The Universe of Discourse

Sun, 09 Aug 2015

A message to the aliens, part 0/23 (framing)

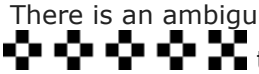
Earlier articles: Introduction

(At left is page 1 of the *Cosmic Call* message. For an enlarged version of the image, click it.)

First, some notes about the general format of each page. The Cosmic Call message was structured as 23 pages, each a 127×127 bitmap. The entire message was therefore 127×127×23 bits, and this would hopefully be suggestive to the aliens: they could try decoding it as 127 pages of 127×23-bit images, which would produce garbage, or as 23 pages of 127×127-bit images, which is correct. Or they might try decoding it as a single 127×2921-bit image, which would also work. But the choices are quite limited and it shouldn't take long to figure out which one makes sense.

To assist in the framing, each page of the message is surrounded by a border of black pixels and then a second smaller border of white pixels. If the recipient misinterpreted the framing of the bit sequence, say by supposing that the message was made of lines of 23 pixels, it would be immediately apparent that something was wrong, as at right. At the very least the regular appearance of the black border pixels every 127 positions, and the fact that the message began with 128 black pixels, would suggest that there was something significant about that number. If the aliens fourier-transform the message, there should be a nice big spike at the 127 mark.

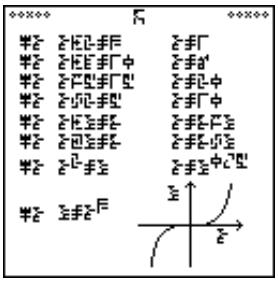
Most of the message is encoded as a series of 5×7-pixel glyphs. The glyphs were generated at random and then subject to later filtering: candidate glyphs were discarded if they don't differ from previous glyphs in enough bit positions. This is to help the recipients reconstruct the glyphs if some of the bits are corrupted in transmission, as is likely. The experimenters then eyeballed the glyphs and tried to match glyphs with their meanings in a way that would be easy for humans to remember, to aid in proofreading. For example, the glyph they chose to represent the digit 7 was  .

People frequently ask why the message uses strange glyphs instead of standard hindu-arabic numerals. This is explained by the need to have the glyphs be as different as possible. Communication with other stars is very lossy. Imagine trying to see a tiny flickering light against the background of a star at a distance of several light years. In between you and the flickering light are variable dust and gas clouds. Many of the pixels are likely to be corrupted in transmission. The message needs to survive this corruption. So glyphs are 35 bits each. Each one differs from the other glyphs in many positions, whereas a change of only a few pixels could change a standard 6 into an 8 or vice versa. A glyph is spread across multiple lines of the image, which makes it more resistant to burst errors: even if an entire line of pixels is destroyed in transit, no entire glyph will be lost. At the top left and top right of each page are page numbers. For example, page number 1:  The page numbers are written in binary, most significant bit first, with representing a 1 bit and  representing a 0 bit. These bit shapes were chosen to be resistant to data corruption; you can change any 4 of the 9 pixels in either shape and the recipient can still recover the entire bit unambiguously. There is an ambiguity about whether the numerals are written right to left or left to right—is  the number 1 or the number 16?—but the aliens should be able to figure it out by comparing page numbers on consecutive pages; this in turn will help them when time comes for them to figure out the digit symbols.

Every page has a topic header, in this case  , which roughly means “mathematics”. The topics of the following pages are something like: * 1–5 Mathematics  * 6–11,21 Physics  * 12–14,19–20 The Earth  * 15–18 Human anatomy and biochemistry  * 22 Cosmology  * 23 Questions  In the next article I'll explain the contents of page 1. Each following article will appear two or three days later and will explain another page. To follow the whole series of articles in your feed reader, subscribe to: [RSS](http://blog.plover.com/aliens/dd/index.rss) [Atom](http://blog.plover.com/aliens/dd/index.atom)

Zip file of all 23 pages



(Next article, to appear 2015-08-10: page 1)

[Other articles in category /aliens/dd] permanent link

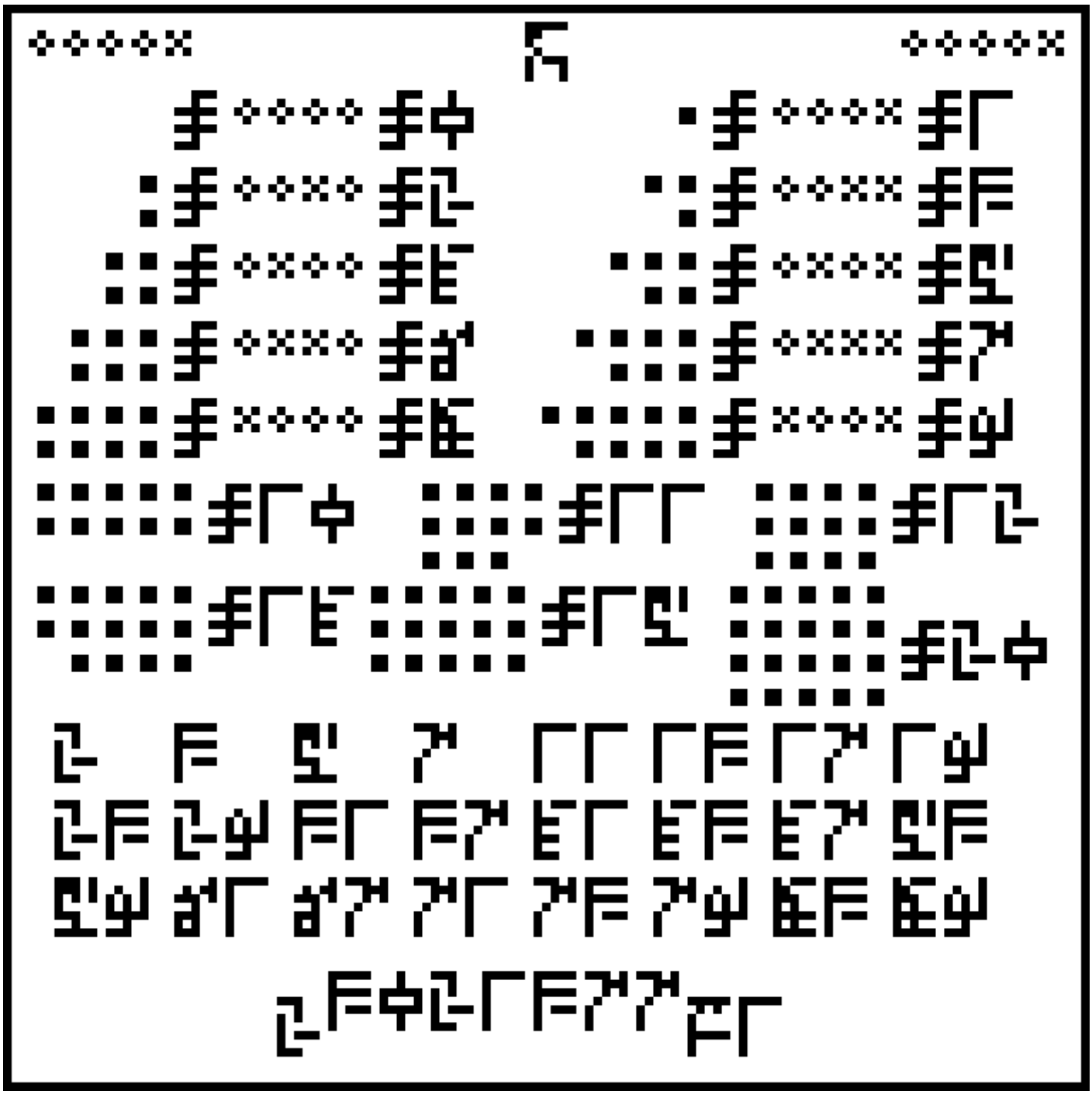
The Universe of Discourse

Wed, 12 Aug 2015

A message to the aliens, part 1/23 (numbers)

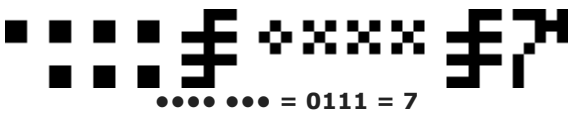
Earlier articles: Introduction Common features

This is page 1 of the *Cosmic Call* message. An explanation follows.



This page, headed with the glyph for "mathematics"  , explains the numeral symbols that will be used throughout the rest of the document. I should warn you that these first few pages are a little dull, establishing basic mathematical notions. The good stuff comes a little later.

The page is in three sections. The first section explains the individual digit symbols. A typical portion looks like this:

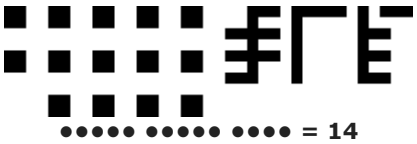


•••• ••• = 0111 = 7

Here the number 7 is written in three ways: first, as seven dots, probably unmistakable. Second, as a 4-bit binary number, using the same bit symbols that are used in the page numbers. The three forms are separated by the glyph  , which means "equals". The ten digits, in order from 0 to 9, are represented by the glyphs

The authors did a great job selecting glyphs that resemble the numerals they represent. All have some resemblance except for 4, which has 4 horizontal strokes. Watch out for 4; it's easy to confuse with 3.

The second section serves two purposes. It confirms the meaning of the ten digits, and it also informs the aliens that the rest of the message will write numerals in base *ten*. For example, the number 14:



Again, there are 14 dots, an equal sign, and the numeral 14, this time written with the two glyphs  (1) and  (4). The base-2 version is omitted this time, to save space. The aliens know from this that we are using base 10; had it been, say, base 8, the glyphs would have been  .

People often ask why the numbers are written in base 10, rather than say in base 2. One good answer is: why not? We write numbers in base 10; is there a reason to hide that from the aliens? The whole point of the message is to tell the aliens a little bit about ourselves, so why disguise the fact that we use base-10 numerals? Another reason is that base-10 numbers are easier to proofread for the humans sending the message.

The third section of the page is a list of prime numbers from 2 to 89:

and finally the number $2^{3021377} - 1$

which was the largest prime number known to humans at the time. (The minus sign and exponentiation notation are explained on later pages.) Why? Again. to tell the aliens about ourselves: here's a glimpse of the limits of our mathematical knowledge.

I often wonder what the aliens will think of the $2^{3021377} - 1$. Will they laugh at how cute we are, boasting about the sweet little prime number we found? Or will they be astounded and wonder why we think we know that such a big number is prime?

The next article, to appear 2015-08-12, will discuss page 2, shown at right. (Click to enlarge.) Try to figure it out before then.

[Other articles in category /aliens/dd] permanent link

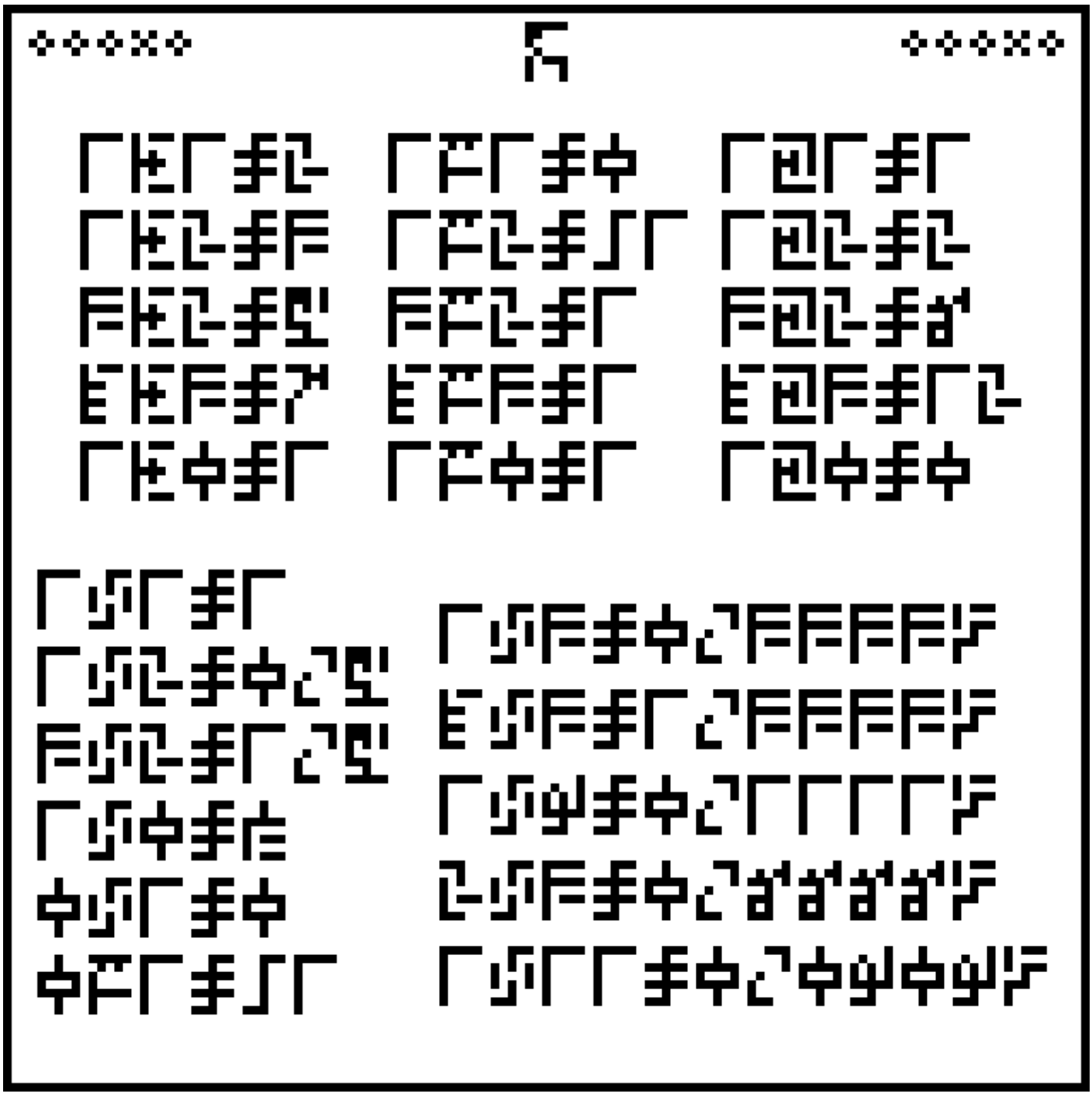
The Universe of Discourse

Wed, 12 Aug 2015

A message to the aliens, part 2/23 (arithmetic)

Earlier articles: Introduction Common features Page 1 (numerals)

This is page 2 of the *Cosmic Call* message. An explanation follows.



Reminder: the previous page explained the ten digits:

0 1 2 3 4 5 6 7 8 9

This page, headed with the glyph for "mathematics"  , explains the arithmetic operations on numbers.

The page is in five sections, three on top and two below.

The first four sections explain addition, subtraction, multiplication, and division. Each is explained with a series of five typical arithmetic equalities. For example, $4 \times 3 = 12$:

The subtraction sign actually appeared back on page 1 in the Mersenne prime $2^{3021377} - 1$.

The negative sign is introduced in connection with subtraction, since $1 - 2 = {}^{-}1$:

Note that the negative-number sign is not the same as the subtraction sign.

The decimal point is introduced in connection with division. For example, $3 \div 2 = 1.5$:

There is also an attempt to divide by zero:

It's not clear what the authors mean by this; the mysterious glyph does not appear anywhere else in the document. What did they think it meant? Infinity? Indeterminate? Well, I found out later they published a cheat sheet, which assigns the meaning "undetermined" to this glyph. Not a great choice, in my opinion, because $1 \div 0$ is not numerically equal to anything.

