Truly Alien

Jeff Nyman

Contents

> “When I think about the possibility of traveling to alien worlds, I always remind myself that the most exotic journey would not be to see a thousand different worlds, but to see a single world through the eyes of a thousand different aliens.”
>
> Clifford Pickover

Do you ever wonder just how *alien* an alien would be? I mean, sure, Hollywood gives us extraterrestrials that want to phone home and we have some serpent-like aliens that fight some predator-like aliens and we have aliens in gigantic ships parked over our cities that want to blow up the world. Interestingly enough, these aliens all seem to have the basic two-arm/two-leg combo and they can usually wield a nifty weapon like a blaster (read: gun) or a lightsaber (read: sword) and, even more strange, they are often shown falling in love with humans or even copulating with them. I guess the problem with all of these aliens is that they seem so ... well, human.

Alien life has always fascinated me even though, of course, we have no direct evidence for it. (That is, we have no direct evidence unless you believe the truth really is out there and the government is hiding a few crashed ships from Roswell but I think even many UFOlogists would consider all their musings indirect evidence, at best.)

What I've found interesting is that people often tend to imagine aliens pretty much like human beings. To me it's interesting to consider what generalizations, if any, we could make about alien life. Obviously this could be a pretty wide-ranging concept so let's constrain ourselves, shall we? In particular, let's constrain ourselves first to some basics of how such creatures may look to us based on their evolutionary history. Then we can constrain ourselves to looking at how mathematics or logical systems (that are perhaps predicated upon mathematical or formulaic systems) could be different to some putative alien culture. We can then consider communication with such alien life.

What generalizations, if any, can we make about alien life?

It is an interesting question I think. Certainly we could at least consider that alien life will probably display at least one axis of symmetry, perhaps left-right bilateral -- hey, just like us! This is safe to postulate, I think, because gravity, which is pretty much necessary for the maintenance of the atmosphere on a planet, will most likely establish a top/bottom gradient. Any form of life that is not sessile (attached to something) will probably also have some sort of front/back differentiation, particularly if the organism has to move. (Yet, I guess we could imagine something that can move equally well in any direction via some setup of multi-jointed “legs” and 360 degree vision.) There will probably be sensory organs in the direction of motion - at a minimum. Since life does (presumably) have to respond to the environment, I think we would probably expect life to have sensors for electromagnetic emissions (vision, temperature sensation), air pressure (hearing), and molecules in the atmosphere (smell and taste).

Putting it in more human terms, particularly for sensing the environment: the organisms will need to be able to detect a useful spectrum of electromagnetic radiation (to see), to detect changes in the surrounding atmosphere (to hear and smell), to detect heat and evaluate surfaces (to touch), and to evaluate food (to taste). You could even imagine something like antennae such as we see on insects. If you imagine a planet with significant atmospheric variations, perhaps with extremes of temperature or barometric pressure in relatively small microclimates, any creatures might need to be continuously aware of atmospheric content, temperature, or barometric pressure in order to stay safe and antennae would serve s a good way to sense the environment. If the organism has to seek out food (which is arguably likely), it would "make sense" for evolutionary pressures to concentrate these sensory organs in the front. For manipulation of the environment it is not too much of a stretch to say that appendages would be required. Some means of locomotion is also probably necessary and, for that, a form of symmetrical design would be ideal, like I said before.

I think what is interesting is that the form alien life would take would be determined by physical constraints and these would simply be outgrowths of the consequences of the laws of physics, chemistry, and biology. Further, since those would probably be very similar on other planets as here, there is at least reason to believe that there might be certain similarities between alien life and life we find here on our own planet. At least that is perhaps one way to look at it. After all, if the similarities of the laws of physics, chemistry and biology are <u>not</u> the same elsewhere, that would actually be a much bigger issue than that of alien life itself.

But it still leaves open the question: would *they* be like us?

Well, if we ask about aliens who are "like" us, what does that actually mean? We need to make that an operational question. What does it mean to be even roughly "like" us (where, technically, "us" means life on Earth, not just human life)? Well, if we measure our hypothetical aliens up to humans, it means that the creature would look humanoid. It would stand upright in some fashion. It would be bilaterally symmetric (meaning the left and right sides look [roughly] the same). We could argue this because the concept of bilateral symmetry seems to produce a streamlined, muscular body structure in environments with gravity. The creature would have to have fingers (or appendages that could pass for them). It would have to have two jointed legs and/or arms. It would have to have a head with two eyes - or at least photo-optic receptors near the cranium, which would have to be relatively large. (As an aside, <u>bilateral symmetry</u> means that only one plane of symmetry divides an animal into two symmetrical halves. There is also the concept of <u>radial symmetry</u> in which the body has the general form of a cylinder or bowl with a central axis from which the body parts radiate or along which they are arranged in a regular fashion.) The concept of symmetry simply means the orderly repetition of parts. The concept of symmetry in living things refers to the position of the body parts on opposite sides of a dividing line or distributed around a central point or axis. So all of this is what it would mean for an alien to be *like us*.

So if we see signs of convergent evolution on Earth (and we do), it is probably fairly likely that we would see something similar in different species from different worlds. What this basically means is that successful solutions will tend to arise independently in species that are separated in time and place. This is due to the similarity of environmental problems which will be due to the constraining laws of physics - which we believe to be operative over the entire visible universe. We have certainly seen this on our own planet. Consider the dolphin (a mammal), the salmon (a fish), and the ichthyosaur (an extinct reptile). They each had to hunt for small, fast-moving prey in the water. To this end they, one and all, developed very streamlined bodies for rapid travel through water. Or consider the concept of the prehensile tail. This developed in opossums, chameleons, sea horses, binturongs (which are catlike carnivores found in dense forests of southern Asia), kinkajous (Central American raccoons), pangolines (scaled anteaters), and tamanduas (nocturnal anteaters, basically), South American tree porcupines, Aneides (a genus of tree-dwelling amphibians), phalangers (Australasian marsupials), and some varieties of monkey. Or consider flight (wings): this came about in birds, insects, bats, and teleost fishes. Or consider photosynthesis: this came about in various different bacterialike organisms such as violet bacteria, cyanobacteria (the ancestors of green plants), and other forms as well.

So the point is that in our experience of life, things tend to converge. And they tend to do this converging because physics (and biology and chemistry) tend to have their way with the organisms. So let's keep going here. We are still looking at the idea of aliens being "like us" and what that means.

Such alien life would probably have digestive and excretory systems of some sort. It could be argued that the digestive is a bit more questionable. It is certainly possible to envision such like that is like us but that has something like a gastrovascular cavity such as that found in cnidarians and flatworms. But why would digestion necessarily be needed? Certainly for forms of life that we know of, digestion allows for distribution based on need. For example, mechanical breakdown of large pieces of material, temporary storage, enzymatic breakdown, reabsorption of water, etc. Our alien life would probably have some sort of internal transportation system that could deliver nutrients to the correct places of the body.

I already mentioned the idea that there would need to be organs to facilitate movement and that, likewise, we could also probably count on appendages for manipulating the external environment and that these aliens would probably have similar senses to that which we have - i.e., some method of sensing the auditory and the visual realm to some degree. However, with those things being said let's consider what that might indicate about them being like us: if the above holds we would probably expect some degree of centralization - some part of the creature would coordinate information from the environment and direct responses based on stimuli. That leads us to some sort of central nervous system or brain. And, on all life forms that we currently know of, this type of centralization has led to the development of bilateral symmetry – something I mentioned before. So we see how various aspects of the discussion always lead back to the same points.

Going with that centralization for a moment, we could probably assume that the sense organs are located near to this postulated central portion so that signals between the two are very fast and thus responses to outside stimuli are correspondingly fast. What about paired sensory organs, like our eyes and ears? I think we could argue that this is probable although not definite; I say “probable” because having such organs paired means we can achieve things such as binocular vision and sound localization and, remember, we are postulating aliens “like us” in many general aspects. Along this same line of thought, I think we could probably expect cephalization - the concentration of the nervous functions in some particular region of the creature (in most invertebrates on Earth, this is called the head).

