amount of the background has to be filled in, by the reader's/listener's imagination. It is neither possible nor desirable to do everything for him. In this first line of attack, the time and effort to be spent on detail work are reasonably limited.

Even the second line, which is my favored technique, has its limits in this respect. However, it does encourage the author to spend longer in the beginning at the straight slide-rule work. As it happens, I get most of the fun out of working out the physical and chemical nature of a planet or solar system, and then dreaming up life forms which might reasonably evolve under such conditions. The story (obviously, as some critics have been known to remark) comes afterward. My excuse for using this general technique, if one is needed, is twofold.

First, I find it more fun. This will carry smaller weight for the author who is writing for a living.

Second, it is not unusual for the nature of the planet and its life forms, once worked out, to suggest story events or even an entire plot line which would never otherwise have occurred to me. This fact should carry some weight even with the more fantasy-oriented writer, who cares less about "realism."

I do have to admit that realism, or at least consistency, is a prime consideration with me; and as I implied some pages back with the Abraham Lincoln metaphor, even the most fantastic story can jar the most tolerant reader if the inconsistency is crude enough—anachronism is only one form of inconsistency.

This sort of realism in life design has to be on at least two levels: biochemical and mechanical.

It is true that we do not yet know all the details of how even the simplest life forms work. It is still defensible to build for story purposes a creature that drinks hydrazine, and say that no one can prove this impossible. Beyond a certain point, however, I have to dismiss this as ducking out the easy way—sometimes justifiable for storytelling purposes, but jarring on the scientific sensibility. Some facts of life are very well known indeed, and to contradict them, a very good excuse and very convincing logic are needed.

For example, any life form converts energy from one form to another. On our own planet, the strongest and most active creatures use the oxygen in the atmosphere to convert food materials to carbon dioxide and water. The chemical reactions supply the needed energy. Obviously, the available oxygen would be quickly used up if there were not some other set of reactions to break down the water and carbon dioxide (actually it's the water, on this planet) to replace what is exhausted. It takes as much energy (actually more must be supplied, since no reaction is completely efficient) to break up a molecule into its elements as is released by forming it from these elements, and any ecological system must have a long-term energy base. On this planet, as is common knowledge, the base is sunlight. There seems no need here to go into the very complicated details; few people get through high school these days (I'd like to believe) without at least a general idea of photosynthesis.

In passing, some people have the idea that fish violate this basic rule, and are some sort of perpetual motion machine, because they "breathe water." Not so; fish use the elemental O_2 gas supplied as usual by photosynthesis and *dissolved* in water, not the O in the H_20. Aquarium suppliers are perfectly justified in selling air pumps; they are not exploiting the innocent fish-fanciers.

Substitutes for free oxygen in energy-releasing reactions are perfectly possible chemically, and as far as anyone can tell should he possible biologically (indeed, some Earthly life forms do use other reactions). There is no chemical need for these substitutes even to be gases; but if the story calls for a nonhuman character to be drowned or strangled, obvious gaseous candidates are fluorine and chlorine. The former can run much more energetic reactions than even oxygen, while chlorine compares favorably with the gas we are *all* hooked on. (That last seems a justified assumption about the present readers. If it is wrong, please come and introduce yourself!)

Neither chlorine nor fluorine occurs free on this planet; but, as pointed out already, neither would oxygen if earthly life were not constantly replenishing it by photosynthesis. It has been pointed out that both these gases are odd-numbered elements and therefore in shorter universal supply than oxygen. This may well be true; but if some mad scientist were to develop a microorganism able to photosynthesize free chlorine from the chloride ion in Earth's ocean, it wouldn't have to do a very complete job to release as much of this gas as we now have of oxygen. Breaking down ten percent or so of the ocean salt would do the trick. Present-day biological engineering is probably not quite up to this job yet, but if you want to use the idea in a story be my guest. I don't plan to use it myself; the crazy-scientist story is old hat now except in frankly political literature, and even the germ-from-space has been pretty well worked to death in the last forty years.

As mentioned, there is no chemical reason why the energy-producing reactants have to include gases at all. Oxidizing a pound of sugar with nitric acid will yield more energy than oxidizing the same pound with oxygen (if this seems improbable at first glance, remember the bond energy of the N_2 molecule which is one of the products of the first reaction). True, raw concentrated nitric acid is rather hard on most if not all Terrestrial tissues; but we do handle hydrochloric acid—admittedly in rather dilute form in spite of the antacid-tablet ads—in our own digestive systems. I see little difficulty in dreaming up a being able to store and utilize strong oxidizers in its system. The protective mucus our own stomachs use is only one of the possibilities.