For some reason, perhaps because of space limitations, the authors have stuck the equation $0 - 1 = {}^{-}1$ at the bottom of the division section.

The fifth section, at lower right, displays some nonterminating decimal fractions and introduces the ellipsis or '…' symbol. For example, $1 \div 9 = 0.1111\ldots$:

I would have put $2 \div 27 = 0.0740\ldots$ here instead of $2 \div 3$, which I think is too similar to the other examples.

The next article, to appear 2015-08-14, will discuss page 3, shown at right. (Click to enlarge.) Try to figure it out before then.

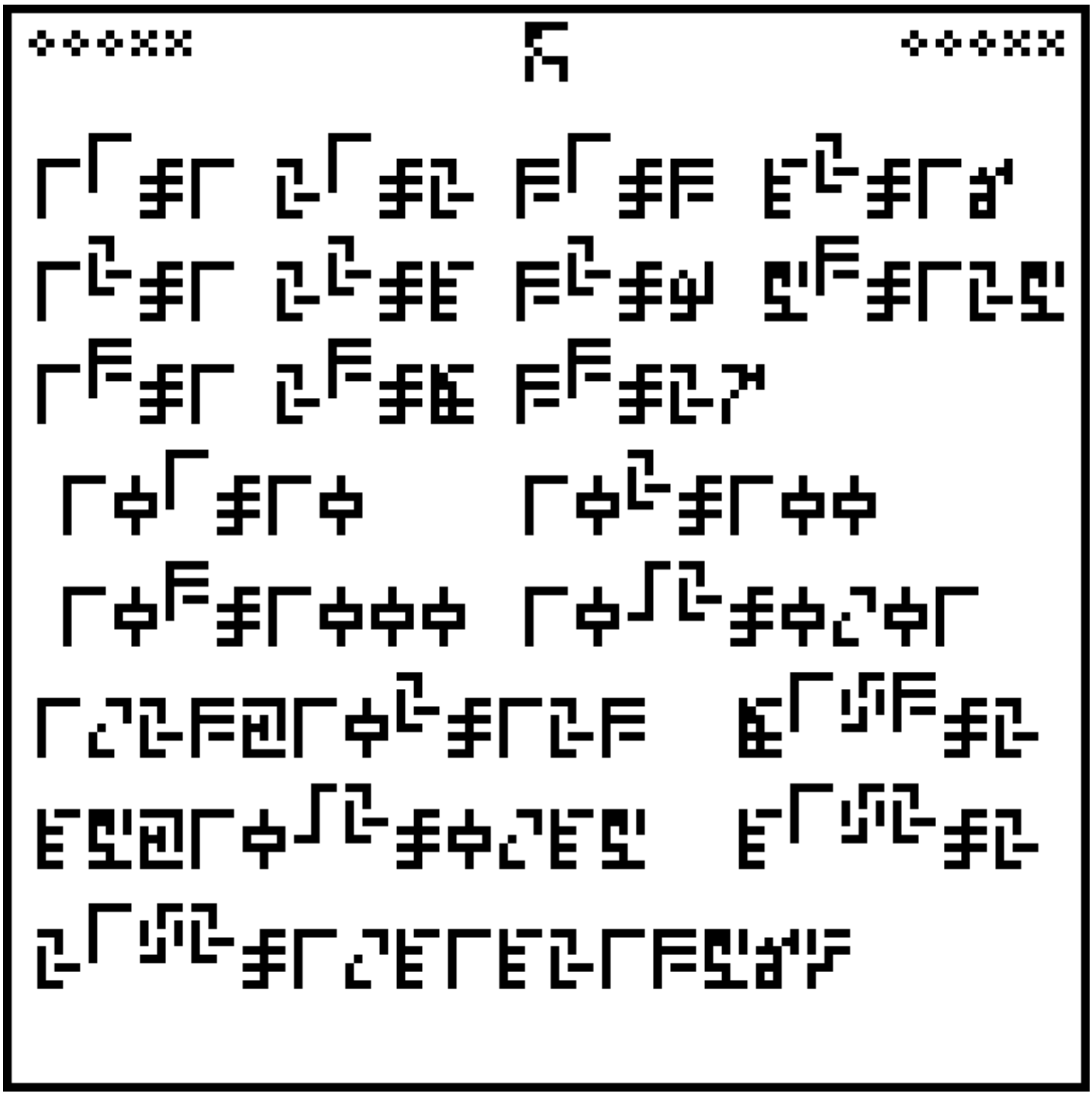
The Universe of Discourse

Fri, 14 Aug 2015

A message to the aliens, part 3/23 (exponentiation)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic)

This is page 3 of the *Cosmic Call* message. An explanation follows.



Reminder: page 1 explained the ten digits:

And the equal sign  . Page 2 explained the four basic arithmetic operations and some associated notions:

addition subtraction multiplication division negation ellipsis (…) decimal indeterminate point

This page, headed with the glyph for "mathematics"  , explains notations for exponentiation and scientific notation.

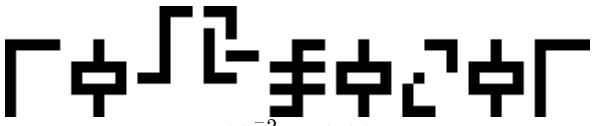
(This notation was first used on page 1 in the mersenne prime  .)

Exponentiation could be represented by an operator, but instead the authors have chosen to represent it by a superscripted position on the page, as is done in conventional mathematical notation. This saves space.

The top section of the page has small examples of exponentiation, including for example $5^3 = 125$:

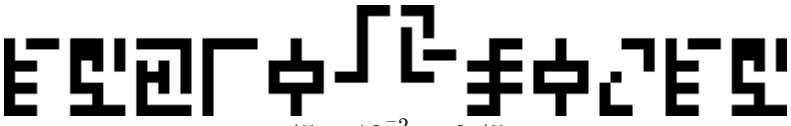
$5^3 = 125$

There is a section that follows with powers of 10: $10^1 = 10, 10^2 = 100, 10^3 = 1000$, and more interestingly $10^{-2} = 0.01$:



$10^{-2} = 0.01$

This is a lead-in to the next section, which expresses various quantities in scientific notation, which will recur frequently later on. For example, 0.045 can be written as 45×10^{-2}:

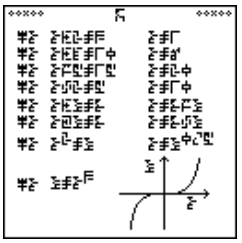


$45 \times 10^{-2} = 0.45$

Finally, there is an offhand remark about the approximate value of the square root of 2:

$2^{1 \div 2} = 1.41421356\ldots$

The next article will discuss page 4, shown at right. (Click to enlarge.) Try to figure it out before then.



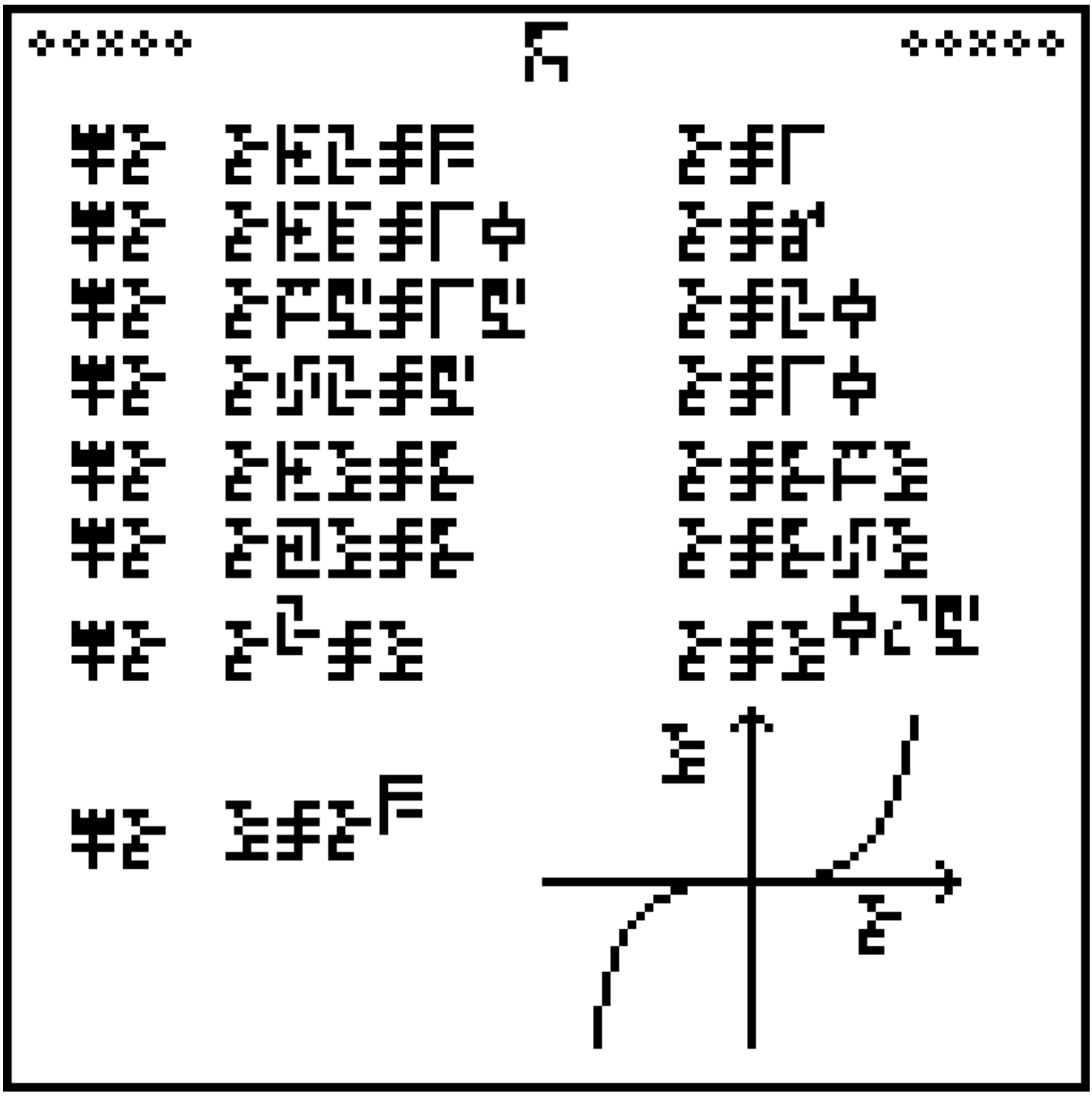
The Universe of Discourse

Mon, 17 Aug 2015

A message to the aliens, part 4/23 (algebra)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents)

This is page 4 of the *Cosmic Call* message. An explanation follows.



Reminder: [page 1](BLOGREF/aliens/dd/p01.html) explained the ten digits:

And the equal sign  . [Page 2](BLOGREF/aliens/dd/p02.html) explained the four basic arithmetic operations and some associated notions:

addition subtraction multiplication division negation ellipsis (…) decimal point indeterminate

This page, headed with the glyph for "mathematics"  , describes the solution of simple algebraic equations and defines glyphs for three variables, which we may as well call $x, y,$ and z:

x y z

Each equation is introduced by the locution  which means "solve for x". This somewhat peculiar "solve" glyph will not appear again until page 23.

For example the second equation is $x + 4 = 10$:

Solve for x: $x + 4 = 10$

The solution, 6, is given over on the right:

$x = 6$

After the fourth line, the equations to be solved change from simple numerical equations in one variable to more abstract algebraic relations between three variables. For example, if

Solve for x: $x \cdot y = z$

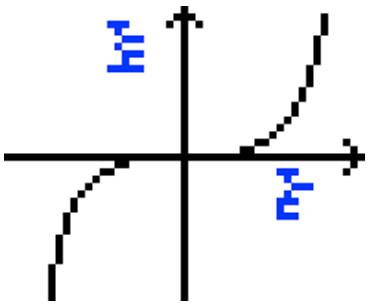
then

$x = z \div y.$

The next-to-last line uses a decimal fraction in the exponent, 0.5:  . On the previous page, the rational fraction $1 \div 2$ was used. Had the same style been followed, it would have looked like this:

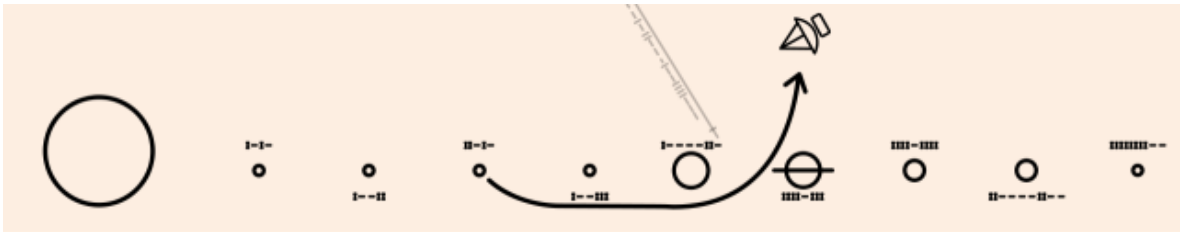
.

Finally, the last line defines $x = y^3$ and then, instead of an algebraic solution, gives a graph of the resulting relation, with axes labeled. The scale on the axes is not the same; the x-coordinate increases from 0 to 20 pixels, but the y-coordinate increases from 0 to 8000 pixels because $20^3 = 8000$. If axes were to the same scale, the curve would go up by 8,000 pixels. Notice that the curve does not peek above the x-axis until around $x = 8, y = 512$ or so. The authors could have stated that this was the graph of $y = x^3 \div 400$, but chose not to.



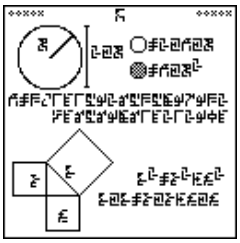
I also wonder what the aliens will make of the arrows on the axes. I think the authors want to show that our coordinates increase going up and to the left, but this seems like a strange and opaque way to do that. A better choice would have been to use a function with an asymmetric graph, such as $y = 2^x$.

(After I wrote that I learned that similar concerns were voiced about the use of a directional arrow in the Pioneer plaque.



(Wikipedia says: “An article in Scientific American criticized the use of an arrow because arrows are an artifact of hunter-gatherer societies like those on Earth; finders with a different cultural heritage may find the arrow symbol meaningless.”)