Now this gets a bit interesting because I do know that a lot of people would say a brain of some sort are a given. And yet I could argue that brains are *not* a given, notwithstanding what I already said about convergences. Even on Earth we have things like coelenterates (types of which are, for example, jellyfish and hydras). There are also Echinoderms. These types of creatures do not have “brains” as we would commonly use the term. Usually, however, these creatures have radial symmetry and are called “lower invertebrates” - meaning they have no backbone or spinal column. Such a feature as this tends to indicate a diffuse nervous system. What I can say is what I already said: that it does seem, at least on Earth, that bilateral symmetry has, as an outgrowth, a central nervous system with a brain. But then we can ask this: what gives that development a chance (meaning the development for a central and complex nervous system)? It would seem that the preconditions are a mobile or active lifestyle with the addition of appendages that can manipulate the external environment to some degree. So, yet again, we can see how all of my above points tie together (or at least seemingly do so).

In this same vein, one could argue that intelligence is also *not* a given. On our own planet it is the case that the vast majority of organisms that are highly successful from an evolutionary point of view (such as sharks or cockroaches) do not have a high intelligence, at least by how that term is usually defined. And additional success to these creatures would probably not be forthcoming even if they did have more intelligence. What this means is that intelligence, on our planet anyway, is not obviously selected for, evolutionarily speaking.

What about something “simple” such as the idea of a nose near the mouth? It works for us, to be sure, but does such a placement actually matter in some wider sense? Well, for us it helps us analyze food before we shove it in our mouths. If food smells rotten we do not eat it (hopefully). But if it took too long for the smell to get to our nose, we might already have eaten the rotten food. Would aliens have this same issue? Obviously, having never met an alien, I cannot say. But certainly most mammals on our planet have that same setup. And speaking of that, would aliens necessarily even have ears or eyes? I sort of talked about this before and my answer is: Probably. We know the entire observable universe is bathed in light and sound. The electromagnetic spectrum is certainly present everywhere. Living organisms, particularly those that rise to intelligence, would

presumably need some way to process that light and sound, even if you only consider instinctual organisms.

But now here is where things get interesting to me because now we can stop considering convergences and start looking at divergences.

What divergences can we postulate for alien life?

One thing we can think about is that humans can perceive cardinality up to about five or six. Cardinality is basically a count of the number of elements in a given set. So if I give you a set of numbers, that might be the set {1,2,3,4,5}. If two sets have the same number of elements, then they are said to have the same cardinality. So the set {1,2,3,4,5} and the set {6,7,8,9,10} have the same cardinality. What this means in a practical sense is that if your average human being is shown anywhere from one to six objects, that person can immediately say how many objects there are. But beyond five or six objects, people begin the process of consciously counting the objects. That is very human of us. Now I ask you to imagine an alien race that could perceive extremely high cardinality. Depending on what "extremely high" means, would these aliens even be able to count? Would they even need to count beyond the cardinality they see (again, if it was high enough)? Perhaps the notion of "counting" to them would make little sense and, in that case, what does it say about how that alien race might have (or might have not) developed mathematics? On the one hand, you could say it would make some abstract elements of mathematics much easier for them but, on the other hand, you could argue that it might make the recognition of those abstract elements a long time in coming since even the need to count would not necessarily be forced upon them.

The point of the above is more just to realize that there is a question there that begs to be asked. Often, in any endeavor (be it historiography, software development, software testing, evolutionary biology, molecular chemistry, etc) the focal point is realizing that a question can be asked in the first place.

Now, along the same line as above, what if an alien race did not develop mathematics because of some genetic quirks? For example, imagine a race with twenty-three fingers (or tentacles or sucker-appendages or whatever equivalent of fingers that pleases your imagination). Humans, if all goes well, have ten fingers and this is nice because it lends itself to math. Now, granted, that is a bit anthropocentric of me but consider that 10 is an even number and can be divided into halves, fifths, and tenths. It is also the sum of the first four whole numbers: 1 + 2 + 3 + 4 = 10. Even six digits/fingers/tentacles/etc would not be too bad if you consider that with 6 you have, again, an even number - and one that suggests halves, thirds, and sixths; plus it is the sum of the first three whole numbers: 1 + 2 + 3 = 6. Like 10, at least 6 is an easily discernible mental basis for mathematics. So now let's hop back to our twenty-three fingered alien. Consider this simple fact: twenty-three is a prime number. It does not suggest any fractions other than twenty-thirds - a divisor too large for most real-world applications (at least that we know of). Beyond that, 23 is not the sum of <u>any</u> continuous sequence of whole numbers. It is the case that 21 and 28 are the sums of the first six and seven whole numbers, respectively - but 23 has no real

significance in that regard. Thus if we postulate such aliens, we might also postulate that they might not develop a system of counting (at least as we would recognize it) or a system of arithmetical math (again, as we would recognize it).

In case that last set of assertions sounds odd, you might consider how, in our own historical development, cubic and quartic formulas came about and how those forced the acceptance of negative numbers and complex numbers. (It would be way too complicated for me to go into that, but basically a lot of this stemmed from issues with taking the square root of a negative number.) These concepts are not absolute or distinct ideas of quantity; rather, they are always relative relationships between quantities. Yes, we as humans (or least our human mathematicians) have defined them as absolute concepts but they are not that in a *sub species aeternitatis* fashion. Negative numbers and complex numbers (and imaginary numbers, for that matter) are a relative property between sets and it is a mistake to think that they are absolute properties of a set. In other words, certain aspects of mathematics certainly are absolute but others are derived and relative based on how we, as human beings, have chosen to understand and utilize mathematics. My overall point there is that aspects of math may not be as "universal" as we tend to think, at least in terms of assuming it as a "given" that *any* intelligence would arrive at similar aspects.

What about logic systems? Could this be affected by biology? We, as human beings, tend to think in terms of dualities (true or false, black or white, right or left). This is probably due, in part, to our biological configuration and the very nature of our bilateral symmetry. But what about other forms of symmetry, such as radial? Would life-forms based on a radial symmetry produce systems of logic such as tertiaries (instead of dualities)? Certainly on our own planet, jellyfish and ctenophores have radial symmetry but, of course, they do not have the intelligence of humans, so we have no idea what a radially-symmetric intelligent creature would develop in terms of math or logic. Or what about pentagonal symmetry? This reflects a five-part symmetry. This may sound "out there" but consider that echinoderms (like sea stars) are an excellent example of pentagonal symmetry on Earth. How would intelligent creatures who developed with this symmetry develop notions of mathematics and logic? With this we could also consider pentamerism, which is a really odd kind of symmetry. It is basically rotational symmetry with respect to an angle of 72 degrees. It is somewhat like radial symmetry, but not quite radial in that the body is arranged around the axis of a central point with five equal sectors. Again, in case this seems too "out there", consider that starfish on Earth have this symmetry with the central point of axis being their mouths. We could also consider hexagonal (six-part) symmetry or perhaps even cubic symmetry.

The point here is that the symmetrical nature of how a life-form develops (particularly if it eventually develops intelligence) could say a lot about how it will perceive the world and the types of counting and mathematical systems it would develop and this, in turn, could speak to the degree to which such a life-form develops systems of logic.

Or, taking another approach to the logic idea, imagine an alien race that could "predict" but without being able to explain (even to themselves) how those predictions are made. In

other words, imagine a race of beings where much that we take as having to be calculated or proven is simply “obvious.” In this case, our hypothetical alien race might have a system of logic that is solely predicated upon an “intuitive” approach, without any deductive elements at all. This then might be a race that does not focus on aspects of existence, such as it is - perhaps they would see things more holistically. In other words, they would tend to have a great grasp of the forest but perhaps be incapable of seeing the individual trees, as it were. This also makes it interesting to consider whether such a race would develop digital-based technology, or if they would tend to base everything in an analog format.

This may sound odd. I mean, after all, if we assume an intelligent species, then why would developing digital computers, as just one example, depend upon the biological development of that species?