Many chemical sources of energy are therefore possible in principle for our life forms; but one should be reasonably aware of the chemistry involved. Water or iron oxide would not be good fuels under any reasonable circumstances; there are admittedly some energy-yielding reactions involving these, but they call for special and unlikely reactants like sodium or fluorine—and if those reactants are around, we could get much more energy by using them on other substances.

To get more fundamental, sunlight is not the only conceivable energy base for an ecological pyramid. It is, however, by far the most likely, assuming the planet in question has a sun. Remember, the energy source must not only be quantitatively large enough; it must be widely available in both space and time, so that life can originate and evolve to complex forms. Radioactivity and raw volcanic heat are both imaginable, but the first demands rather unusual conditions if much of it is to be on hand. Vulcanism, if Earth is a fair example, tends to be restricted in space at any one time and in time at any one location, a discouraging combination. Also, radioactive energy in its most direct form comes in high-energy quanta, furnishing an additional complication to the molecular architecture problem to be considered next.

It seems pretty certain that life, as well as needing energy, must be of complex structure. It has to do too many things for a simple machine. An organism must be able to absorb the chemicals needed for its energy, and carry out at the desired rate the reactions which they undergo. It must develop and repair its own structure (immortal, invulnerable, specially created beings are conceivable, but definitely outside the realm of this discussion). It must *reproduce* its own structure, and therefore keep on file a complete set of specifications—which must itself be reproducible.

Whatever mystical, symbolic, and figurate resemblances there may be between a candle flame and a living creature, the concrete *differences* between them seem to me to constitute a non-negotiable demand for extreme complexity in the latter.

On Earth, this complexity involves the phosphate-sugar-base polymers called popularly DNA and RNA for specifications, polypeptide and polysaccharide structures for most of the machinery, and—perhaps most fundamentally—the hydrogen bond to provide structural links which can be changed around as needed without the need for temperatures high enough to ruin the main framework.

I see no reason why other carbon compounds could not do the jobs of most of these, though I cannot offhand draw formulas for the alternates. The jobs in general depend on the shapes of the molecules, or perhaps more honestly the shapes of the force fields around them; these could presumably be duplicated closely enough by other substances.

I am rather doubtful that the cruder substitutions suggested by various writers, such as that of silicon for carbon, would actually work, though of course I cannot be sure that they wouldn't. We have the fact that on Earth, with silicon many times more plentiful than carbon, life uses the latter. The explanations which can be advanced for this fact seem to me to be explanations as well of why silicon won't work in life forms. (To be more specific: silicon atoms are large enough to four-coordinate with oxygen, and hence wind up in hard, crystalline, insoluble macromolecular structures—the usual run of silicate minerals. The smaller carbon atom, able to react with not more than three oxygens at once, was left free to form the water-reactive carbon dioxide gas.) True, some Earthly life such as scouring rushes, basket sponges, and foraminifera use silicon compounds in skeletal parts; but not, except in trace amounts, in active life machinery.

I also doubt that any other element could do the job of hydrogen, which I am inclined to regard as "the" essential life element, rather than the more popular carbon. Life machinery is complex, but it must have what might be called "moving parts" —structures which have to be altered in shape, or connected now one way and now another. A chemical bond weak enough to be changed without affecting the rest of the machine seems a necessity—a gasoline engine would be hard to design if springs didn't exist and a cutting torch were needed to open the valves each cycle. The hydrogen bond (I don't propose to explain what this is; if you don't know, consult any beginning chemistry text) is the only thing I know of which meets this need on the molecular level.

This, however, is not much of a science fiction problem. Something like 999 out of every 1000 atoms in the universe are hydrogen atoms; even Earth, which seems to be one of the most thoroughly dehydrogenated objects in the observable part of space, has all it needs for an extensive collection of life forms. I suspect it will generally be easier for an author to use hydrogen in his homemade life forms than to work out a credible substitute.

To finish with the fundamental-structure level, one must admit that very complex electric and magnetic field structures other than those supplied ready-formed by atoms and molecules are conceivable. At this point, it really is necessary to fall back on the "we can't say it's impossible" excuse. Personally I would develop such life forms only if my story demanded of them some ability incompatible with ordinary matter, such as traveling through a telephone wire or existing without protection both in the solar photosphere and a cave on Pluto. At this point, simple scientific realism fades away, and I must bow out as an expert. It's not that I'm above doing it; it's just that practically anyone else could do it equally well.