The next article will discuss page 5, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

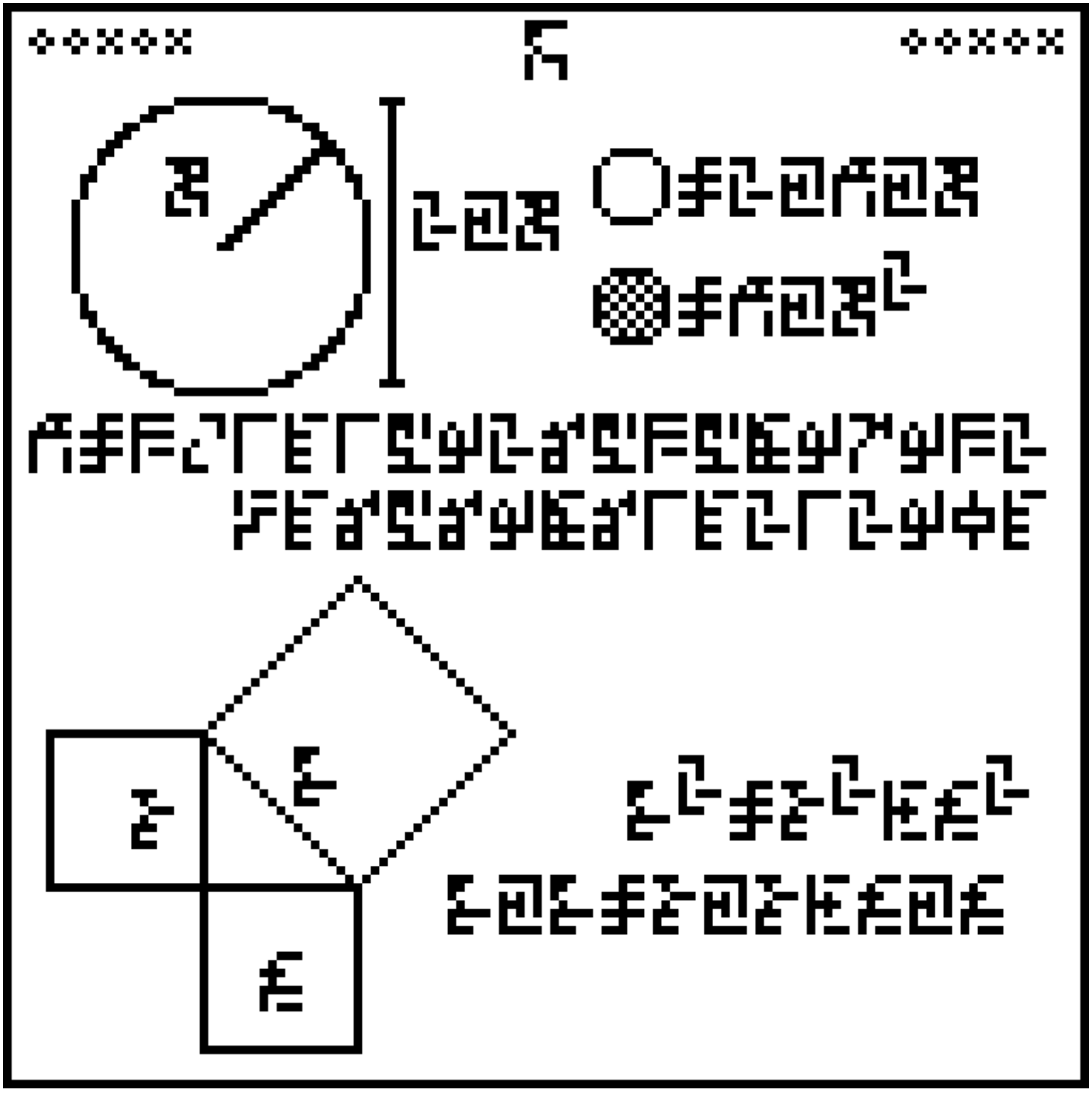
The Universe of Discourse

Wed, 19 Aug 2015

A message to the aliens, part 5/23 (geometry)

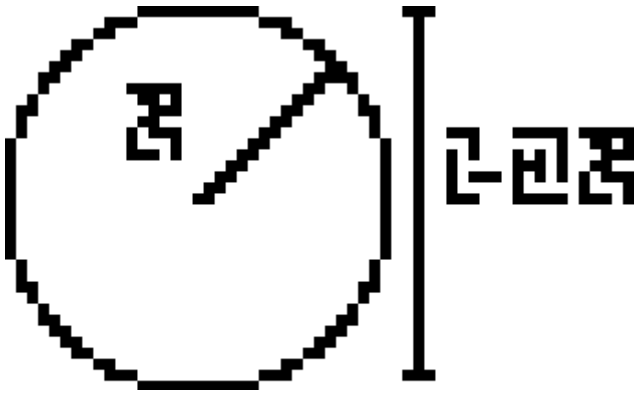
Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra)

This is page 5 of the *Cosmic Call* message. An explanation follows.



The 10 digits again:

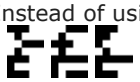
Page 5 discusses two basic notions of geometry. The top half concerns circles and introduces π. There is a large circle with its radius labeled  :



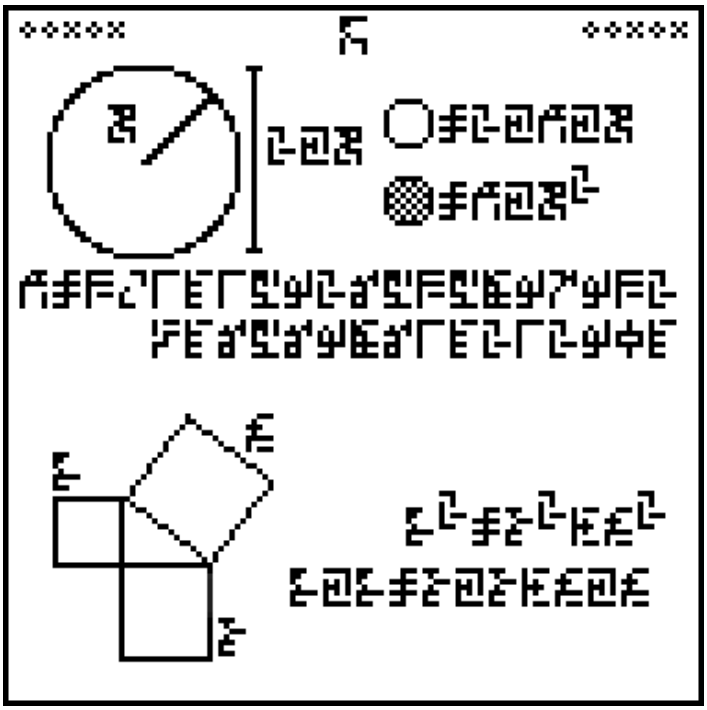
The outer diameter is then  which is $2 \cdot r$.

The perimeter  is twice  times the radius  , and the area  is times the square of the radius .

What is  ? It's π of course, as the next line explains, giving $\pi = 3.1415926545697932\ldots365698614212904$, which gives enough digits on the front to make clear what is being communicated. The trailing digits are around the 51 billionth places and communicate part of the state of our knowledge of π. I almost wish the authors had included a sequence of fifteen random digits at this point, just to keep the aliens wondering.

The bottom half of the page is about the pythagorean theorem. Here there's a rather strange feature. Instead of using the three variables from the previous page,  , the authors changed the second one and used  instead. This new  glyph does not appear anywhere else. A mistake, or did they do it on purpose?

In any case, the pythagorean formula is repeated twice, once with exponents and once without, as both $z^2 = x^2 + b^2$ and $z \cdot z = x \cdot x + b \cdot b$. I think they threw this in just in case the exponentiation on the previous pages wasn't sufficiently clear. I don't know why the authors chose to use an isosceles right triangle; why not a 3–4–5 or some other scalene triangle, for maximum generality? (What if the aliens think we think the pythagorean theorem applies only for isosceles triangles?) But perhaps they were worried about accurately representing any funny angles on their pixel grid. I wanted to see if it would fit, and it does. You have to make the diagram smaller, but I think it's still clear:



(I made it smaller than it needed to be and then didn't want to redo it.)

I hope this section will be sufficiently unmistakable that the aliens will see past the oddities.

The next article will discuss page 6, shown at right. (Click to enlarge.) Try to figure it out before then.

[Other articles in category /aliens/dd] permanent link

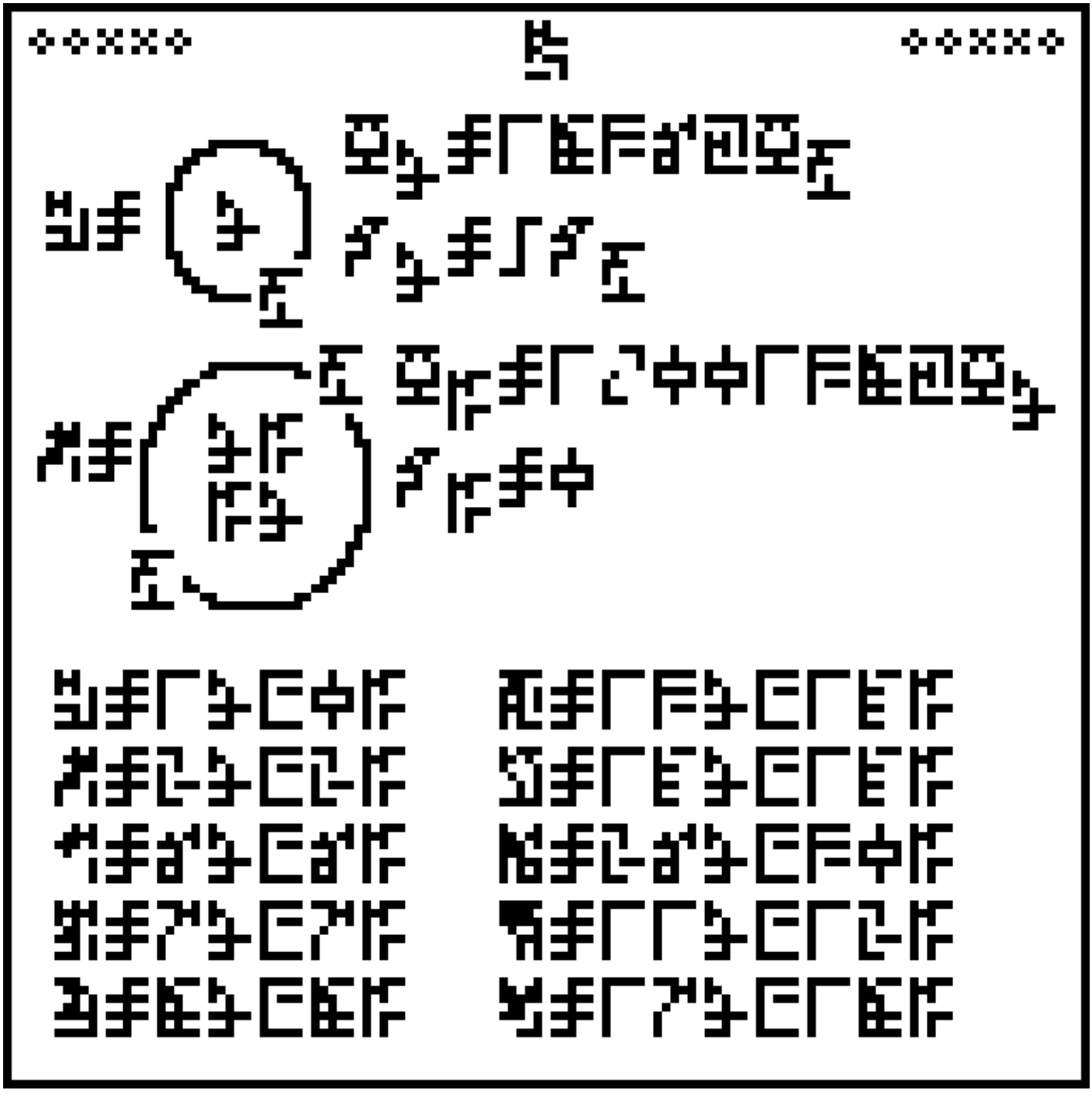
The Universe of Discourse

Fri, 21 Aug 2015

A message to the aliens, part 6/23 (chemistry)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry)

This is page 6 of the *Cosmic Call* message. An explanation follows.



The 10 digits again:

Page 6 discusses fundamental particles of matter, the structure of the hydrogen and helium atoms, and defines glyphs for the most important chemical elements.

Depicted at top left is the hydrogen atom, with a proton in the center and an electron circulating around the outside. This diagram is equated to the glyph for hydrogen.

The diagram for helium is similar but has two electrons, and its nucleus has two protons and also two neutrons.

Proton Neutron Electron

The illustrations may puzzle the aliens, depending on how they think of atoms. (Feynman once said that this idea of atoms as little solar systems, with the elctrons traveling around the nucleus like planets, was a hundred years old and out of date.) But the accompanying mass and charge data should help clear things up. The first formula says

$$M_p = 1836 \cdot M_e$$

the mass of the proton is 1836 times the mass of the electron, and that 1836, independent of the units used and believed to be a universal and fundamental constant, ought to be a dead giveaway about what is being discussed here.

If you want to communicate fundamental constants, you have a bit of a problem. You can't tell the aliens that the speed of light is $1.8 \cdot 10^{12}$ furlongs per fortnight without first explaining furlongs and fortnights (as is actually done on a later page). But the proton-electron mass ratio is dimensionless; it's 1836 in *every* system of units. (Although the value is actually known to be 1836.15267; I don't know why a more accurate value wasn't given.)

This is the first use of subscripts in the document. It also takes care of introducing the symbol for mass. The following formula does the same for charge : $Q_p = -Q_e$.

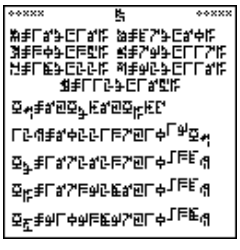
The next two formulas, accompanying the illustration of the helium atom, describe the mass (1.00138 protons) and charge (zero) of the neutron. I wonder why the authors went for the number 1.00138 here instead of writing the neutron-electron mass ratio of 1838 for consistency with the previous ratio. I also worry that this won't be enough for the aliens to be sure about the meaning of . The 1836 is as clear as anything can be, but the 0 and -1 of the corresponding charge ratios could in principle be a lot of other things. Will the context be enough to make clear what is being discussed? I suppose it has to; charge, unlike mass, comes in discrete units and there is nothing like the 1836.

The second half of the page reiterates the symbols for hydrogen and helium and defines symbols for eight other chemical elements. Some of these appear in organic compounds that will be discussed later; others are important constituents of the Earth. It also introduces symbol for "union" or "and": . For example, sodium is described as having 11 protons and 12 neutrons.

Hydrogen Helium Carbon Nitrogen Oxygen Aluminium Silicon Iron Sodium Chlorine

Most of these new glyphs are not especially mnemonic, except for hydrogen—and aluminium, which is spectacular.

The blog is going on hiatus until early September. When it returns, the next article will discuss page 7, shown at right. It has **three errors**. Can you find them? (Click to enlarge.)