I was thinking about that and one thing I can thing of is imagining an alien race that can more easily conceive of elements in various multi-dimensional matrices. For example, it can be hard to get a human to deal with information that has been transformed from digital to analog. Let’s consider the idea of a representation of an amino acid chain being represented in a two-dimensional digital form and then converted to that of a three-dimensional shape. That is not so bad. Humans rarely have trouble doing something like that. However, now imagine the reverse process: take that amino acid chain back from a three-dimensional representation into a two-dimensional representation. That is a bit trickier. Why? Because what we lose in that second transformation is the information carrying capacity of a three-dimensional shape from the two-dimensional binaries that encode that shape. More to the point, this transformation causes the information flow to become irreversible (thus entropic) because it is easy to get from a two-dimensional binary to a three-dimensional analog but it is pretty much impossible to work out the binary specification solely from a three-dimensional shape. Try it, if you do not believe me. I’ll give you a bacteriophage example to consider in a moment that should make this clear. But let’s start with something simpler. Consider this binary string:

`100000111000000110000010`

Here you have an 8-bit binary string that corresponds to a letter or punctuation symbol or a set thereof. What does that get you? In the above case, the word CAB. Why? Well, because in this system of notation `10000001` equates to A, `10000010` equates to B and `10000011` equates to C. Without knowing that encoding, however, you would have a hard time drawing reason from it and seeing the word. Now consider the following binary string:

`000000000101000010100000000001000100011100000000`

What does that symbolize? Well, it symbolizes the following:

You may be wondering how this can be. Well, graphical images might be encoded as binary strings just as text can be. In fact, we sort of do that even with the messages we send into space right now with the hopes that some aliens can figure out what the heck we are sending them (such as graphical representations of our solar system). For simplicity, the example I am giving you above only considers an image made up of two different colors: yellow and black. From this, you can view an image as a two-dimensional grid of pixels, each one of which is either black or yellow. The grid can be encoded by writing each row of the grid as a binary string (0 for a yellow pixel and 1 for a black pixel), and then concatenating the binary strings for successive rows. That is what the image shows you: an image that is 7 pixels high, 7 pixels wide and a binary string that is 49 bits long.

My point here is that while using a computer and given the encoding scheme it is easy to see how to turn the "digital" to the "analog" and the "analog" back to the "digital." However, consider that what I am talking about with our hypothetical aliens is more about perceptions in their environment itself. In other words, imagine a race that could see only the encoding but not the image or, more to my point, they could see the image (holistically, as it were) but that is all they could see: they could not see or understand the underlying representation.

Now, you may be thinking: who cares? Well, current "search" initiatives (like the SETI project) are predicated upon sending messages to an alien race that would have developed along similar lines to that of ourselves and, more importantly, that had very similar conceptions of mathematics and/or logic. Yet we have no idea if they would have a similar system of logic and/or mathematics and thus such search programs may be based upon faulty operating assumptions. (That said, how would you go about communicating with an alien civilization that had fundamentally different notions of things like numbers or counting or logic? I have no idea. I just like thinking about the question.)

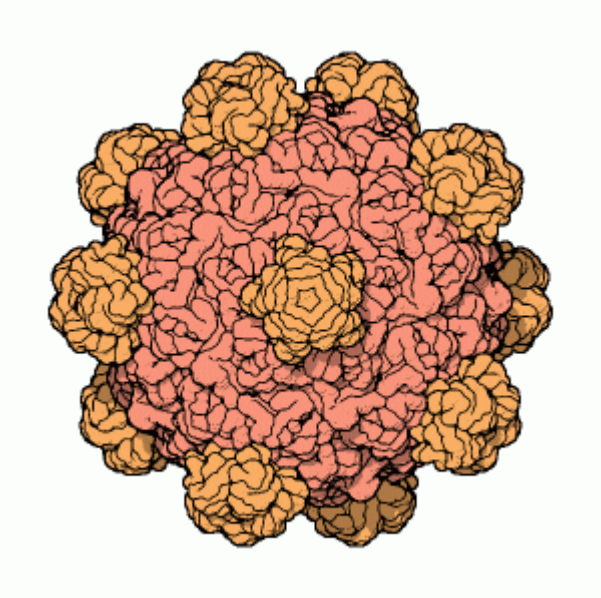
As one further example that I had mentioned above (about going from three-dimensional to two-dimensional), consider the encoding of a particular bacteriophage. The genome of this bacteriophage (a bacteriophage is a virus that attacks bacteria, incidentally) is 5,386 base pairs in length and that corresponds to 10,772 bits of information. Below you can see its full encoding and below that I have an image that shows you an idealized image of what the encoding "means."

GAGTTTTATCGCTTCCATGACGCAGAAGTTAACACTTTCGGATATTTCTGATGAGTCGAA
AAATTATCTTGATAAAGCAGGAATTACTACTGCTTGTTTACGAATTAAATCGAAGTGGAC
TGCTGGCGGAAAATGAGAAAATTCGACCTATCCTTGCGCAGCTCGAGAAGCTCTTACTTT
GCGACCTTTCGCCATCAACTAACGATTCTGTCAAAAACTGACGCGTTGGATGAGGAGAAG
TGGCTTAATATGCTTGGCACGTTCGTCAAGGACTGGTTTAGATATGAGTCACATTTTGTT
CATGGTAGAGATTCTCTTGTTGACATTTTAAAAGAGCGTGGATTACTATCTGAGTCCGAT
GCTGTTCAACCACTAATAGGTAAGAAATCATGAGTCAAGTTACTGAACAATCCGTACGTT
TCCAGACCGCTTTGGCCTCTATTAAGCTCATTCAGGCTTCTGCCGTTTTGGATTTAACCG
AAGATGATTTCGATTTTCTGACGAGTAACAAAGTTTGGATTGCTACTGACCGCTCTCGTG
CTCGTCGCTGCGTTGAGGCTTGCGTTTATGGTACGCTGGACTTTGTGGGATACCCTCGCT