The other principal basis for believability of life forms lies in the field of simple mechanics, much more common sense than biochemistry. For example, in spite of Edgar Rice Burroughs's calots, a fast-running creature is far more likely to have a few long legs than a lot of short ones. Whether muscle tissue on Planet X is stronger or weaker than on Earth, muscular effort will be more efficiently applied by fewer, longer strokes. Even if the evolutionary background for some reason started off with the ten legs (e.g., high gravity), I would expect an organism specializing in speed to develop two, or perhaps four, of them to greater length and either have the others degenerate or put them to other uses as the generations rolled on.

On the same general principle, if the creature lives on grass or the local ecological equivalent, it will probably not have much of a brain. If it doesn't have to catch food or climb trees, it will lack any equivalent of a hand—in short, any anatomical part an organism has should either be useful to that creature in its current life, or be the degenerate remnant of something useful to its remote ancestors. Exceptions to this rule among Earthly life forms are hard to find, and may be only apparent; we simply don't know the purpose of the organ in question. A former example was the "sail" on the backs of some Permian reptiles, now believed to be a temperature control device.

In addition to being useful itself, a structure must have been at least slightly useful through its early stages of development; it is hard to believe that a single mutation would produce a completely developed ear, but any ability to sense pressure variations would clearly be useful to an animal. Creatures must have existed showing development all the way from a slightly refined sense touch to the present organ capable of detecting and recognizing a tiger's footfall in a windy forest—or an out-of-tune flute in an orchestra.

Similarly with the eye. There are now alive on Earth creatures with light-sensitive organs ranging from the simple red spot of the single-celled Euglena, through pinhole cameras with complex retinas (some cephalopods), to the lens-and-iris-equipped diffraction-limited organ of most mammals and birds, complete with automatic focusing. There are also examples of parallel evolution which were good enough to help their owners survive all the way along the route: the compound mosaic-lens eyes of arthropods and, I have heard, at least one organism that scans the image of a single lens by moving a single retinal nerve over the field.

But eyes and ears are hardly original enough for a really imaginative science fiction story. What other long-range senses might an organism evolve? Could an intelligent species develop without any such sense? If so, what would be that creature's conception of the universe? How, if at all, could sighted and hearing human beings communicate with it?

The first question at least can be partially answered without recourse to mysticism. Magnetic fields do exist, as do electric ones. Certainly some creatures can sense the latter directly (you can yourself, for that matter; bring your hand close to a highly charged object and feel what happens to the fine hairs on your skin). There is some evidence that certain species of birds can detect the earth's magnetic field. Sound is already used in accordance with its limitations, as is scent. A gravity-sense other than the one we now use for orientation would probably not be discriminating enough, though I could certainly be wrong (read up on lunar mascons if you don't see what I mean by lack of discrimination).

It is a little hard to envision what could be detected by a magnetic sense, and how its possessor would imagine the universe. Most substances on this planet have practically no effect on a magnetic field, and this is what makes me a little doubtful about the birds mentioned above. I can see the use of such a sense in navigation for a migratory species, but I have trouble thinking through its evolutionary development. Perhaps on a planet with widely distributed ferromagnetic material, the location of which is of life-and-death importance to the life forms, it would happen; maybe our Regulus IV character who can dissolve iron needs it for biochemical reasons.

The important point, from which we may have been wandering a trifle, is not whether I can envision such a situation in detail, but whether the author of the story can do so, and thereby avoid having to invent *ad hoc* a goose which lays golden eggs. If the life form in question has hearing but no sight, all right; but it should not be able to thread a needle with the aid of sonic perception. Sound waves short enough to have that kind of resolving power would demand a good deal of energy to produce, would have very poor range in air, and would incidentally be decidedly dangerous to human explorers. Of course, a story could be built on the unfortunate consequences of the men who were mowed down by what they thought must be a death ray, when the welcoming committee was merely trying to take a good look. . . .

Sound does have the advantage of being able to diffract around obstacles, so that straight-line connection is not needed; light (that is, light visible to human beings) is of such short wavelength that diffraction effects are minor. This means that the precise direction of origin of a sound ray cannot be well determined, while a good eye can measure light's direction to a small fraction of a degree. On Earth, we both eat and keep this particular piece of cake, since we have evolved both sight and hearing.

Scent seems to have all the disadvantages and none of the advantages, as a long-range sense. However, under special circumstances even a modified nose may fill the need. In a story of my own some years ago ("Uncommon Sense," *Astounding Science Fiction,* September 1945), I assumed an airless planet, so that molecules could diffuse in nearly straight lines. The local sense organs were basically pinhole cameras, with the retinal mosaic formed of olfactory cells. Since the beings in question were not intelligent, the question of what sort of universe they believed in did not arise.