[Other articles in category /aliens/dd] permanent link

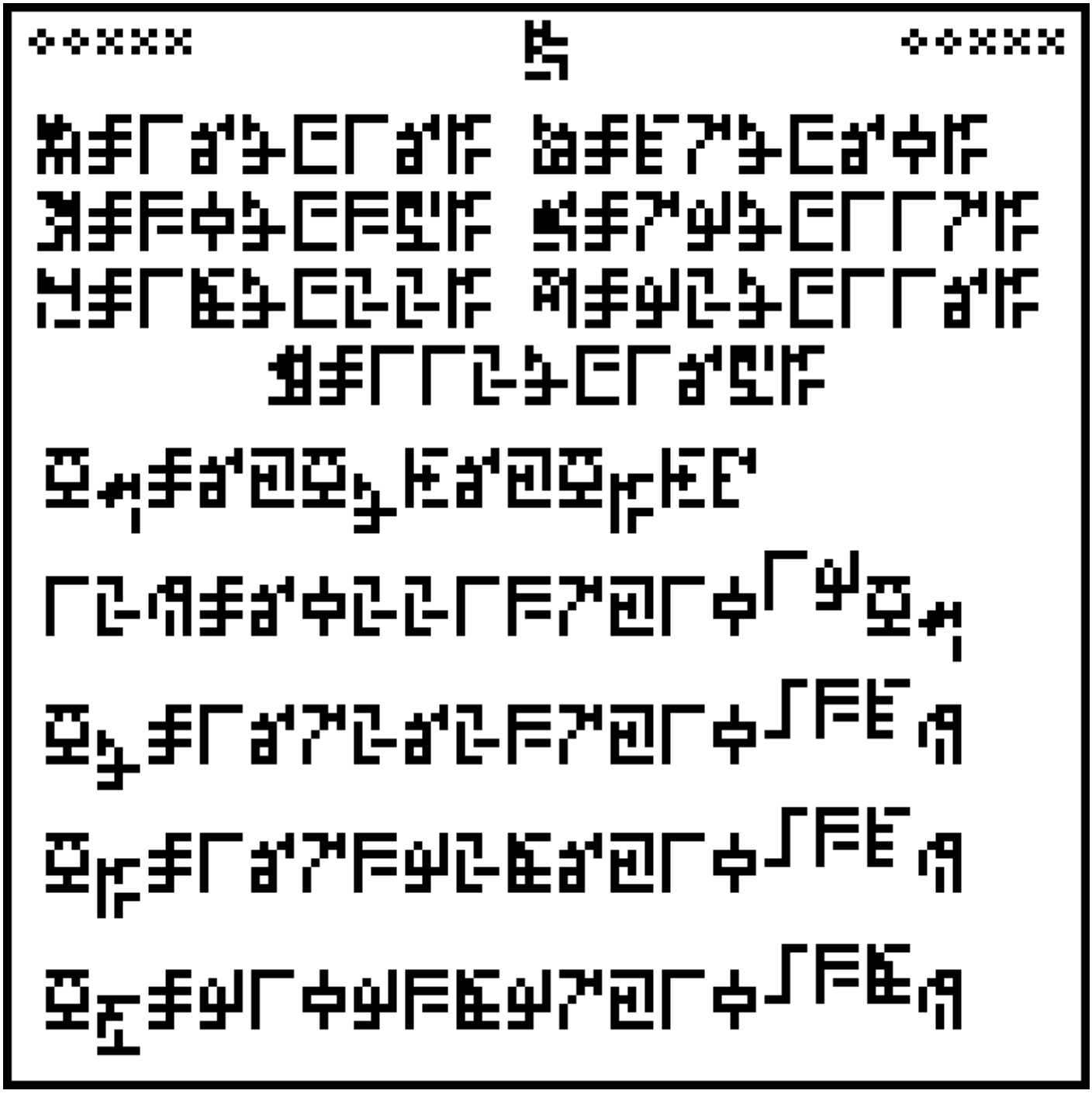
The Universe of Discourse

Wed, 09 Sep 2015

A message to the aliens, part 7/23 (mass)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry)

This is page 7 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

Page 7 discusses mass and defines the kilogram.

The top section of the page continues the table of chemical elements from the previous page, giving the number of

protons and neutrons. For example, gold  is described as having 79 protons  and 117 neutrons  .


Sulfur Zinc Argon Silver Gold Uranium Copernicium

Copernicium, element 112, had been discovered but not named at the time the document was written.

There is a major error here. Uranium  is given as having 92 protons and 116 neutrons. There is no such substance. It should have said 146 neutrons.

I sometimes imagine the aliens, having received the message, come to visit us. "We weren't going to bother," they say, "but we had to know about the uranium-208." And then we will have to tell them that we messed up. Ouch. (It could be an error for lead-208 or bismuth-208 instead; one can't be sure because the glyph does not appear elsewhere in the document.)

I'd been planning to write that paragraph about uranium-208 for more than ten years, but it wasn't until just now that I realized there is a much more serious mistake two lines down, so that the uranium is no longer the most serious error that I know of in the entire document. The line after the table of elements says that the mass of a carbon atom is the mass of six protons plus the mass of six neutrons plus "energy",  , by which I think they mean the binding energy in the nucleus. This is the first appearance of the glyph for energy, which will recur later. And then the following line commits a really horrible boner, one that has the potential to spoil the whole message.

With the mass of the carbon nucleus pinned down, the authors want to define the kilogram  : the document says that 12 kilograms is the mass of $6022137 \cdot 10^{19}$ carbon-12 atoms. That $6022137 \cdot 10^{19}$ is Avogadro's number. Except it's not. Avogadro's number is usually given as $6.022137 \cdot 10^{23}$, and this number is 100 times that big. But it should be 1000 times that big.

Normally, one would say that $6.022137 \cdot 10^{23}$ carbon atoms mass 12 grams, but there are two confusing factors here. One is that the authors have written 6022137 instead of 6.022137 and the other is that they are defining 12 *kilograms* instead of 12 *grams*. But it should be that $6.022137 \cdot 10^{23} = 6022137 \cdot 10^{17}$ atoms is 12 grams so that 602213710^{20} atoms is 12 kilograms, and the number written is instead 602213710^{19} atoms, making the kilogram 90% smaller than it should have been.

It's possible that the aliens can figure this out, because it is detectably inconsistent with the following statements about the masses of the fundamental particles in kilograms. But it may not be clear to the recipients which of the two definitions of the kilogram is the correct one. Especially given the—I really hate to report this—the typo in the second statement.

The three following lines give the masses of the proton, neutron, and electron in kilograms. These are all more or less correct (although the book values have changed since the message were written) and I think the value for the neutron has a typo; it says $1.6739286 \cdot 10^{-34}$ kg but it probably should have been $1.674\mathit{9}286 \cdot 10^{-34}$ kg which would agree with the current book value of $1.674927351 \cdot 10^{-34}$ kg.

Since we're going over the errors on this page, here is yet another oddity. The number of neutrons in a gold atom  is given at the top of the page as 117. Unlike uranium-208., the isotope gold-196 actually exists. But it is radioactive, breaking down into platinum or mercury after about a week. One would expect the listing to be for gold-197 instead, which is the only stable isotope and so is the only isotope occurring in naturally-found gold. (Thanks to Peter Annema for bringing this to my attention.) A similar oddity occurs in the listing for zinc  : zinc-65 is given instead of the stable zinc-64 or zinc-66. The other isotopes listed here (sulfur-32, argon-40, silver-107) are more plausible.

The next article will discuss page 8, shown at right. (Click to enlarge.) Try to figure it out before then.

[Other articles in category /aliens/dd] permanent link

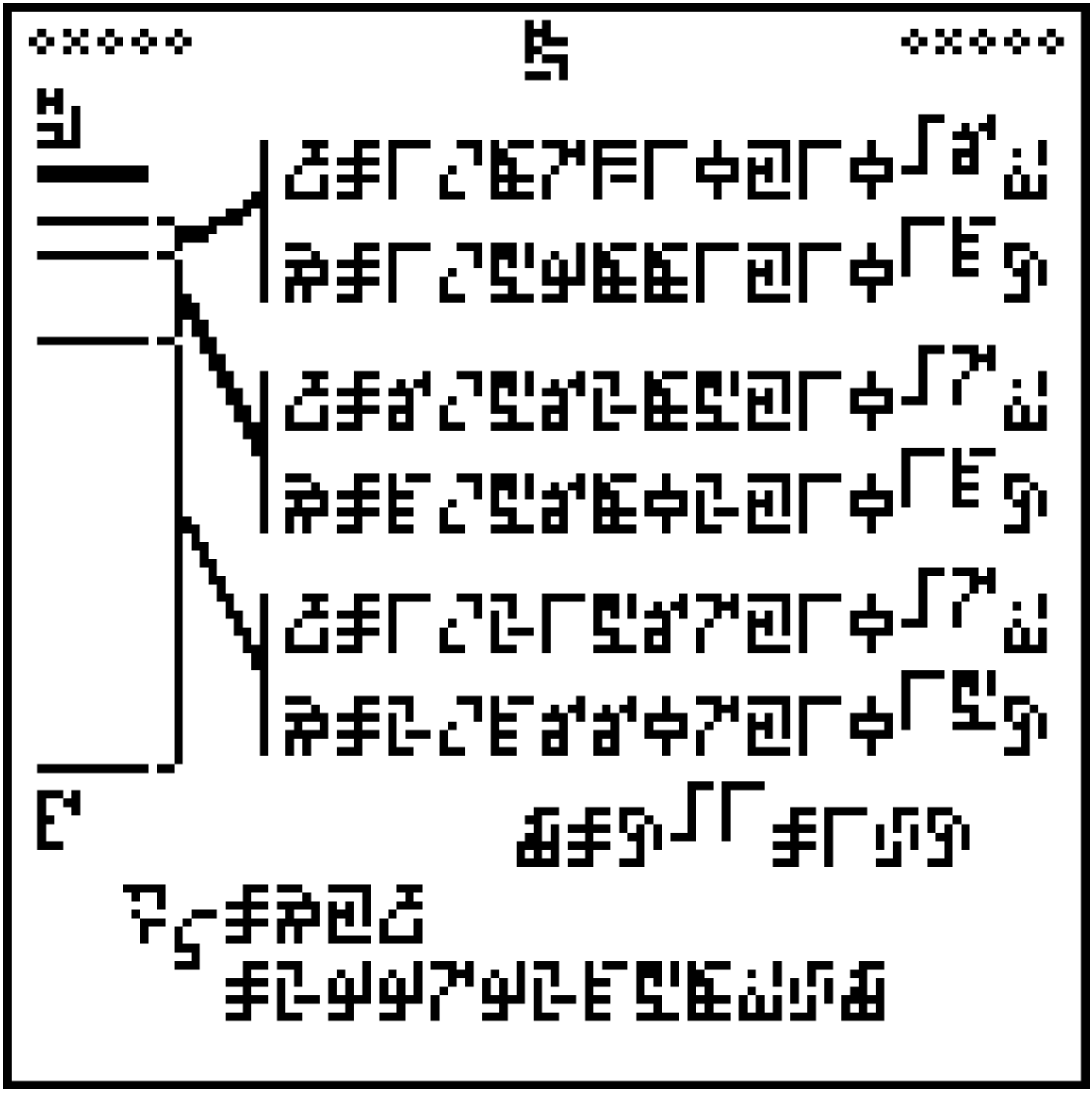
The Universe of Discourse

Fri, 11 Sep 2015

A message to the aliens, part 8/23 (time and space)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass)

This is page 8 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

The main feature of this page is a diagram of the electron energy levels for a hydrogen atom, annotated at the top with the glyph for hydrogen  and at the bottom with the glyph for energy  . The four lowest levels are shown, with the lowest level (the ground state) at the bottom. Above these is a thicker bar representing the way the higher energy levels

all pile up into a smear. If the bottom level is at 0 and the smear is at 1, then the three intermediate levels are shown at approximately their exact values of $\frac{3}{4}$, $\frac{8}{9}$, and $\frac{15}{16}$; these are given by the Rydberg formula.

The aliens should be familiar with hydrogen. Normally a hydrogen atom's sole electron is in the ground state. If a photon couples with the electron, say because starlight is falling on the atom, or someone has applied an electric current to it, the electron may jump up to a higher quantum state. (This is the only correct use of the phrase "quantum leap".) When it drops back down, it will emit a photon. But the energy of the emitted photon must be one of a few particular values, corresponding to the difference between the old and the new energy level; the electron never drops down partway to the next level. An incandescent cloud of hydrogen gas will not typically glow in every possible color; it will emit light in only a few particular, characteristic wavelengths, and these colors can be separated with a spectroscope. The wavelengths of these characteristic colors of light, visible everywhere the message is likely to reach, provide a basis for defining the meter.

For example, the second pair of numbers labels the transition from the $n = 3$ to the $n = 2$ state, and an electron transiting between these two states will always emit a photon with a wavelength of 656.2852 nanometers and a frequency of 456.8021 terahertz, and these are the two numbers in the pair. The product of the two numbers in each pair is a constant, which should further confirm to the recipients that they have the right interpretation. The constant product is close to 299792458, which is the speed of light in meters per second. This defines four glyphs, for wavelength and frequency, and meters and hertz.

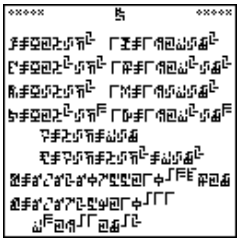
wavelength frequency meters hertz seconds

The following item

defines the second as the inverse of the hertz (written as Hz^{-1} and as $1 \div \mathrm{Hz}$).

Finally, the speed of light is given, first theoretically, as the product of wavelength and frequency and then numerically, as 299792458 meters per second.

The next article will discuss page 9, shown at right. (Click to enlarge)
Try to figure it out before then.



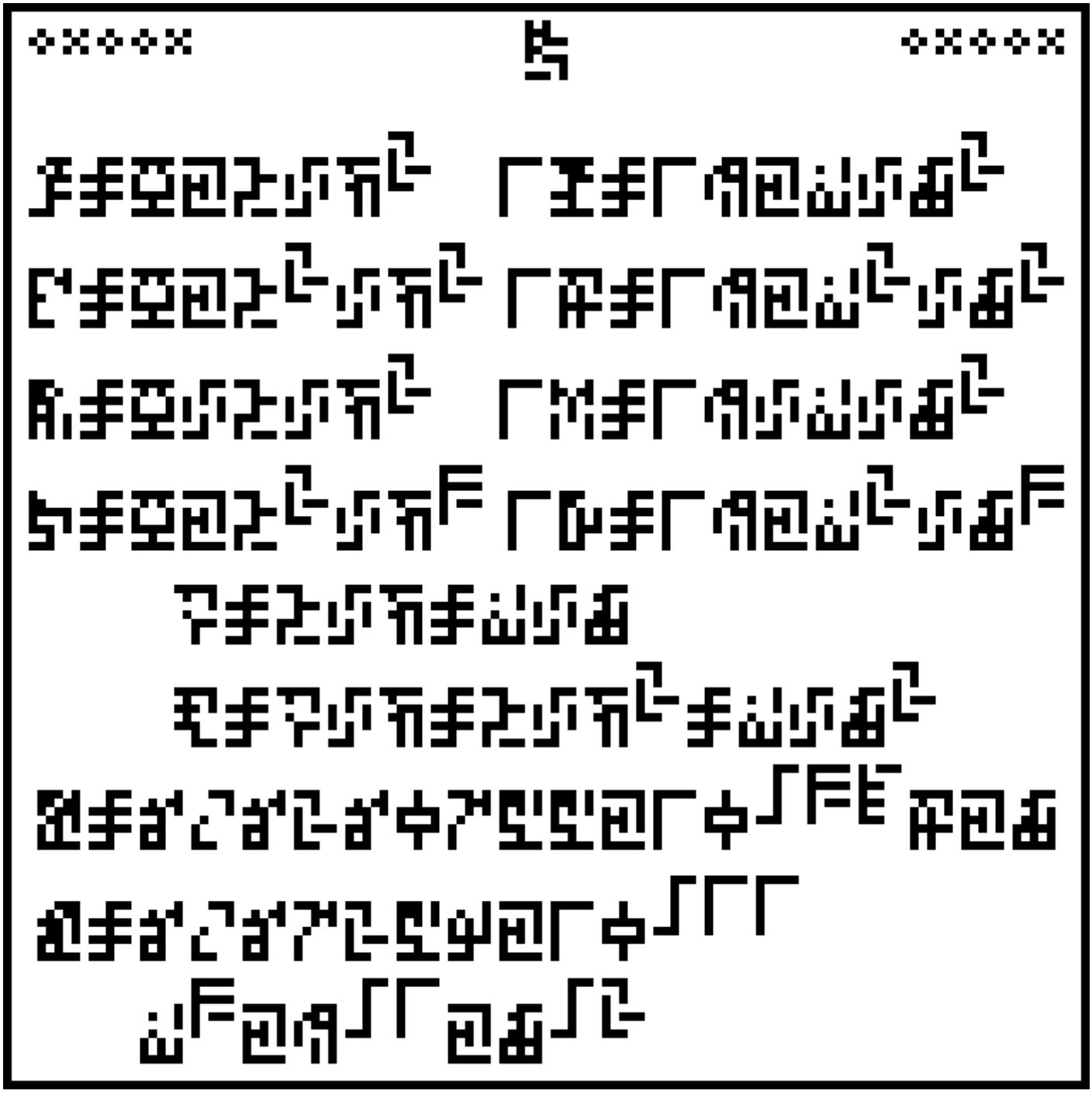
The Universe of Discourse

Mon, 14 Sep 2015

A message to the aliens, part 9/23 (physical units)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space)

This is page 9 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

The previous two pages defined fundamental units of mass, distance, and time. This page adds some derived notions: force, energy, pressure, and power; velocity and acceleration.