TTCCTGCTCCTGTTGAGTTTATTGCTGCCGTCATTGCTTATTATGTTCATCCCGTCAACA
TTCAAACGGCCTGTCTCATCATGGAAGGCGCTGAATTTACGGAAAACATTATTAATGGCG
TCGAGCGTCCGGTTAAAGCCGCTGAATTGTTCGCGTTTACCTTGCGTGTACGCGCAGGAA
ACACTGACGTTCTTACTGACGCAGAAGAAAACGTGCGTCAAAAATTACGTGCGGAAGGAG
TGATGTAATGTCTAAAGGTAAAAAACGTTCTGGCGCTCGCCCTGGTCGTCCGCAGCCGTT
GCGAGGTACTAAAGGCAAGCGTAAAGGCGCTCGTCTTTGGTATGTAGGTGGTCAACAATT
TTAATTGCAGGGGCTTCGGCCCCTTACTTGAGGATAAATTATGTCTAATATTCAAACTGG
CGCCGAGCGTATGCCGCATGACCTTTCCCATCTTGGCTTCCTTGCTGGTCAGATTGGTCG
TCTTATTACCATTTCAACTACTCCGGTTATCGCTGGCGACTCCTTCGAGATGGACGCCGT
TGGCGCTCTCCGTCTTTCTCCATTGCGTCGTGGCCTTGCTATTGACTCTACTGTAGACAT
TTTTACTTTTTATGTCCCTCATCGTCACGTTTATGGTGAACAGTGGATTAAGTTCATGAA
GGATGGTGTTAATGCCACTCCTCTCCCGACTGTTAACACTACTGGTTATATTGACCATGC
CGCTTTTCTTGGCACGATTAACCCTGATACCAATAAAATCCCTAAGCATTTGTTTCAGGG
TTATTTGAATATCTATAACAACTATTTTAAAGCGCCGTGGATGCCTGACCGTACCGAGGC
TAACCCTAATGAGCTTAATCAAGATGATGCTCGTTATGGTTTCCGTTGCTGCCATCTCAA
AAACATTTGGACTGCTCCGCTTCCTCCTGAGACTGAGCTTTCTCGCCAAATGACGACTTC
TACCACATCTATTGACATTATGGGTCTGCAAGCTGCTTATGCTAATTTGCATACTGACCA
AGAACGTGATTACTTCATGCAGCGTTACCATGATGTTATTTCTTCATTTGGAGGTAAAAC
CTCTTATGACGCTGACAACCGTCCTTTACTTGTCATGCGCTCTAATCTCTGGGCATCTGG
CTATGATGTTGATGGAACTGACCAAACGTCGTTAGGCCAGTTTTCTGGTCGTGTTCAACA
GACCTATAAACATTCTGTGCCGCGTTTCTTTGTTCCTGAGCATGGCACTATGTTTACTCT
TGCGCTTGTTCGTTTTCCGCCTACTGCGACTAAAGAGATTCAGTACCTTAACGCTAAAGG
TGCTTTGACTTATACCGATATTGCTGGCGACCCTGTTTTGTATGGCAACTTGCCGCCGCG
TGAAATTTCTATGAAGGATGTTTTCCGTTCTGGTGATTCGTCTAAGAAGTTTAAGATTGC
TGAGGGTCAGTGGTATCGTTATGCGCCTTCGTATGTTTCTCCTGCTTATCACCTTCTTGA
AGGCTTCCCATTCATTCAGGAACCGCCTTCTGGTGATTTGCAAGAACGCGTACTTATTCG
CCACCATGATTATGACCAGTGTTTCCAGTCCGTTCAGTTGTTGCAGTGGAATAGTCAGGT
TAAATTTAATGTGACCGTTTATCGCAATCTGCCGACCACTCGCGATTCAATCATGACTTC
GTGATAAAAGATTGAGTGTGAGGTTATAACGCCGAAGCGGTAAAAATTTTAATTTTTGCC
GCTGAGGGGTTGACCAAGCGAAGCGCGGTAGGTTTTCTGCTTAGGAGTTTAATCATGTTT
CAGACTTTTATTTCTCGCCATAATTCAAACTTTTTTTCTGATAAGCTGGTTCTCACTTCT
GTTACTCCAGCTTCTTCGGCACCTGTTTTACAGACACCTAAAGCTACATCGTCAACGTTA
TATTTTGATAGTTTGACGGTTAATGCTGGTAATGGTGGTTTTCTTCATTGCATTCAGATG
GATACATCTGTCAACGCCGCTAATCAGGTTGTTTCTGTTGGTGCTGATATTGCTTTTGAT
GCCGACCCTAAATTTTTTGCCTGTTTGGTTCGCTTTGAGTCTTCTTCGGTTCCGACTACC
CTCCCGACTGCCTATGATGTTTATCCTTTGAATGGTCGCCATGATGGTGGTTATTATACC
GTCAAGGACTGTGTGACTATTGACGTCCTTCCCCGTACGCCGGGCAATAACGTTTATGTT
GGTTTCATGGTTTGGTCTAACTTTACCGCTACTAAATGCCGCGGATTGGTTTCGCTGAAT
CAGGTTATTAAAGAGATTATTTGTCTCCAGCCACTTAAGTGAGGTGATTTATGTTTGGTG
CTATTGCTGGCGGTATTGCTTCTGCTCTTGCTGGTGGCGCCATGTCTAAATTGTTTGGAG
GCGGTCAAAAAGCCGCCTCCGGTGGCATTCAAGGTGATGTGCTTGCTACCGATAACAATA
CTGTAGGCATGGGTGATGCTGGTATTAAATCTGCCATTCAAGGCTCTAATGTTCCTAACC
CTGATGAGGCCGCCCCTAGTTTTGTTTCTGGTGCTATGGCTAAAGCTGGTAAAGGACTTC
TTGAAGGTACGTTGCAGGCTGGCACTTCTGCCGTTTCTGATAAGTTGCTTGATTTGGTTG
GACTTGGTGGCAAGTCTGCCGCTGATAAAGGAAAGGATACTCGTGATTATCTTGCTGCTG
CATTTCCTGAGCTTAATGCTTGGGAGCGTGCTGGTGCTGATGCTTCCTCTGCTGGTATGG
TTGACGCCGGATTTGAGAATCAAAAAGAGCTTACTAAAATGCAACTGGACAATCAGAAAG
AGATTGCCGAGATGCAAAATGAGACTCAAAAAGAGATTGCTGGCATTCAGTCGGCGACTT
CACGCCAGAATACGAAAGACCAGGTATATGCACAAAATGAGATGCTTGCTTATCAACAGA
AGGAGTCTACTGCTCGCGTTGCGTCTATTATGGAAAACACCAATCTTTCCAAGCAACAGC
AGGTTTCCGAGATTATGCGCCAAATGCTTACTCAAGCTCAAACGGCTGGTCAGTATTTTA
CCAATGACCAAATCAAAGAAATGACTCGCAAGGTTAGTGCTGAGGTTGACTTAGTTCATC
AGCAAACGCAGAATCAGCGGTATGGCTCTTCTCATATTGGCGCTACTGCAAAGGATATTT
CTAATGTCGTCACTGATGCTGCTTCTGGTGTGGTTGATATTTTTCATGGTATTGATAAAG
CTGTTGCCGATACTTGGAACAATTTCTGGAAAGACGGTAAAGCTGATGGTATTGGCTCTA
ATTTGTCTAGGAAATAACCGTCAGGATTGACACCCTCCCAATTGTATGTTTTCATGCCTC
CAAATCTTGGAGGCTTTTTTATGGTTCGTTCTTATTACCCTTCTGAATGTCACGCTGATT
ATTTTGACTTTGAGCGTATCGAGGCTCTTAAACCTGCTATTGAGGCTTGTGGCATTTCTA
CTCTTTCTCAATCCCCAATGCTTGGCTTCCATAAGCAGATGGATAACCGCATCAAGCTCT
TGGAAGAGATTCTGTCTTTTCGTATGCAGGGCGTTGAGTTCGATAATGGTGATATGTATG
TTGACGGCCATAAGGCTGCTTCTGACGTTCGTGATGAGTTTGTATCTGTTACTGAGAAGT
TAATGGATGAATTGGCACAATGCTACAATGTGCTCCCCCAACTTGATATTAATAACACTA
TAGACCACCGCCCCGAAGGGGACGAAAAATGGTTTTTAGAGAACGAGAAGACGGTTACGC
AGTTTTGCCGCAAGCTGGCTGCTGAACGCCCTCTTAAGGATATTCGCGATGAGTATAATT
ACCCCAAAAAGAAAGGTATTAAGGATGAGTGTTCAAGATTGCTGGAGGCCTCCACTATGA
AATCGCGTAGAGGCTTTGCTATTCAGCGTTTGATGAATGCAATGCGACAGGCTCATGCTG
ATGGTTGGTTTATCGTTTTTGACACTCTCACGTTGGCTGACGACCGATTAGAGGCGTTTT
ATGATAATCCCAATGCTTTGCGTGACTATTTTCGTGATATTGGTCGTATGGTTCTTGCTG
CCGAGGGTCGCAAGGCTAATGATTCACACGCCGACTGCTATCAGTATTTTTGTGTGCCTG
AGTATGGTACAGCTAATGGCCGTCTTCATTTCCATGCGGTGCACTTTATGCGGACACTTC

```
CTACAGGTAGCGTTGACCCTAATTTTGGTCGTCGGGTACGCAATCGCCGCCAGTTAAATA
GCTTGCAAAATACGTGGCCTTATGGTTACAGTATGCCCATCGCAGTTCGCTACACGCAGG
ACGCTTTTTCACGTTCTGGTTGGTTGTGGCCTGTTGATGCTAAAGGTGAGCCGCTTAAAG
CTACCAGTTATATGGCTGTTGGTTTCTATGTGGCTAAATACGTTAACAAAAAGTCAGATA
TGGACCTTGCTGCTAAAGGTCTAGGAGCTAAAGAATGGAACAACTCACTAAAAACCAAGC
TGTCGCTACTTCCCAAGAAGCTGTTCAGAATCAGAATGAGCCGCAACTTCGGGATGAAAA
TGCTCACAATGACAAATCTGTCCACGGAGTGCTTAATCCAACTTACCAAGCTGGGTTACG
ACGCGACGCCGTTCAACCAGATATTGAAGCAGAACGCAAAAAGAGAGATGAGATTGAGGC
TGGGAAAAGTTACTGTAGCCGACGTTTTGGCGGCGCAACCTGTGACGACAAATCTGCTCA
AATTTATGCGCGCTTCGATAAAAATGATTGGCGTATCCAACCTGCA
```

That is the encoding. Now what follows is what is actually being encoded and note that when I say that what I mean is that I am showing you what the encoding "means" and that in turn means how this "thing" appears in the world:



So what I am asking you to do here is imagine an alien race that could see this representation <u>not</u> as the format I am laying it out as, but as the actual image that it encodes in nature. Further, imagine they could <u>not</u> see it any other way except that. This also makes you wonder if such a race might be better able to conceive extra-dimensional objects, like a hypercube or a hypersphere. Perhaps such an alien race could easily conceive of an eleven-dimensional superstring spacetime and yet not have any way to decode that into a formulaic method of interpretation; in other words they could "see" it, but they could not write down the equations that would describe it.