Granting the intelligence, it would have been—would still be, indeed—interesting to work out their cosmology. Naturally, the first few hours are spent wondering whether and how they could fill the intellectual gaps imposed by their lack of sight and hearing. Then, of course, the intelligent speculator starts wondering what essential details are missing from *our* concept of the universe, because of our lack of the sense of (you name it). This, for what my opinion is worth, is one of the best philosophical excuses for the practice of science fiction—if an excuse is needed. The molecule-seers presumably lack all astronomical data; what are *we* missing? This question, I hope I needn't add, is not an excuse to go off on a mystical kick, though it is one which the mystics are quite reasonably fond of asking (and then answering with their own version of Truth). The human species has, as a matter of fact, done a rather impressive job of overcoming its sensory limitations, though I see no way of ever being sure when the job is done.

Philosophy aside, there are many more details of shape to be considered for nonhuman beings. Many of the pertinent factors have been pointed out by other writers, such as L. Sprague deCamp ("Design for Life," *Astounding Science Fiction,* May-June, 1939). DeCamp reached the conclusion that an intelligent life form would have to wind up not grossly different in structure from a human being—carrying its sense organs high and close to the brain, having a limited number of limbs with a minimum number of these specialized for locomotion and the others for manipulation, having a rigid skeleton, and being somewhere between an Irish terrier and a grizzly bear in size. The lower size limits was set by the number of cells needed for a good brain, and the upper one by the bulk of body which could be handled by a brain without overspecialization. Sprague admitted both his estimates to be guesses, but I have seen no more convincing ones since. Whenever I have departed greatly from his strictures in my own stories, I have always felt the moral need to supply an excuse, at least to myself.

The need for an internal skeleton stems largely from the nature of muscle tissue, which can exert force only by contracting and is therefore much more effective with a good lever system to work with. I belittle neither the intelligence nor the strength of the octopus; but in spite of Victor Hugo and most other writers of undersea adventure, the creature's boneless tentacles are not all that effective as handling organs. I don't mean that the octopus and his kin are helpless hunks of meat; but if I had my choice of animals I was required to duel to the death, I would pick one of this tribe rather than one of their bonier rivals, the barracuda or the moray eel, even though neither of the latter have any prehensile organs but their jaws. (If any experienced scuba divers wish to dispute this matter of taste, go right ahead. I admit that so far, thank goodness, I am working from theory on this specific matter.)

This leads to a point which should be raised in any science fiction essay. I have made a number of quite definite statements in the preceding pages, and will make several more before finishing this chapter. Anyone with the slightest trace of intelligent critical power can find a way around most of these dicta by setting up appropriate situations. I wouldn't dream of objecting; most of my own stories have developed from attempts to work out situations in which someone who has laid down the law within my hearing would be wrong. The Hunter in *Needle* was a deliberate attempt to get around Sprague's minimum-size rule. *Mission of Gravity* complicated the size and speed issue by variable gravity.

And so on. If no one has the urge, imagination, and knowledge to kick specific holes in the things I say here, my favorite form of relaxation is in danger of going out with a whimper. If someone takes exception to the statement that muscles can only pull, by all means do something about it. We know a good deal about Earthly muscle chemistry these days; maybe a pushing cell *could* be worked out. I suspect it would need a very strong cell wall, but why not? Have fun with the idea. If you can make it plausible, you will have destroyed at a stroke many of the currently plausible engineering limitations to the shapes and power of animals. I could list examples for the rest of my available pages, but you should have more fun doing it yourself.

There is a natural temptation to make one's artificial organisms as weird as possible in looks and behavior. Most authors seem to have learned that it is extremely hard to invent anything stranger than some of the life forms already on our planet, and many writers as a result have taken to using either these creatures as they are, or modifying them in size and habit, or mixing them together. The last, in particular, is not a new trick; the sphinx and hippogriff have been with us for some time.

With our present knowledge, though, we have to be careful about the changes and mixtures we make. Pegasus, for example, will have to remain mythological. Even if we could persuade a horse to grow wings (feathered or not), Earthly muscle tissue simply won't fly a horse (assuming, of course, that the muscle is going along for the ride). Also, the horse would have to extract a great deal more energy than it does from its hay diet to power the flight muscles even if it could find room for them in an equine anatomy.