The first four lines are in two parts each. The left part defines an abstract quantity like force or energy; the right part

defines a unit of that quantity like newtons or joules. For example, the second line defines energy and units of energy. The left side says that energy  is equal to mass  times distance  squared divided by time  squared. (This is the first appearance of the glyphs for distance and time.) The right side says that a joule  of energy is $1 \frac{\mathrm{kg\ m^2}}{\mathrm{s^2}}$.

The two following lines define the abstract concepts of velocity  (which has appeared before in connection with the speed of light) and acceleration  (which is new). There are no units given for these.

Concept	 force	 energy	 pressure	 power	 velocity	 acceleration
Unit	 newton	 joule	 pascal	 watt	(none)	(none)

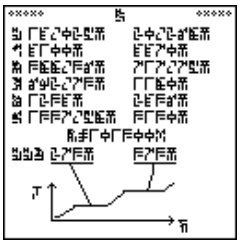
The newton and the joule won't appear again. Force won't appear again except on the last page, which asks “force WTF?”.

The final part of the page is the most interesting. It mentions the Planck constant h  (not the related $\hbar$) which is $6.6260755 \cdot 10^{-34}$ joule-seconds and the universal gravitation constant G  which is $6.67259 \cdot 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$.

It's quite possible that the recipients won't recognize the gravitational constant, which is tricky to measure directly. Newton's law of universal gravitation was known on Earth for hundreds of years before the value of G was worked out. But if the recipients don't know it, they will be able to work it out from the later statements about the mass and radius of the Earth and the gravitational force at its surface, This would in turn allow them to calculate the mass of their own planet.

Note that on this page some inverse units are written with a division sign and some with a negative exponent. Will this inconsistency puzzle the aliens? My coworker Jeff Ober suggests that it communicates the important personal information that humans are confused and inconsistent.

The next article will discuss page 10, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

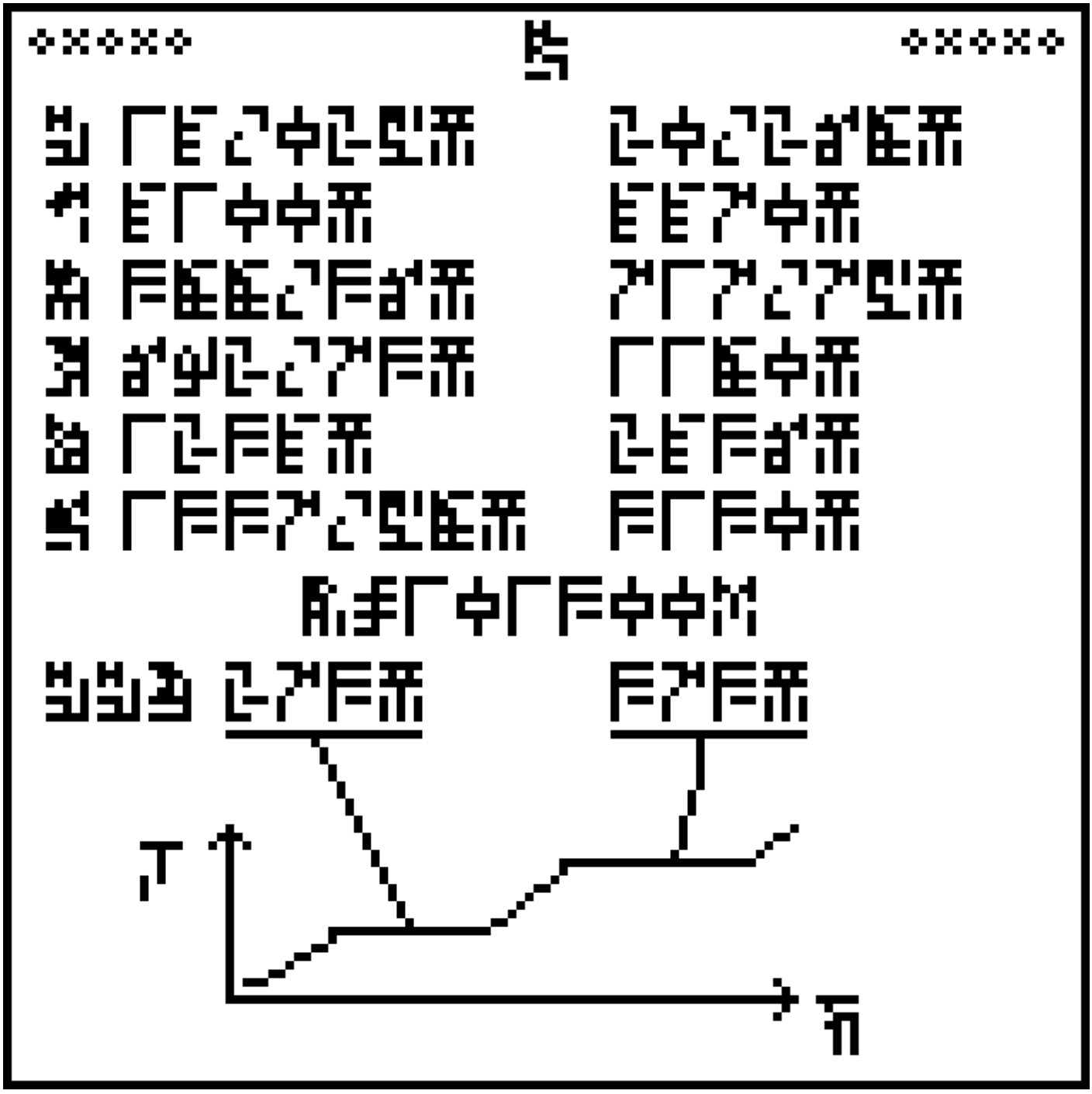
The Universe of Discourse

Wed, 16 Sep 2015

A message to the aliens, part 10/23 (temperature)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units)

This is page 10 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

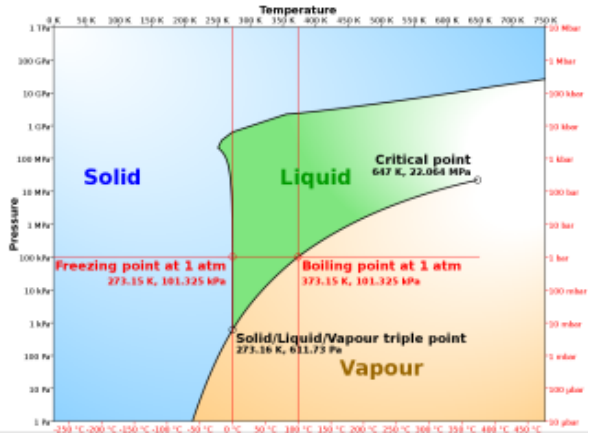
The top half of this page is a table of melting points (on the left) and boiling points (on the right) for various substances: hydrogen, carbon, sulfur, zinc, silver, and gold. The temperatures are given in kelvins.

The boiling points depend on pressure, so there is a notation at the bottom of the list that the pressure should be 101300 pascals. This is one standard atmosphere, so it may tell the aliens a little more about our planet.

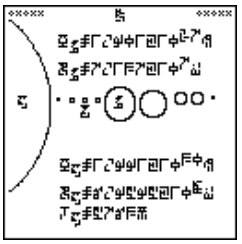
To help calibrate the kelvins, the bottom of the page is a chart of the temperature increase of water, showing how the temperature stops increasing at the melting point (273K) and the boiling point (373K). This introduces the glyph for temperature, which will recur later.

There are two regrettable things about this chart. One is that the horizontal axis is labeled "time". Why is the temperature of the water increasing with time? It should be energy.

But a more serious complaint, I think, it that this is the wrong chart. It depends crucially on the (Earth-)standard atmospheric pressure, with which the recipients may not be familiar. And the kelvin is not defined in terms of standard pressure anyway. It is defined in terms of the triple point of water, the unique, universal temperature and pressure at which all three states of water can coexist. Why not a temperature and pressure chart with the triple point labeled? This is something one might more reasonably expect the aliens to have studied.



The next article will discuss page 11, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

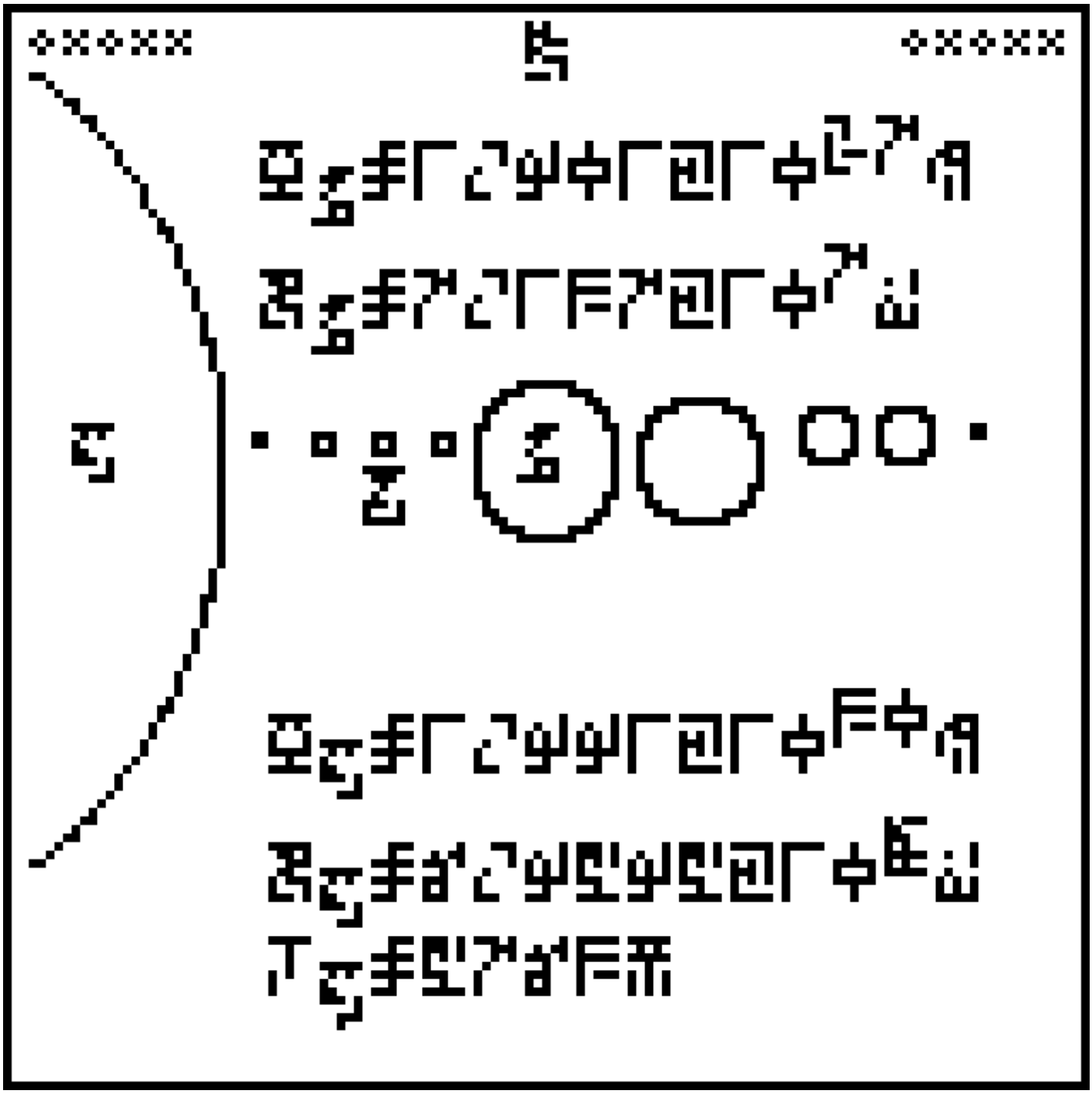
The Universe of Discourse

Fri, 18 Sep 2015

A message to the aliens, part 11/23 (solar system)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature)

This is page 11 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

Page 11, headed with the glyph for "physics" is evidently a chart of the solar system, with the Sun at left. The

Earth  is also labeled, as is Jupiter  , the planet most likely to be visible to the recipients. The "Jupiter" glyph does not appear again. Pluto is included, as it was still considered a planet in 1999. (Pluto's status as only one of many similar trans-Neptunian objects was not well appreciated in 1999 when the message was composed, the second TNO having only been discovered in 1992.) To the extent permitted by the low resolution of the image, The diameters of the planets and the Sun are to scale, but not their relative positions; the page is much too small for that. Saturn's rings are not shown, as they are in the Pioneer plaque; by this time it was appreciated that ring systems may be common around large planets.

The masses  and radii  of Jupiter and the Sun are given, Jupiter above the illustration and the Sun below. The (external) temperature  of the Sun is also given, 5763 kelvins. This should be visible to the aliens because the Sun is a blackbody emitter and the spectrum of blackbody radiation is a clear indicator of its temperature. This data should allow the aliens to locate us, should they be so inclined: they know which way the message came from, and can look for a star with the right size and temperature in that direction. When they get closer, Jupiter and the sizes of the planets will provide a confirmation that they are in the right place. Later pages explain that we live on the Earth, so the aliens will know where to point their fusion cannon in order to obliterate our planet.

The next article will discuss page 12, shown at right. (Click to enlarge.) Try to figure it out before then.