With all this being said, I am starting to get more and more abstract, as it were, and I think the logical systems and mathematical notions I have been talking about are one way to look at this, but probably not the most eminently practical as a starting point.

For example, what if we are dealing with life whose very base processes are entirely different from our own? For example, maybe we could imagine life whose base processes are regulated by the strong nuclear force rather than the electromagnetic force. The strong force is, as its name would suggest, the strongest of the four fundamental forces that we know of, but it acts only over the distance of an atomic nucleus (about 10^{-13} centimeters).

Essentially, the "job" of the strong force is to keep quarks together inside protons and neutrons and to help keep protons and neutrons inside atomic nuclei. (After all, something must keep those protons from repelling each other, right?) The key point here, however, is that the strong force mediates nuclear reactions, not chemical ones as electromagnetism does. Nuclear reactions happen faster than chemical ones which means a putative alien race that had life processes based on the strong force would live something like a million times faster than we do, in terms of perception. Would any sort of common ground be possible with an alien race like this?

Of course, some of this gets into the difference between "life" as a process and any other chemical process that we would call "non-life." As for the basis life, my contention is always that we define life as we want to define it – and that is based on what we know. Which is good, up to a point. But it reminds me of how astronomers often said that all solar system formation would force large Jupiter-like planets to the outer part of the system, leaving the rocky and smaller worlds to the inner part of the solar system. Yet everything we have found so far says that this is not a rule at all. Likewise, the idea of biologists that "all life needs sunlight" was shown to be incorrect by the discovery and classification of extremophiles. It was also stated, by both groups, that "all life needs to exist in the habitable zone" and yet now we have evidence that this need not be so or, at the very least, we have evidence that the notion of "habitable zone" is a contextual and situational concept. In other words, how we have defined life is an example of a selection effect. We have selected that definition based solely on what we know and have observed. That is good as far as it goes – but does it go very far? I am not sure.

Moving along to other ideas, what about an alien race that developed entirely under water? Say the planet of this hypothetical race had no significant land masses. We might think that underwater "high intelligence" is less likely because of the fact of water being a turbulent, viscous environment. However, it is possible to imagine shelters of sorts being constructed that localize a region of water and make it not so turbulent. But then we have to consider the notion of fire which, as far as we know, is a very big boon for development of technology and intelligence. Could a strictly water-based intelligence ever come up with fire? A bare fire is highly unlikely but might such a race use electrical currents in the water to simulate some aspects of technological development? If so, how? Could small enclaves of "non-water" be created somehow (by evaporating the water in enclosed locations) and then fire be utilized in those regions? Again, if so, how?

At this point, many people might think of dolphins and whales. The idea is that they seem to be "smart" and they spend all of their time in water, but they have never developed anything like fire or any sort of "civilization" – at least not that we are aware of. Even the notion of such creatures being "smart" is a matter of debate in itself. Dolphins and whales are very intelligent -- depending upon how you define intelligence, of course; similar to the issue of how we define life. If part of how you define intelligence is a tool-making species, then dolphins and whales have a ways to go. Personally, I think people have been too limiting in how they define intelligence and I think dolphins, in particular, show us that life can be intelligent and yet not possess some of the attributes that we refer to as "high intelligence."

This also brings up a very interesting question to me: can diffuse patterns of molecules make up a life form? Along the lines of the water example above, now consider a "water-based" intelligent life form. Not a life-form that exists in water, but rather a life-form that, essentially, is water. Beyond even that, let's generalize the idea: could such life exist as some sort of oscillating chemical reaction? That may sound really strange but then consider this: there is a naturally occurring substance called *nicotinamide adenine dinucleotide* that exists in a reduced and oxidized form. This is a coenzyme molecule that is formed from vitamin B or B3. It is found in all living cells and is in fact essential for their development and energy production. Now the point about this, in particular, is that the jump between the low and high concentrations of this coenzyme is actually quite abrupt and can be thought of as a tiny switch that goes on and off. Why does that matter? Because the chemical switch almost acts like a neuron in a brain. So could a form of intelligent life somehow come about through processes such as this? Would it be a sort of distributed intelligence? Or would the notion of intelligence, as we understand it, not even make any sense? Would an intelligence like this (assuming we could communicate with it) even be able to understand a non-distributed intelligence, such as an individual human being?

Somewhat along this same line of thought, it makes me wonder: could life occur in hydrocarbons? Again, it is one of those things that sounds a little silly but there is logic to suggest that it could. Specifically, the life would occur with a mixture of hydrocarbons functioning as the solvent. Hydrocarbons are organic compounds (such as acetylene or benzene) containing only carbon and hydrogen. You find all this stuff a lot in petroleum, natural gas, and coal. Hydrocarbons serve as fuels and lubricants as well as raw materials for the production of plastics, fibers, rubbers, solvents, explosives, and industrial chemicals. That would be an interesting life-form, yes? Meeting an alien race that could equally well fuel our automobiles! On a slightly more serious note, perhaps such a race would be noxious to us or even harmful to us. Or let us say we discover a planet that is "bathed" in such a life-form. If we are still using such fuels, would we want to harvest this life-form for our own use? Would we even recognize we are harvesting a life-form? (This sort of makes me think of the Horta in the original series of *Star Trek*, where the miners were killing off the Horta and did not even realize it.)

Another neat thing, again along these same lines, is that we could also consider a life-form that is composed of something like aluminum gallium arsenide. This would make the life-form a very efficient conductor of electrical signals. The "blood" of these creatures might consist of what are called *electrorheological fluids*, which transform from a liquid to a solid and back again in response to variations in an electric field.

Or consider another idea near and dear to all of us: crystalline silicon chips are used to code information in computers. Now imagine a broad array of organized crystals - say, an array that was the size of a whole planet. Now imagine that this array is bathed in a specialized sort of electrolyte solution that would supply the contact between crystal stations or nodes. If we have power supplied by sunlight to this "system," is it conceivable that a brain-like neural network capable of independent thought processes

could exist? A sort of living planet? It would probably look like an elaborate and complex geological structure rather than a life-form. Again, could we even have a common understanding with a life-form like this? Would we recognize that we are landing our spaceships not just on the "surface" of a planet but on an actual lifeform itself?

Communicating With Aliens

The key points of much the above material does speak to the issue of communication with a life-form that is radically different from us. But then you can think that even if the life-form was not "radically" different, it might still be hard to communicate. For example, imagine you have some race that developed two or more larynxes or had an odd tongue structure, say one that was angular shaped or even tubular shaped. Any sort of communication, in this case, may simply be hampered by the ability to pronounce anything in the alien language. Even on Earth, this can be difficult for people. For example, how many people do you know that know how to pronounce this: !Kung. This refers to the !Kung San, an African tribe that live in the Kalahari. The ! in the word represents a type of "clicking sound." There are at least four different kinds of "click" and they mean different things, based on how you touch your tongue to your front teeth or to the back roof of your mouth when you pronounce the word. Many people who do not hail from such cultures have a very difficult time pronouncing such words – and this is one of the simpler examples of such a situation. So how much harder might it be for us all to communicate in the language of an alien race, with a different anatomical structure?

I suppose we could also wonder about the situation where, say, the speech of the alien race has subtleties that depended solely on pitch rather than intonation or enunciation. Our aliens might also be considered to have a larger number of phonemes than any human language. (A *phoneme* is the smallest unit of sound in a language that can differentiate one word from another.) In other words, perhaps the alien language would simply be so nuanced, for lack of a better term, that it would be inordinately difficult for humans to (a) speak it and (b) understand the subtle differences in terms of how the language was spoken.