Actually, the realization that body engineering and life-style are closely connected is far from new. There is a story about Baron Cuvier, a naturalist of the late eighteenth and early nineteenth centuries. It seems that one night his students decided to play a practical joke, and one of them dressed up in a conglomeration of animal skins, including that of a deer. The disguised youth then crept into the baron's bedroom and aroused him by growling, "Cuvier, wake up! I am going to eat you!"

The baron is supposed to have opened his eyes, looked over his visitor briefly, closed his eyes again and rolled over muttering, "Impossible! You have horns and hooves." A large body of information, it would seem, tends to produce opinions in its possessor's mind, if not always correct ones.

The trick of magnifying a normal creature to menacing size is all too common. The giant amoeba is a familar example; monster insects (or whole populations of them) even more so. It might pay an author with this particular urge to ask himself why we don't actually have such creatures around. There is likely to be a good reason, and if he doesn't know it perhaps he should do some research.

In the case of both amoeba and insect, the so-called "square-cube" law is the trouble. Things like strength of muscle and rate of chemical and heat exchange with the environment depend on surface or cross-section area, and change with the square of linear size; Swift's Brobdingnagians would therefore have a hundred times the strength and oxygen intake rate of poor Gulliver. Unfortunately the mass of tissue to be supported and fed goes up with the cube of linear dimension, so the giants would have had a thousand times Gulliver's weight. It seems unlikely that they could have stood, much less walked (can *you* support ten times your present weight?). This is why a whale, though an air breather, suffocates if he runs ashore; he lacks the muscular strength to expand his chest cavity against its own weight. An ant magnified to six-foot length would be in even worse trouble, since she doesn't have a mammal's supercharger system in the first place, but merely a set of air pipes running through her system. Even if the mad scientist provided his giant ants with oxygen masks, I wouldn't be afraid of them.

It is only because they are so small, and their weight has decreased even faster than their strength, that insects can perform the "miraculous" feats of carrying dozens of times their own weight or jumping hundreds of times their own length. This would have favored Swift's Lilliputians, who would have been able to make some remarkable athletic records if judged on a strictly linear scale. That is, unless they had to spend too much time in eating to offset their excessive losses of body heat. . . .

Really small creatures, strong as they may seem, either have structures that don't seem to mind change in temperature too much (insects, small reptiles), or are extremely well insulated (small birds), or have to eat something like their own weight in food each day (shrew, hummingbird). There seems reason to believe that at least with Earthly biochemistry, the first and last of these weaknesses do not favor intelligence.

A rather similar factor operates against the idea of having a manlike creature get all his energy from sunlight, plant style. This was covered years ago by V. A. Eulach ("Those Impossible Autotrophic Men," *Astounding Science Fiction,* October 1956), who pointed out that a man who tries to live like a tree is going to wind up looking much like one. He will have to increase his sunlight-intercepting area without greatly increasing his mass (in other words, grow leaves), cut down his energy demands to what leaves can supply from sunlight's one-and-a-half-horse-power-per-square-yard (become sessile), and provide himself with mineral nutrients directly from the soil, since he can't catch food any more (grow roots!).

Of course, we can get around some of this by hypothesizing a hotter, closer sun, with all the attendant complications of higher planet temperature. This is fun to work out, and some of us do it, but remember that a really basic change of this sort affects everything in the ecological pyramid sitting on that particular energy base—in other words, *all* the life on the planet.

It may look from all this as though a really careful and conscientious science fiction writer has to be a junior edition of the Almighty. Things are not really this bad. I mentioned one way out a few pages ago in admitting there is a limit to the detail really needed. The limit is set not wholly by time, but by the fact that too much detail results in a Ph.D. thesis—perhaps a fascinating one to some people, but still a thesis rather than a story. I must admit that some of us do have this failing, which has to be sharply controlled by editors.

Perhaps the most nearly happy-medium advice that can be given is this:

Work out your world and its creatures as long as it remains fun; then write your story, making use of any of the details you have worked out which *help the story*. Write off the rest of the development work as something which built your own background picture—the stage setting, if you like—whose presence in your mind will tend to save you from the more jarring inconsistencies (I use this word, very carefully, rather than *errors).*

Remember, though, that among your readers there will be some who enjoy carrying your work farther than you did. They will find inconsistencies which you missed; depend on it. Part of human nature is the urge to let the world know how right you were, so you can expect to hear from these people either directly or through fanzine pages. Don't let it worry you.

Even if he is right and you are wrong, he has demonstrated unequivocally that you succeeded as a storyteller. You gave your audience a good time.