[Other articles in category /aliens/dd] permanent link

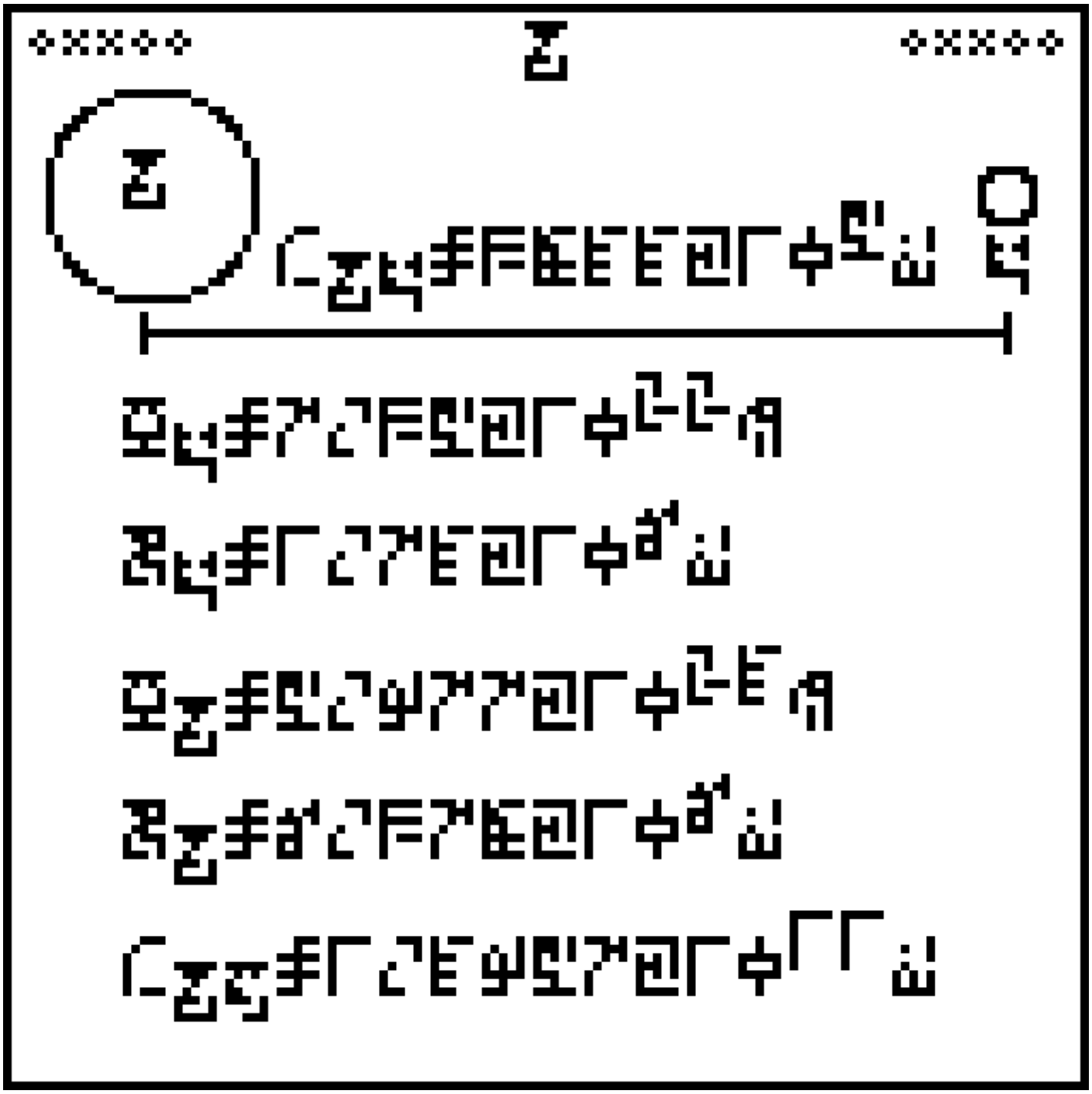
The Universe of Discourse

Mon, 21 Sep 2015

A message to the aliens, part 12/23 (earth-moon system)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system)

This is page 12 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

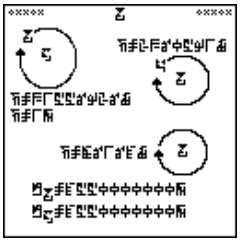
Page 12, begins a new section of the document, with pages headed with the glyph  "Earth", describing the Earth and its environs. This will help the recipients locate our planet, should they come to visit.

The top of the page has a diagram of the Earth -Moon system and a ruler labeled with the distance between them, $3844 \cdot 10^5$ meters. Since the distance between Earth and Moon varies (the orbit is elliptical) an average value is given.

The glyph used here for distance, , is different from the one defined on page 9 . Neither appears elsewhere in the message, so this is probably a mistake.

The following five lines give the mass and radius of the Moon and the Earth, and also the distance from the Earth to the Sun. The latter would have been better on the previous page, which discussed the solar system, but was omitted from there for some reason.

The next article will discuss page 13, shown at right. (Click to enlarge.) Try to figure it out before then.



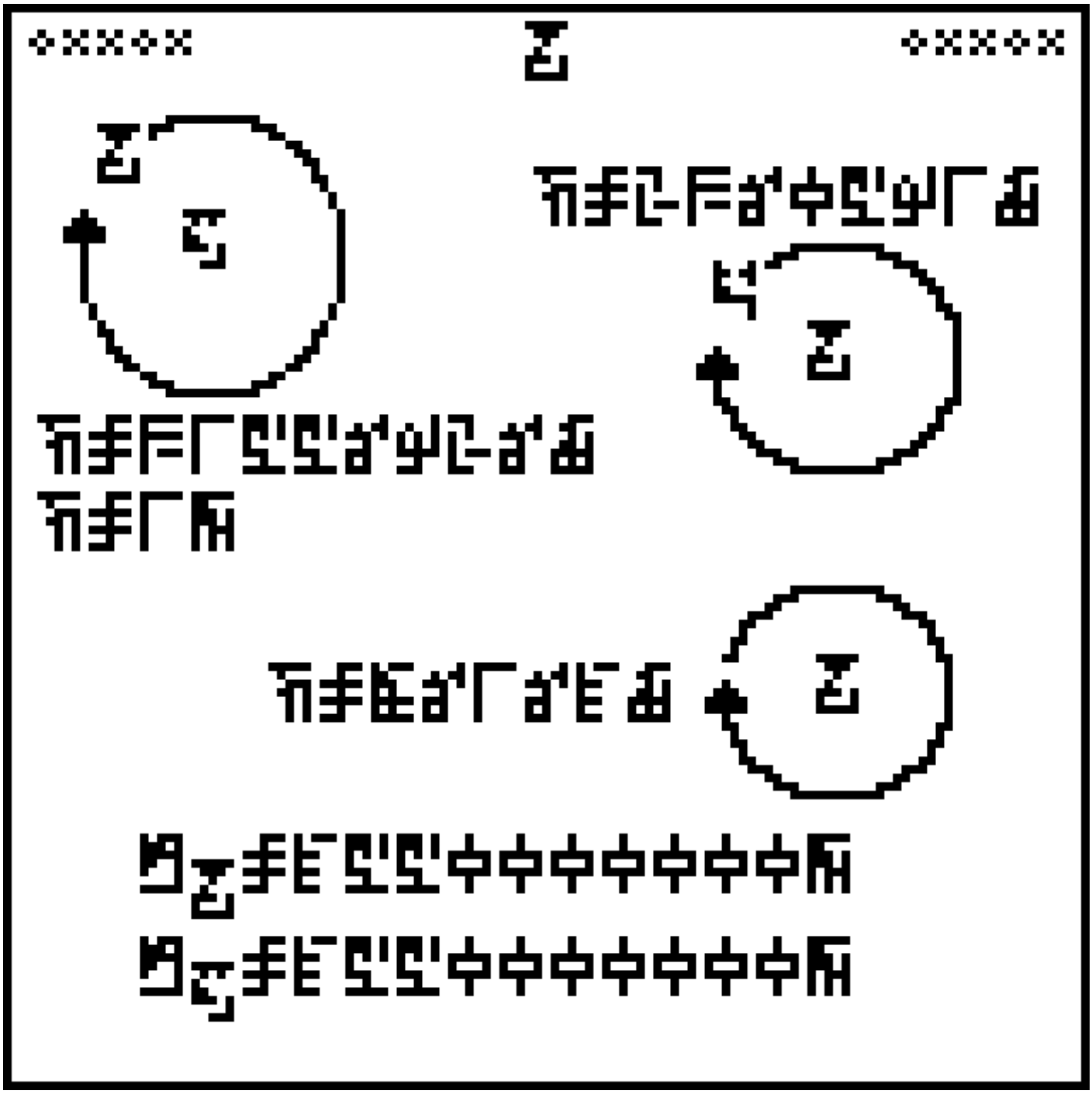
The Universe of Discourse

Wed, 23 Sep 2015

A message to the aliens, part 13/23 (days, months, and years)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system)

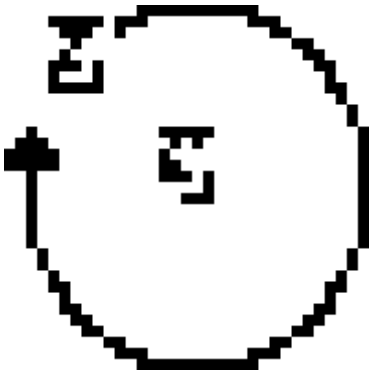
This is page 13 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

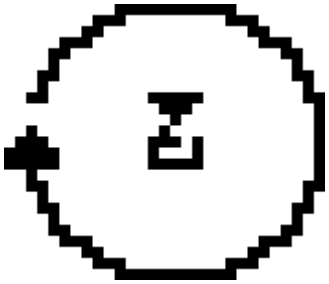
There are three diagrams on this page, each depicting something going around. Although the direction is ambiguous (unless you understand arrows) it should at least should be clear that all three rotations are in the same direction. This is all you can reasonably say anyhow, because the rotations would all appear to be going the other way if you looked at

them from the other side.



The upper left diagram depicts the Earth going around the Sun and underneath is a note that says that the time is equal to 315569268 seconds, and is also equal to one year. This defines the year.

The upper-right diagram depicts the Moon going around the Earth; the notation says that this takes 2360591 seconds, or around 27⅓ days. This is not the 29½ days that one might naïvely expect, because it is the sidereal month rather than the synodic month. Suppose the phase of the Moon is new, so that the Moon lies exactly between the Earth and the Sun. 27⅓ days later the Moon has made a complete trip around the Earth, but because the Earth has moved, the Moon is not yet again on the line between the Earth and the Sun; the line is in a different direction. The Earth has moved about !!\frac1{13}!! of the way around the sun, so it takes about another !!\frac1{12}\cdot 27\frac13!! days before the moon is again between Earth and Sun and so a total of about 29½ days between new moons.



The lower-right diagram depicts the rotation of the Earth, giving a time of 86163 seconds for the day. Again, this is not the 86400 seconds one would expect, because it is the sidereal day rather than the solar day; the issue is the same as in the previous paragraph.

None of the three circles appears to be circular. The first one is nearly circular, but it looks worse than it is because the Sun has been placed off-center. The curve representing the Moon's orbit is decidedly noncircular. This is reasonable, because the Moon's orbit is elliptical to approximately the same degree. In the third diagram, the the curve is intended to represent the surface of the Earth, so its eccentricity is indefensible. The ellipse is not the same as the one used for the Moon's orbit, so it wasn't just a copying mistake.

The last two lines state that the ages of the Sun and the Earth are each 4550000000 years. This is the first appearance of the glyph for “age”.

The next article will discuss page 14, shown at right. (Click to enlarge.) Try to figure it out before then.

[Other articles in category /aliens/dd] permanent link

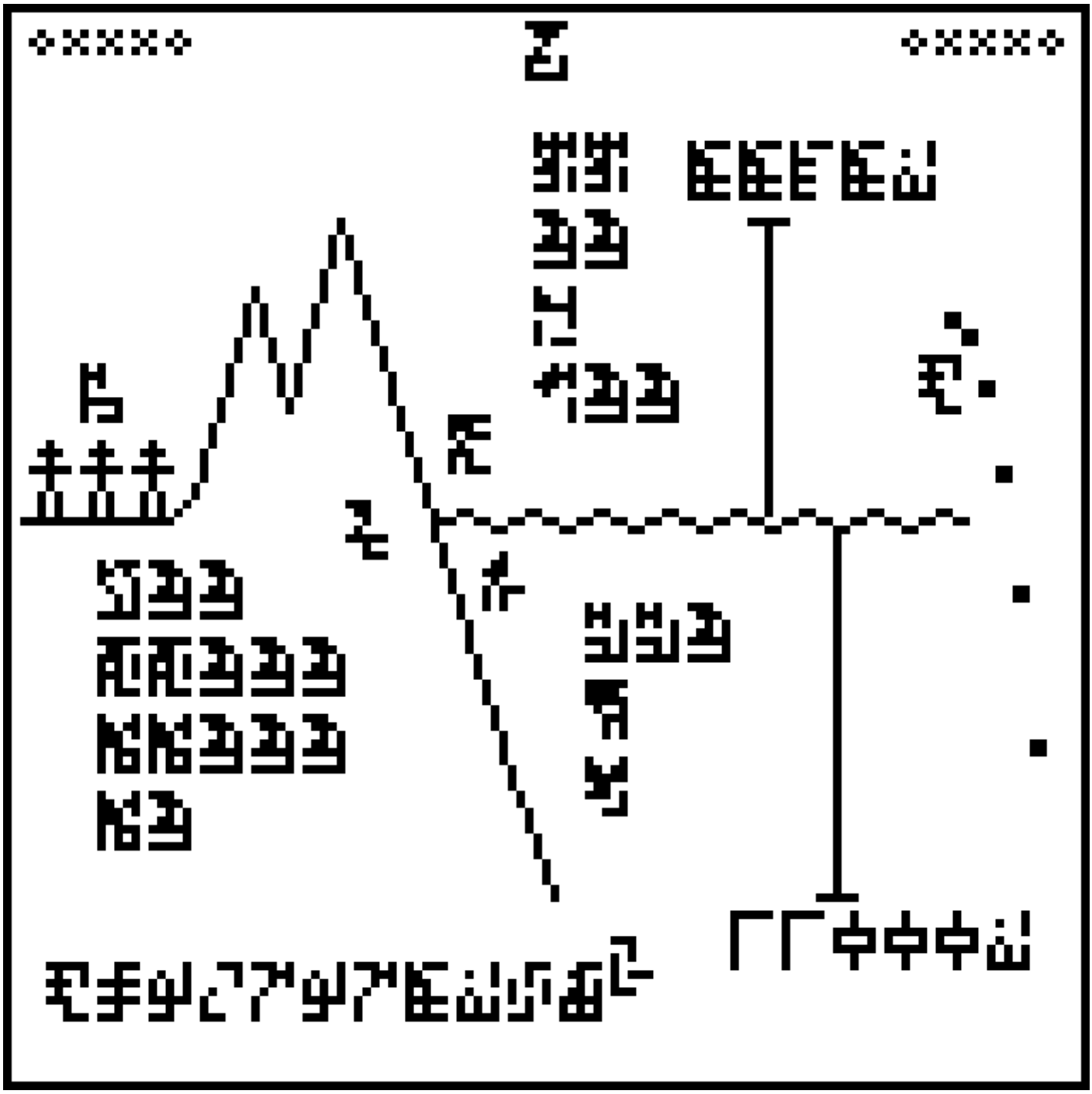
The Universe of Discourse

Fri, 25 Sep 2015

A message to the aliens, part 14/23 (terrain)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years)

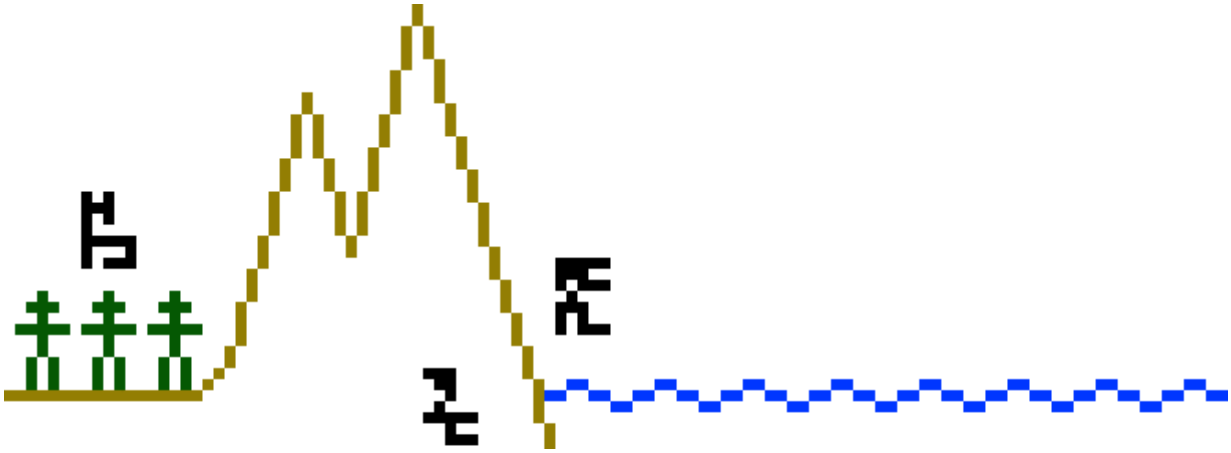
This is page 14 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

This is my favorite page: there is a lot of varied information and the illustration is ingenious. The page heading says  to match up with the corresponding labels on the previous three pages. The page depicts the overall terrain of the Earth.