And, of course, what if the communication of our alien race is wholly different in nature than vocal? What if they communicate via light signals or electrical discharges that they are capable of generating? Imagine a race that had a firefly-like appendage that was used for communication. Or think of octopii and certain forms of squid on Earth that appear to have a system of communication (if we can call it that) that relies on their body colors changing. This is based on cells called *chromatophores*. Basically, muscles controlled by the nervous system surround each chromatophore. The muscles expand or contract to reveal the colors of pigments within the skin layer. When the muscles tighten the octopus or squid will darken in color and when those muscles relax the squid becomes a lighter color. With controlled muscle movements, the octopus or squid can change colors and this can depend on mood. But it can also be used to communicate (such as to attract mates) and, of course to camouflage themselves. But think of trying to communicate with such a species. Where do you start? Even if you could mimic the color changes, you would still have no true understanding of their "language" or how concepts in that

"language" are expressed. In that case, we could certainly set up a system of mimicking the color patterns, but not the meaning behind them. (This reminds of the movie *Star Trek IV: The Voyage Home*, wherein the crew encounters a probe vessel that communicates via the sounds made by humpback whales. While the crew could replicate the sounds, they could not replicate the language and communicate with the probe.)

Consider if aliens sensed (and communicated) by thermal vision or by smell. In this case, they would have relics of the past. They would "see" what was there previously. One can imagine that if the sense was attuned enough, they could determine how long something had been gone and the speed with which it moved off but then communicating with such a race might always require translating from past and future tenses.

And what about sight or smell? What if the aliens were incredibly repugnant to us based on sight? Or what if they exuded unbelievably obnoxious odors? This would not bode well for easy communication, at least if we were able to meet "in person," as it were. Also consider if the aliens use some means of electromagnetism in a different manner than us. What if they evolved to assimilate and use radio waves so that they could actually use their own bodies as radio signaling devices. (This might be the case in a world that was very much without light of the visible sort and yet bathed in a particular sort of radiation. This also might mean that such creatures could see in the infrared or ultraviolet.) Something with infrared is interesting because a possible way to communicate is to alter the heat distribution patterns on a body. Communication of this sort could be difficult. In fact, in the case of radio communication we might find that our means of communicating could actually "disrupt" the aliens in some fashion.

With all this said, what would be one of the most likely ways that humans and aliens could communicate? It would seem that aliens and humans would probably have to communicate via mathematics, at least initially. Now, of course, this goes smack into my claim about aliens possibly having a different mathematical-logical basis. However, the fact that reality can be described or approximated by simple mathematical expressions suggests to many astronomers that nature has mathematics at its core, such as with formulas like $E=mc^2$, $F=ma$, $1+e^{i\pi}$, and $\lambda = h/mv$. The first is Einstein's equation relating energy and mass. The second one is Newton's second law: force acting on a body is proportional to its mass and its acceleration. The third equation is known as Euler's formula relating three fundamental mathematical terms: e (Euler's number, 2.71828, the base of the natural logarithms), π, and i (the square root of minus one). The last equation is Louis de Broglie's wave equation, indicating matter has both wave and particle characteristics. The lambda is the wavelength of the wave-particle and m is its mass. If these mathematical elements hold true over the visible universe (and cosmologists and physicists have good reason to believe they do) then it is at least possible that our alien friends have discovered these things or, at least, have the potential of doing so.

Alien Sexuality and Love

Clifford Pickover says: "It is only by a quirk of evolution that our sexual organs and excretory organs are united. This has led to the human race seeing sex as dirty and embarrassing. If alien sexual appendages developed in different locations, aliens would

not have hang-ups, and their entire sexual psychology would be different." I find that very interesting.

Consider that on Earth, earthworms, land snails, slugs, flatworms, tapeworms, and barnacles are all hermaphrodites. *Tanais* crustaceans have three "sexes": two male types and one female. Getting into smaller (and odder) life, the single-celled *Paramecium amelia* have eight different sexes and creatures in the genus *Chlamydomonas* have about ten sexes. Consider the spotted hyena (*Hyaenidae crocuta*) has an almost complete lack of external sexual dimorphism - the external genitals of the two sexes closely resemble each other. The female's clitoris is perforated by the urogenital canal and resembles the penis of the male. Oddly enough, the female also has scrotal pouches beneath the clitoris. The point is that we have some odd aspects of sexuality on our own planet so envisioning that of alien life may be simple – or exceedingly difficult.

But what about sexual mores? We consider many things "acts against what nature intended." But consider the vast majority of the animal kingdom: it routinely engages in oral sex, rape, cross-species copulating (bestiality, basically), sadism, and exhibitionism. Homosexuality is quite common among monkeys, bulls, cows, rats, porcupines, guinea pigs, rams, antelopes, donkeys, horses, elephants, hyenas, bats, mice, martens, hamsters, raccoons, and dogs. What about sex with objects rather than mates? A human might masturbate, leave his sperm somewhere; then a female wanders along and inserts it manually into her vagina. Sound strange? Well, bees, wasps, and flies often mate with flowers (parts of which resemble those of female insects of the same species as the males) and the results of their mating can be picked up by other members of their species. Or consider vicious sex. Praying mantis females bite the heads off of males during copulation – and the male can still go at it, amazingly enough. Certain fly species have females that eat parts of the male lover during copulation.

One particular interesting fly is *Serromyia femorata* – these mate belly to belly (like humans do for the most part) with their mouths (or equivalent) locked together. After the male ejaculates the female then sucks the contents of the body of the male through the mouth. Or consider male bees. When the male bee inserts his penis into the queen's vagina, the penis is immediately broken off and the male bleeds to death. Other insect species have the same case where the male penis breaks off and usually this stays in the vagina as a sort of plug to make sure the sperm does not leak back out. The sex organs of the bristle worm (*Playnereis megalops*) are eaten by a pursuing female – and this actually helps fertilization.

Or consider self-copulation such as what occurs with the worm *Diplozoon paradoxum*, a species that resides on the gills of a carplike fish and can mate with its own self. Two of the worms can grow together in the middle of their bodies and the vagina of each half (it is a hermaphrodite) becomes permanently linked to the sperm duct of the other half. So you have four sexual organs in one creature that are mating crosswise in a decidedly odd (to humans) way of doing things. Some creatures on Earth, like some snakes, have paired penises, or *hemipenises*. Usually each hemipenis can be split in two resulting in four effective sexual copulatory organs.

Beyond these kinds of practical biological issues, length of time for sex is always interesting. Humans range from just a few seconds to, at most, a couple of hours (although most of that is actual foreplay before penetration and sustained thrusting). Snakes can remain in union for about a day (although snake penises can come with hooks, spines, knobs, and various corrugations to secure the female once the male has inserted himself into her). The female of the fluke species *Schistosoma heamatobium* (a parasitic type of flatworm) lives within a fissure in the male's body and pretty much means it copulates constantly. Many insects go for days. Consider *Anacridium*, a genus of winged insects, can copulate for sixty hours. Impressive, to say the least.

In the case of humans, we have genetic sex (XX for women, XY for men), core gender identity (that is, one's sense of oneself as male or female), and a sexual phenotype (the male and female body build and secondary sexual characteristics). We also have gender roles, which are culturally determined window dressing that is transmitted through learning. In humans these are all, for the most part, consistent within each individual. But what if there were species where these various layers were dealt out in different ways. Then you could have as many as sixteen different sexes. (One can only imagine what the alien dating scene would be like in that case.) The point of this is that sexual proclivities of life on Earth are so varied that it is difficult to even draw simple distinctions in many cases so postulating too much about the proclivities and abilities of alien life seems a futile exercise.

Yet, going beyond the pure sexual side of things, what about emotions or concepts like love? Can that be a basis of evolutionary biology? Well, why not? Let's consider "love" as a notion. This emotion is made possible via the neocortex, an evolutionarily advanced part of the brain, as well as the chemical oxytocin. (Specifically, oxytocin is a nine amino acid peptide that is synthesized in hypothalamic neurons and transported down axons of the posterior pituitary for secretion into blood. But why get picky?) Reptiles do not have a neocortex and this might be why they eat their young sometimes or why they seem to not care for them. (Granted, however, some human and primate females kill their young as well but reptiles tend to do it more often.) What we do know is that, with life on Earth, the more connections there are between the limbic system (a primitive part of the brain that is the site of delight, disgust, fear, and anger) and the neocortex (the advanced part of the brain allowing for planning, memory, and learning) then more emotional responses are possible. People with damage to these connections often have inhibited or stunted emotional development. Obviously we have no idea of an alien race would even share this kind of biology, but that is really the point: we have no idea regarding the basis of their emotions.

For example, what about aliens that had emotions easily visible or could be sensed by other means? For example, by smell. Or perhaps like octopuses and certain squid, their body colors would change based on emotion thus making it hard to hide those emotions. Would this lead to a calmer society, say one that did not have a great deal of guile? Hard to say, certainly. Perhaps it would lead to a society that would annihilate itself because nothing of how they felt would be hidden.

But when you start talking about reified concepts like “love”, this actually brings up other odd things we could imagine about alien life or alien societies. Let’s go back to love for a moment. What is it? What does it mean?

Well, keep in mind that the feelings of “love” are often rooted in touch. Touch causes our bodies to produce a hormone called oxytocin. In fact, not only does touch stimulate production of oxytocin, but oxytocin promotes a desire to touch and be touched: a sort of chemical feedback loop. Oxytocin makes us feel good about the person who causes the oxytocin to be released, and it causes (or at least appears to cause) a bonding between the two persons. Now, again, as I said earlier, if we look at things from a purely chemical perspective, oxytocin is a peptide that is synthesized in neurons and eventually transported into the bloodstream. So there is love.

Yet, that is not all it is, right? Of course not. People’s feelings and emotions, however regulated by chemicals, are still subject to the notion of our minds and how we think about the things we are experiencing and the way that we give meaning to things. The key here is that “Love” is a reified concept. To “reify” something means that we regard or treat an abstraction or an abstract concept as if it had concrete or material existence. We sometimes do that with concepts like “Trust” or “Justice” or “Morality.” One could argue that we do the same thing with the concept of “God.” Anyway, what this means is that “love” is a label for an idea which may include many things: respect, concern, passion, admiration, acts of compassion and benevolence. And whatever else you want to imbue it with.

Obviously there really is no such “thing” as love. It is not a substance you can gain or give away. You cannot measure it on some scale. I adhere to the viewpoint that “love” is a label for ideas and actions of ours which are based on a rational appraisal of value to ourselves and to others that we value strongly. There is a key word: value. I think we do not have any sort of “love” just by chemicals; yes, we have attraction; yes, we have lust. But the concept of “love” does not just come about by chemicals, I believe, but also by the value we put in ourselves and that which we put in others. This means it does not take a spouse to “love” someone. It does not mean that “love” has to lead to marriage. It does not even mean that love is a critical component of marriage, except insofar as love is a manifestation of the values we hold for another person. Friends are capable of just as much (if not more) love than you might find in some marriages.

The point here is that the basis for how an alien culture may interact in its societal structures would be very hard to determine just by any sort of consideration of their biological aspects.

Other Alien Considerations

In talking about alien sexuality and then dealing with emotions such as love, I think it was obvious that it is difficult to talk about an alien society. Yet, that said, I do think we can at least imagine some particulars or conditions regarding how a society may develop and extrapolate from there.

As an example, if we consider a higher-gravity world, we have to consider that the actual soil of the world would be more compacted, which means any creatures evolving on this world would need to be capable of digging very well in that soil. We might find a greater preponderance of live that lives under or in the soil. Would that lead to a more hive society? We might also find that aquatic life is more prevalent on such worlds. On such worlds the atmosphere may be very, very thin. If the gravity was too incredibly high, the creatures could probably never leave their world (although this would be getting into neutron star densities). The collapsed matter making up their bodies would transform into normal atoms when the creatures got out of the gravity region and they would literally blow up. So what kind of society might form for a species that found every aspect of the universe totally hostile to them?

It would be interesting if it were the case that carnivores are a common feature of planets that evolve a diverse biosphere. Certainly here on Earth the growth of intelligence is greatly helped by carnivorous species because this usually requires hunting in groups so a degree of social organization and cooperation becomes essential. (It is also likely that herbivores might be common as well as things like parasites.) Yet, imagine creatures that evolved where there were no carnivores. The selective factors operating would be totally different. They might evolve no fight-or-flight instinct since there is nothing (or very little) to defend against and nothing to necessarily flee from, barring natural disasters like fires. Perhaps no behavior patterns would develop based on fear, anger, or aggression since such emotions would have little or no survival value and thus they would not be selected and reinforced. Perhaps this would lead to a species with no fast runners since there are no predators to run from. Perhaps there would be no need for natural camouflage since there is nothing to hide from to that degree. Perhaps no birds would evolve since nothing would exist to necessarily stimulate their appearance, at least in a pure predator-prey environment. What kind of society might evolve from these sorts of beginnings?

Or, beyond even the presence or absence of carnivores, assume something like the so-called Pangea that existed on Earth. In this type of world (where continents had not broken up) the diversity of languages would probably be a lot less. The study of comparative linguistics on Earth seems to indicate that languages multiply more rapidly in tropical areas along coastlines rather than in the interiors of continents. For this reason the little island of New Guinea has eighty different families of languages. If we further assume that the land of our alien world is not massively mountainous it would also be possible for life to develop very efficient systems of transportation and communication thus further reducing the diversity of languages. Again, what kind of society might we see develop from this?

Alien Alternatives

Let’s consider some “alternatives” to the basic forms of life we have been considering here, moving from the more likely to the less knowable.

Could life be based on sulfur? Sulfur does offer a variety of possible bounds, indicating that it is somewhat versatile. (For example, when sulfur burns we get sulfur dioxide, although sometimes we get sulfur oxide or even sulfur trioxide.) Sulfur likes to form chains and rings that are somewhat similar to those of carbon. A commonly occurring compound is a ring of eight sulfur atoms, S_8. Sulfur will also form long chains of sulfur atoms, one linked with the other. However, sulfur has limited potential. Sulfur does not possess the richness of possible bonds with other elements. Carbon forms long chains or rings to which *other* elements - hydrogen, oxygen, nitrogen, and others - are bound. Sulfur's long molecules tend to include only sulfur. This does not seem to allow for the wide spectrum of compounds necessary for life as we know it.

Could life be based on silicon? Here things are a little more promising from that of sulfur. Silicon does have the same valence as carbon - four. However, silicon does not work similarly to carbon when it combines with itself and other elements. Silicon (along with boron and germanium) is a *metalloid*, meaning its chemical properties are between those of metals and non-metals. Metals, regardless of their chemical valence, do not form compounds that are similar to the life-bringing carbon bonds. Being in between a metal and a nonmetal, silicon forms the basis for quartz (hexagonal crystalline silicon dioxide), glass (boron and aluminum silicates), and portland cement (calcium silicates), as well as sand, mortar, and asbestos.

When silicon bonds with hydrogen and oxygen, it cannot form long chains or rings with other silicon atoms, as carbon does with itself. The longest such molecules contain there silicon atoms in succession. Silicon is really the only other element whose atomic structure allows for the formation of the polymers, or long-chain molecules, that life seems to require. One of the most common forms of silicon is known as silicon dioxide (SiO_2) – sand. The ability of silicon to bond with oxygen and form crystal lattices that incorporate atoms of heavier elements leads to the formation of silicates in multiple manifestations of topaz, garnet, quartz (including amethyst), beryl, jade, and others. In combination with carbon, silicon can form rubber-like silicone polymers. On the other hand of that, though, silicon forms such strong bonds with oxygen that it lacks the versatility required for metabolic reactions, where bonds must be formed and broken within the homeostatic environment of the living cell. A silicon-based life-form would have no ATP or nucleic acids.

Overall, a complex system of something akin to organic-chemistry reactions could take place with silicon chains in liquid ammonia (NH_3) rather than water. The problem is that ammonia is only liquid within a narrow range of intensely cold temperatures. Frozen water is quite remarkable because it is less dense than liquid water, and this causes ice to float to the top of oceans during frigid weather. (This is mainly because the molecules of H_2O are tetrahedral, rather than flat, and due to the particular order of its crystals.) In a liquid-ammonia ocean, frozen chunks of ammonia would sink, thereby exposing the surface of the liquid ammonia to the cold so that eventually all the ammonia in the ammonia sea would be frozen. But life could occur in liquid ammonia (with temperatures near -58 degrees Fahrenheit) with weaker bonds involving nitrogen predominating in the metabolism. Ammonia is, thus, a poorer solvent than water and what is even worse:

silicon and its compounds are not optimized for wither water or ammonia. The most reliable solvent for silicon would be hydrofluoric acid. But fluorine is a rare element, which might mean silicon-based life is spread thin. Silicon-based life seems to require the absence of oxygen because the Si-O (silicon-oxygen) bond is very strong and prevents formation of Si-Si-Si complex chains. The radius of the outer electron shell is larger - which means it forms weaker bonds, especially with itself. Generally compounds with more than three silicon atoms in a row are unstable unless they form into a crystal lattice. Thus any such creatures would probably be very brittle.