The main feature is a large illustration of some mountains (yellow in my highlighted illustration below) plunging into the sea (blue).



The land part is labeled , the air part , and the water part . Over on the left of the land part are little stick figures, labeled people . This is to show that people live on the land part of the Earth, not under water or in the air. The stick figures may not be clear to the recipients, but they are explained in more detail on the next page.

Each of the three main divisions is annotated with its general chemical composition, with compounds listed in order of prevalence., All the chemical element symbols were introduced earlier, on pages 6 and 7:

The lithosphere : silicon dioxide (SiO_2) ; aluminium oxide (Al_2O_3) ; iron(III) oxide (Fe_2O_3) ; iron(II) oxide (FeO) . Wikipedia and other sources dispute this listing, giving instead: SiO_2, MgO, FeO, Al_2O_3, CaO, Na_2O, Fe_2O_3 in that order.

The atmosphere : nitrogen gas (N_2) ; oxygen gas (O_2) ; argon (Ar) ; carbon dioxide (CO_2) .

The hydrosphere : water (H_2O) ; sodium (Na) ; chlorine (Cl) .

There are rulers extending upward from the surface of the water to the height of top of the mountain and downward to the bottom of the ocean. The height ruler is labeled 8838 meters, which is the height the peak of Mount Everest, the point highest above sea level. The depth ruler is labeled 11000 meters, which is the depth of the Challenger Deep in the Mariana Trench, the deepest part of the ocean. The two rulers have the correct sizes relative to one another. The human figures at left are not to scale (they would be about 1.7 miles high), but the next page will explain how big they really are.

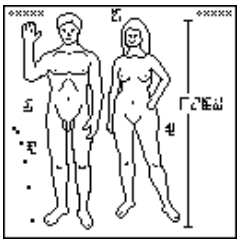
I don't think the message contains anything to tell the recipients the temperature of the Earth, so it may not be clear that the hydrosphere is liquid water. But perhaps the wavy line here will suggest that. The practice of measuring the height of the mountains and depth of the ocean from the surface may also be suggestive of a liquid ocean, since it would not otherwise have a flat surface to provide a global standard.

There is a potential problem with this picture: how will the recipients know which edge is the top? What if they hold it upside-down, and think the human figures are pointing down into the earth, heads downwards?

This problem is solved in a clever way: the dots at the right of the page depict an object accelerating under the influence of gravity, falling in a characteristic parabolic path. To make the point clear, the dots are labeled with the glyph for acceleration.

Finally, the lower left of the page states the acceleration due to gravity at the Earth's surface, 9.7978 m/s^2. The recipients can calculate this value from the mass and radius of the Earth given earlier. Linked with the other appearance of acceleration on the page, this should suggest that the dots depict an object falling under the influence of gravity toward the bottom of the page.

The next article will discuss page 15, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

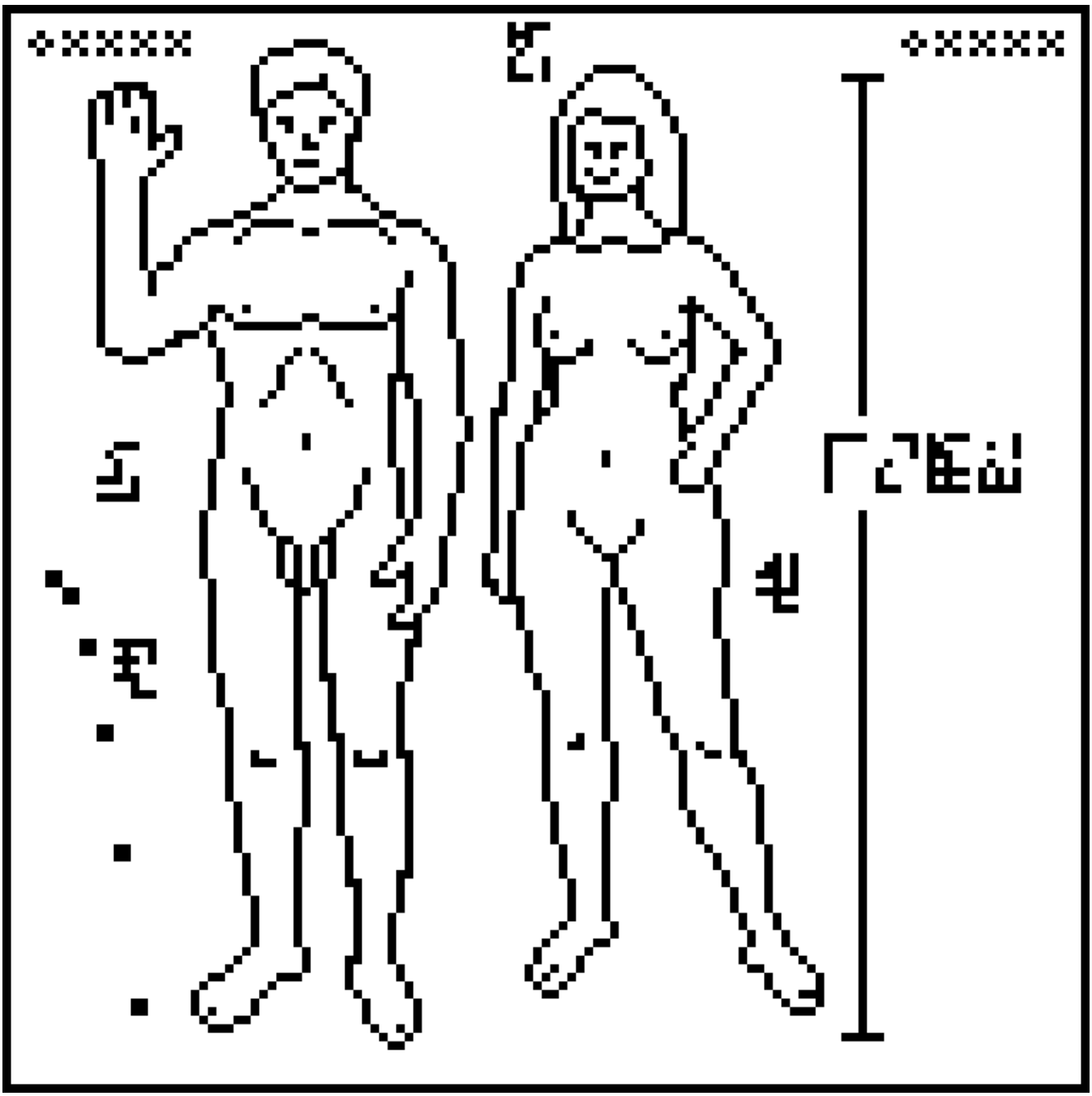
The Universe of Discourse

Mon, 28 Sep 2015

A message to the aliens, part 15/23 (human anatomy)

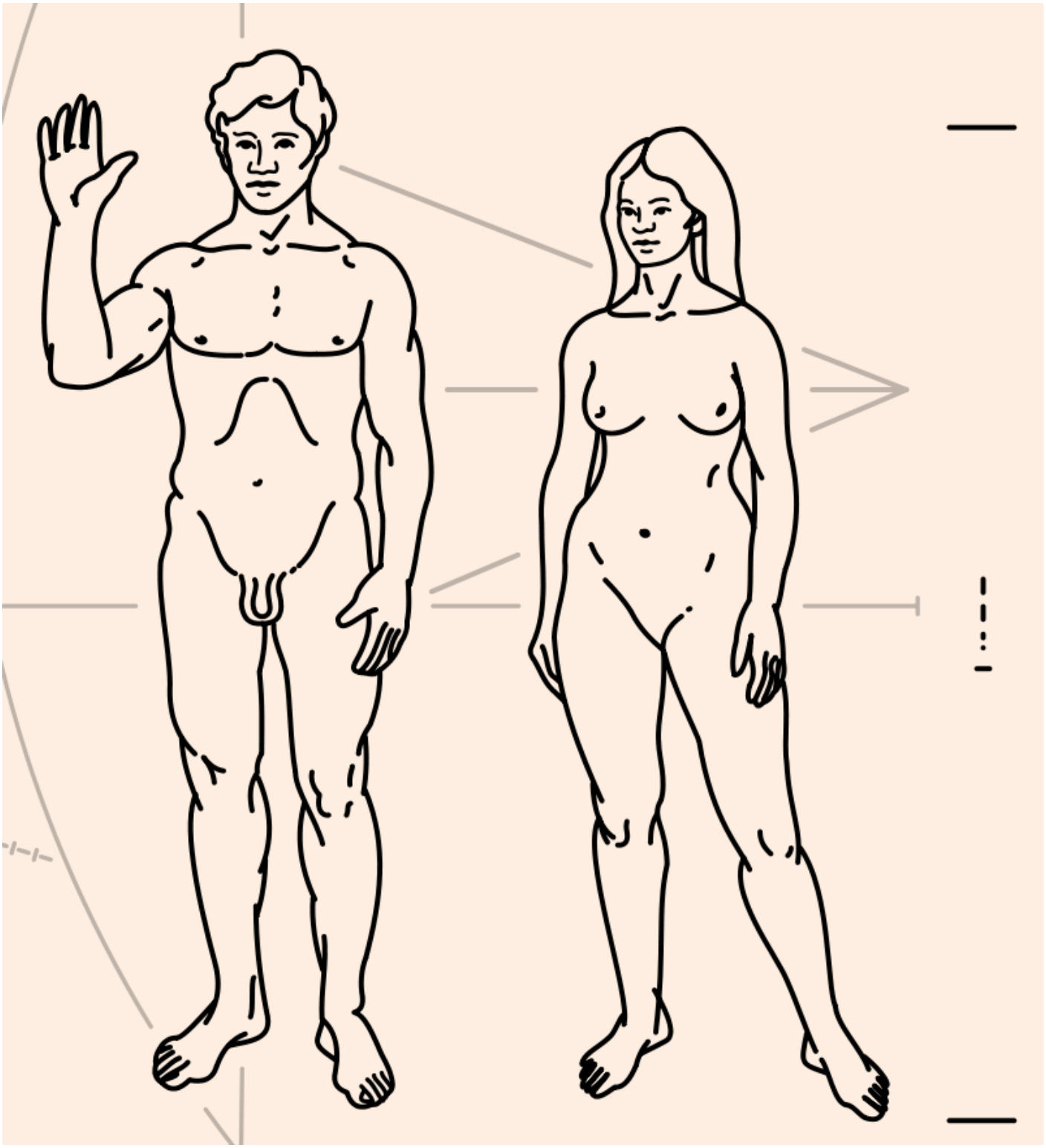
Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain)

This is page 15 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

This page starts a new section of the document, each page headed with the glyph for "biology"  . The illustration is adapted from the Pioneer plaque; the relevant portion is shown below.



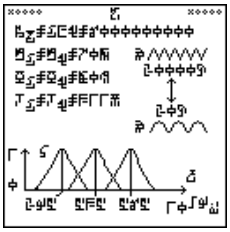
Copies of the plaque were placed on the 1972 and 1973 Pioneer spacecraft. The Pioneer image has been widely discussed and criticized; see the Wikipedia article for some of the history here. The illustration suffers considerably from its translation to a low-resolution bitmap. The original picture omits the woman's vulva; the senders have not seen fit to correct this bit of prudery.

The man and the woman are labeled with the glyphs and , respectively. The glyph for "people" , which identified the stick figures on the previous page, is inexplicably omitted here.

The ruler on the right somewhat puzzlingly goes from a bit above the man's toe to a bit below the top of the woman's head; it does not measure either of the two figures. It is labeled 1.8 meters, a typical height for men. The original Pioneer plaque spanned the woman exactly and gave her height as 168 cm, which is conveniently an integer multiple of the basic measuring unit (21 cm) defined on the plaque.

To prevent the recipients from getting confused about which end of the body is the top, a parabolic figure (shown here at left), annotated with the glyph for "acceleration", shows the direction of gravitational acceleration as on the previous page.

The next article will discuss page 16, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

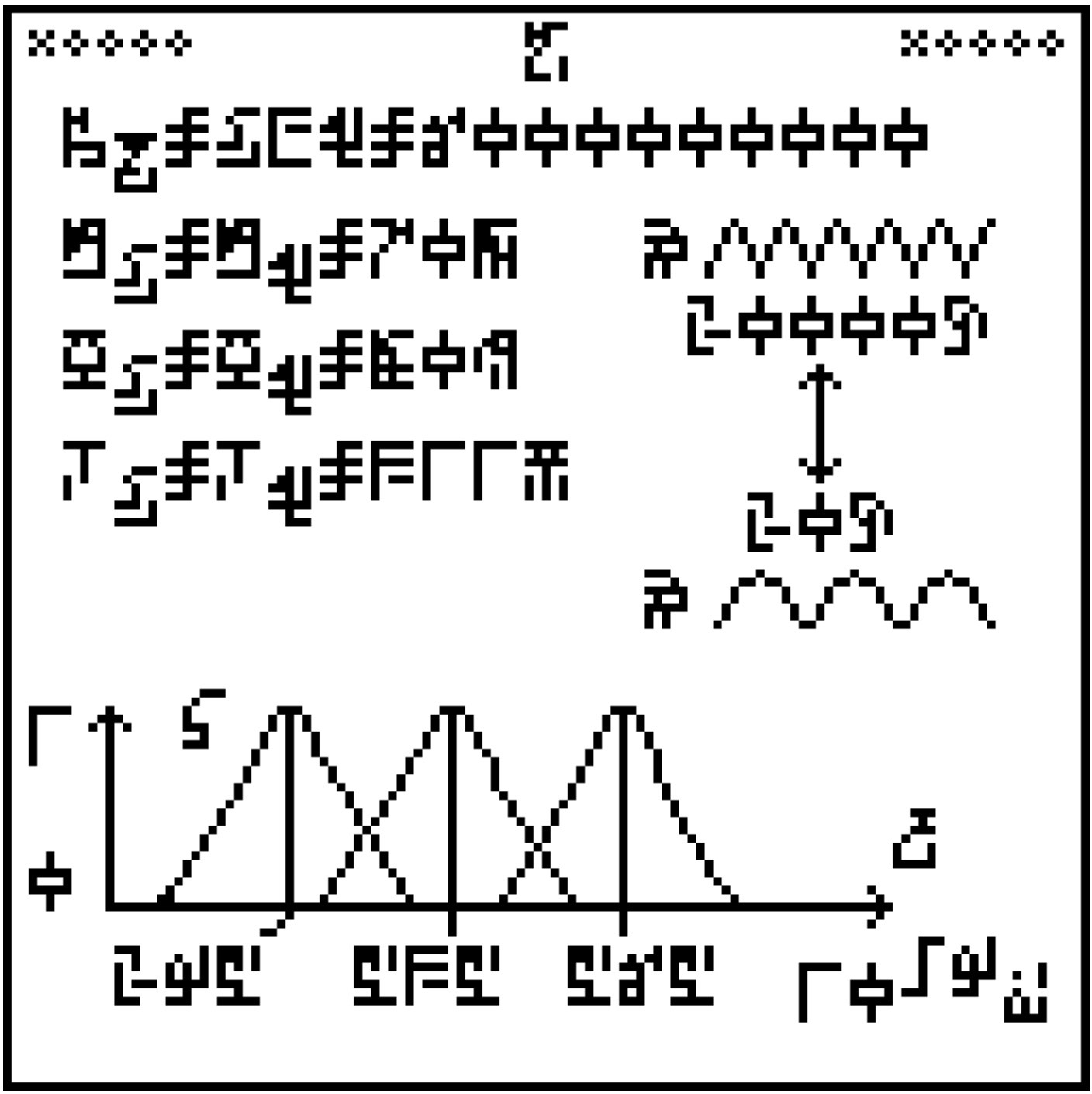
The Universe of Discourse

Wed, 30 Sep 2015

A message to the aliens, part 16/23 (vital statistics)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy)

This is page 16 of the *Cosmic Call* message. An explanation follows.