Somewhat along the lines of the chemical makeup of creatures, a popular conception is that of the shape-shifting alien. (Perhaps one of the more famous of these was Odo on the *Star Trek: Deep Space Nine* series.) Regardless of chemical structure, you run into the conservation laws here. If you change a human into a wineglass you can either convert the extra mass to energy (thereby causing a massive explosion) or you can retain the mass and become an object that is disproportionately heavy for its size. Also the means to shape shift would probably overwhelm the gene coding capacity. For a shape-shifter to completely become the life-form being impersonated, it would have to mimic that life-form at a molecular level. So how would this reflect in the genome? Viral and bacterial genomes are compact, often having overlapping genes. Gene coding segments in higher organisms represent a low percentage of the total genome (somewhere around ten percent). But gene coding is not the only game. The chromosome must also contain instructions for folding, which are basically little signposts that show where genes begin and end, regulatory sequences that dictate when a gene is to be activated and by whom, and how its product is to be processed into message RNA (spliced), exported from the nucleus, and made into protein in the cytoplasm (translated). This means a shape-shifter would have to have the coding capacity for many life-forms. Obviously we cannot say this is impossible in some categorical sense but it would be a very radical form of life.

Would very intelligent aliens be able to fly, as in some sort of avian species? Obviously we do not know but the thinking among many biologists is probably not. On our own planet birds are not very intelligent creatures because they cannot afford to have a large brain (since they would have to lug it into the air every time) nor can they accord a large heart system that could help sustain the brain. However, what if the gravity of a planet were sufficiently low or an atmosphere was much more dense? In that case, perhaps such creatures could evolve to have a high intelligence.

Thinking at a “lower” level for a moment, could an alien virus infect humans (or vice versa)? This is somewhat unlikely. Pathogens, like viruses, usually have a certain degree of specificity about them regarding who/what they attack. Viruses evolve to attack specific receptors on cells and then use the host’s cellular machinery to reproduce itself. Consider the rhinovirus, which is essentially the cause behind the common cold - these have adapted to infect humans and are most successful in doing so. (The only way out of this scenario of non-infection would be if all life were somehow related, *a la* the various panspermia theories but, even then, it is not guaranteed because conditions on different worlds may have led to different biologies and different mutations.) It is, however, more possible that bacteria from two different cultures could harm other cultures, even though

they did not evolve together in the same ecosystem and this is because bacteria can produce toxins or cause mechanical effects (such as blockages).

Alien Alternative: A Radical Extreme?

Here I want to pontificate on something I might call a “Quantum God,” very much for a lack of a better term, but I use the term because this kind of alien might appear to be some sort of “god” to us, given what it could potentially do.

Could an alien life-form be a construct of quantum functions? A sort of tapestry of acausal and nonlocal effects? What would such a “quantum god” entail? You would have this “super-entity” that was aware of both its own existence and aware of a canonical body of observations of experimental results that had to be accounted for in order to ascertain its own existence. If this being lacked either the information density or the organizational schema to explain its own existence self-consistently, the whole “event” would be sub-critical – there would be nothing that was implied. Of course the process of creating – starting (coming into existence; being born) or stopping (going out of existence; dying) - does not make sense in those words because it does not take place in time at all. Successive frames in this “simulation” simply correspond to increments in logical extension - like steps in a mathematical proof, adding successive layers of consequences to an initial set of premises. The history of the life-form would be embedded in those consequences like the sequence of a murder, pieced together by pure deduction from evidence at the scene of the crime.

The point here is that every physical structure encodes information – but normally it is the laws of physics alone which control how the structure behaves. The fact that laws of physics are themselves information is irrelevant. They are as absolute as Newtonian space-time, meaning they serve as a fixed backdrop, not a player. The problem is that nothing is pure; nothing is totally independent. Time and space mix at high velocities. Macroscopic possibilities mix at the quantum level. The four fundamental forces of nature mix at high temperatures. And physics and information must mix - but how? What is the process? There must be a symmetry group but what would it be? And what are the detailed dynamics of that group? (A “quantum god” could come into effect here in the sense that it is that process is knowledge.)

This pattern of information, this state of being conscious and possessing these perceptions, wraps itself in ever-growing layers of corollaries: neurons to encode the information, blood to nourish the neurons, a heart to pump the blood, intestines to enrich it, a mouth to supply the intestines, food to pass through it, etc, etc. Neurons, heart, intestines, cells of proteins and ions and water wrapped in lipid membranes, tissues differentiated in development, genes switched on by intersecting marker hormone gradients, a million interlocking molecular shapes, tetravalent carbon, monovalent hydrogen, electrons shared in bonds between nuclei of protons, neutrons to balance electrostatic repulsion, quarks spinning in both to partner the leptons in a hierarchy of field excitations, a ten-dimensional manifold to support them ... defining a broken symmetry on the space of all possible topologies – and thus the (creation? emergence?) of a new sort of life-form.

Imagine such a creature that had axioms for its bones, logic for its sinews. Its very structure would be made up of pure mathematics. This would a race of self-conscious observers within a greater formalism, sort of islands of awareness in a sea of logic. I am referring to a creature made up of Gödelian mathematics; a structure of life so intricate that by its very nature rationality is simply imposed as opposed to derived from other causes.

What Could We Determine?

Like us: Modern man belongs to the phylum Vertebrata. So do all the mammals, fish, birds, amphibians and reptiles. They all share a common pattern of basic architecture. This architecture has remained largely unchanged over millions of years, although allowance is made for specialized, but superficial adaptations. The basic vertebrate pattern is as follows: an internal skeleton of bone or cartilage and a vertebral column. The vertebrate has two pairs of appendanges, which may be highly developed or degenerate, likewise a tail. It has a ventrally located heart, divided into two or more chambers, and a closed circulatory system of blood made up of red cells containing hemoglobin. It has a dorsal nerve cord which bulges at one end into a five-part brain contained in the head. It also has a body cavity that contains most of its vital organs and its digestive system. All vertebrates conforom to these rules and are related.

Assume we had an alien body. What could we tell about it?
From detailed chemical analysis we might be able to build a quantitative model of the alien's cell-metabolism cycles and enyzme processes. We might be able to calculate the rate of accumulation of waste materials and toxins in the blood and tissues, and from those results you might be able to form an estimate of his natural periods of sleep and wakefulness. This might lead to a figure for the length of the day on the planet of the alien. This might give you the planet's orbital period. You might also be able to guess the mass of the planet by doing a structural analysis of the alien's bone and muscle formations and then working out the power-weight ration. That would (possibly) give the planet's mean distance from its sun.

If the alien was found with any glass or crystalline materials, you could try to get the planet's mass that way as well. From the crystal structure, you could figure out the strength of the gravitational field they cooled in.

By analyzing the sizes and shapes of the alien's blood vessels and associated muscle tissues, we might be able to produce equations describing the performance of the alien's circulatory system. From these you could then derive a set of curves that would show the proportions of body heat that would be retained and lost for any given body temperature and outside temperature. An assumption here would be that, as in the case of terrestrial mammals, the process of evolution would have led to the alien's body regulating its temperature to such a level that the chemical reactions within its cells would proceed at their most efficient rates. What you could do here, however, is arrive at an estimate of the

outside temperature or, more precisely, the temperature of the environment in which the alien seemed best adapted to function.

Summary

Given what we have deduced about life on our own planet, are we in any position to make informed speculations about life we might find on other planets? Is it possible that we could come across life that we would not even recognize as life? What about the possible places we could hope to find life?

We have to apply our study of ecology, biology, genetics, chemistry, biochemistry, astronomy, physics, to see what we can think about alien life. The question is whether or not this database gives us enough information to put forth and test our hypotheses about alien life. Implicit within this structure is not just the notion of whether we can put forth hypotheses about alien life, but rather if we can put forth hypotheses about life that is radically different from life as we know it. This, in turn, allows us to wonder if life even could be radically different from what we know.