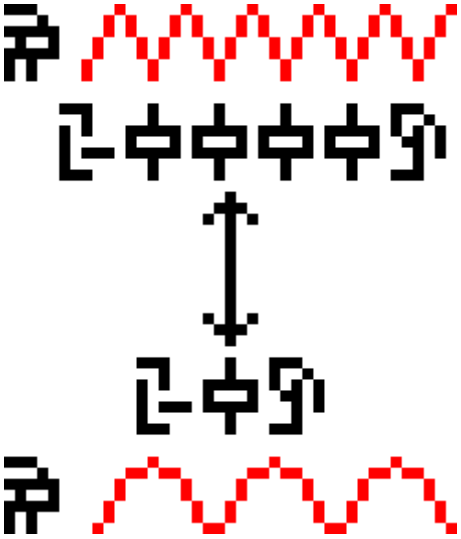
The 10 digits are:

This page, about human vital statistics and senses, is in three sections. The text in the top left explains the population of the Earth: around 6,000,000,000 people at the time the message was sent. The three following lines give the life

expectancy (70 years), mass (80 kg), and body temperature (311K) of humans. In each case it is stated explicitly that the value for men and for women is the same, which is not really true.

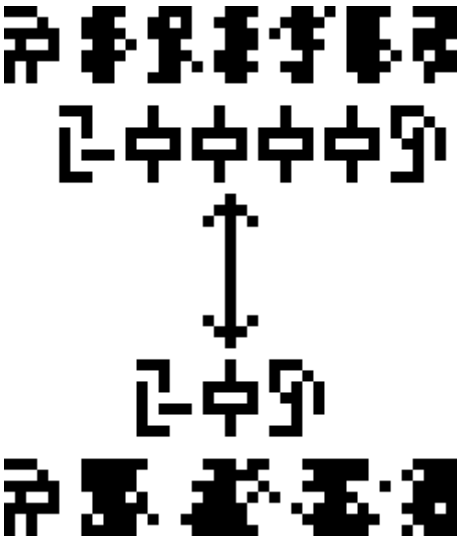
The glyph used for life expectancy  is the same one used to denote the age of the Earth back on page 13 even though the the two notions are not really the same. And why 311K when the commonly-accepted value is 310K?

The diagram at right attempts to explain the human sense of hearing, showing a high-frequency wave at top and a low frequency one at bottom, annotated with the glyph for frequency  and the upper and lower frequency limits of human hearing, 20,000 Hz and 20 Hz respectively. I found this extremely puzzling the first time I deciphered the message, so much so that it was one of the few parts of the document that left me completely mystified, even with the advantage of knowing already what humans are like. A significant part of the problem here is that the illustration is just flat out wrong. It depicts transverse waves:



but sound waves are not transverse, they are compression waves. The aliens are going to think we don't understand compression waves. (To see the difference, think of water waves, which are transverse: the water molecules move up and down—think of a bobbing cork—but the wave itself travels in a perpendicular direction, not vertically but toward the shore, where it eventually crashes on the beach. Sound waves are not like this. The air molecules move back and forth, *parallel* to the direction the sound is moving.)

I'm not sure what would be better; I tried generating some random compression waves to fit in the same space. (I also tried doing a cartoon of a non-random, neatly periodic compression wave, but I couldn't get anything I thought looked good.) I think the compression waves are better in some ways, but perhaps very confusing:

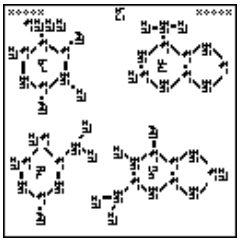


On the one hand, I think they express the intended meaning more clearly; on the other hand, I think they're too easy to confuse with glyphs, since they happen to be on almost the same scale. I think the message might be clearer if a little more space were allotted for them. Also, they could be annotated with the glyph for pressure  , maybe something like this:

This also gets rid of the meaningless double-headed arrow. I'm not sure I buy the argument that the aliens won't know about arrows; they may not have arrows but it's hard to imagine they don't know about *any* sort of pointy projectile, and of course the whole purpose of a pointy projectile (the whole point, one might say) is that the point is on the *front* end. But the arrows here don't communicate motion or direction or anything like that; even as a human I'm not sure what they are supposed to communicate.

The bottom third of the diagram is more sensible. It is a diagram showing the wavelengths of light  to which the human visual system is most sensitive. The x-axis is labeled with "wavelength"  and the y-axis with a range from 0 to 1. The three peaks have their centers at 295 nm (blue), 535 nm (green), and 565 nm (often called "red", but actually yellow). These correspond to the three types of cone cells in the retina, and the existence of three different types is why we perceive the color space as being three-dimensional. (I discussed this at greater length a few years ago.) Isn't it interesting that the "red" and green sensitivities are so close together? This is why we have red-green color blindness.

The next article will discuss page 17, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

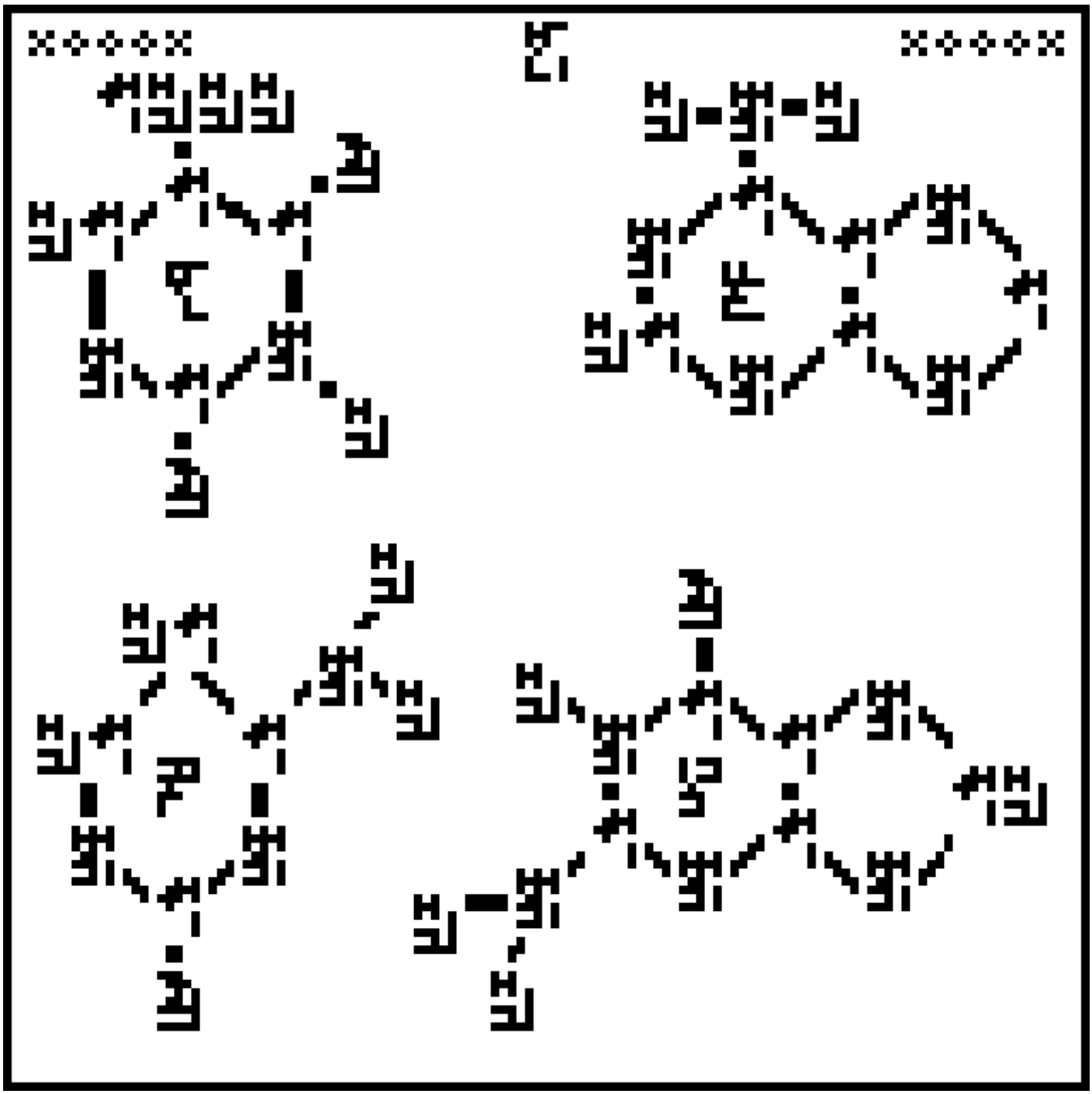
The Universe of Discourse

Fri, 02 Oct 2015

A message to the aliens, part 17/23 (DNA chemistry)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics)

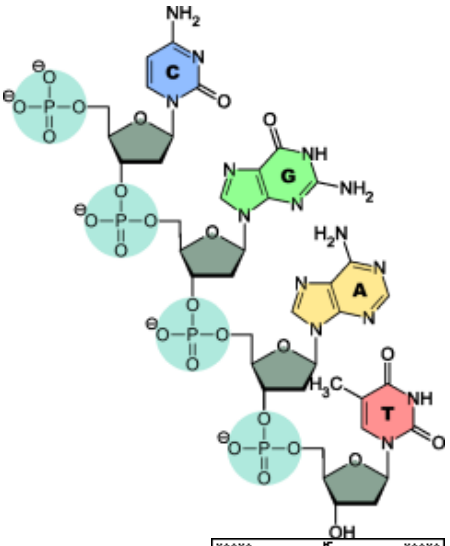
This is page 17 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

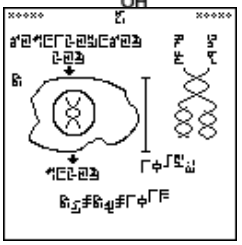
This page depicts the chemical structures of the four nucleobases that make up the information-carrying part of the DNA

molecule. Clockwise from top left, they are thymine , adenine , guanine , and cytosine .



The deoxyribose and phosphate components of the nucleotides, shown at right, are not depicted. These form the spiral backbone of the DNA and are crucial to its structure. Will the recipients understand why the nucleobases are important enough for us to have mentioned them?

The next article will discuss page 18, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

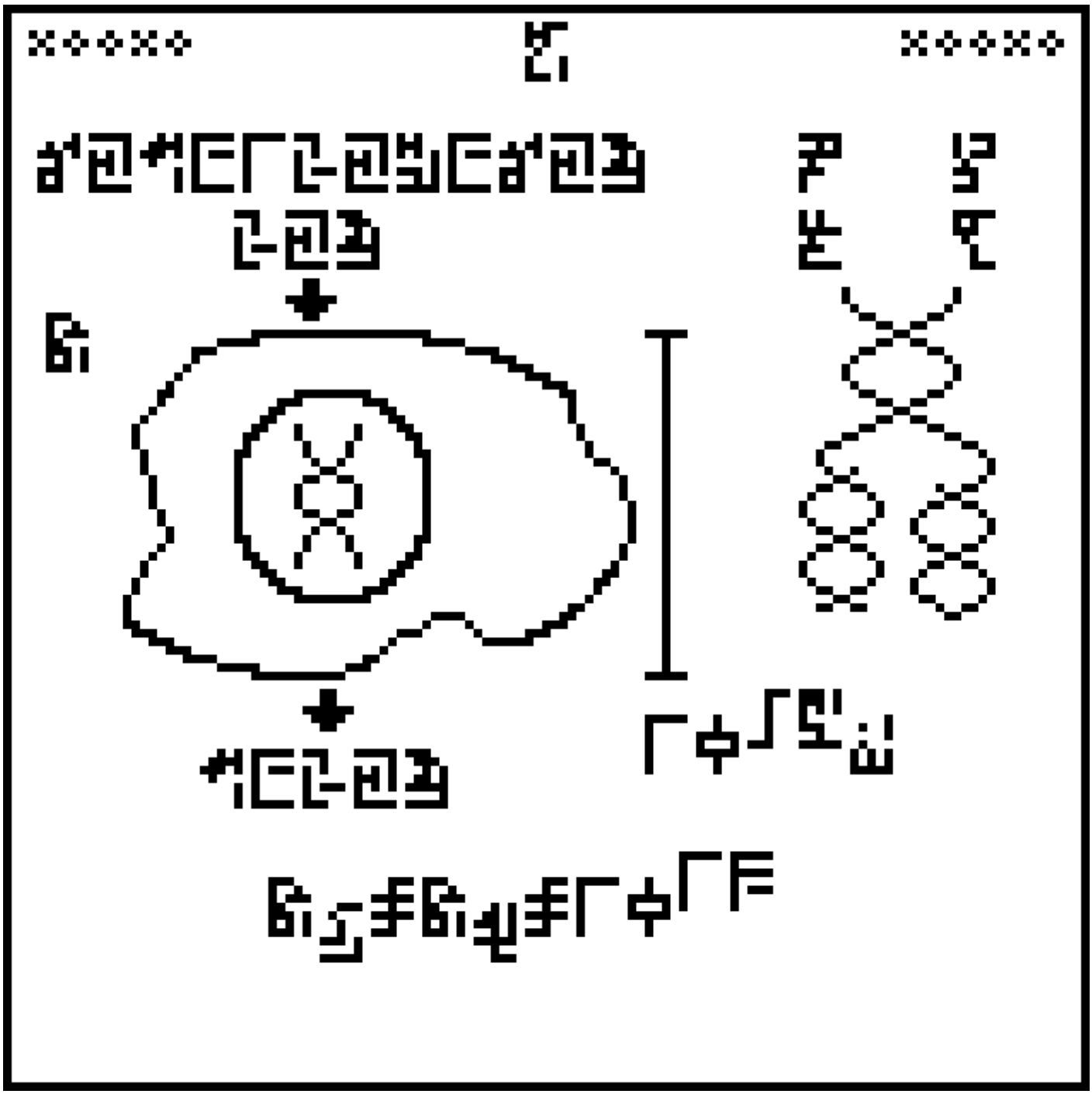
The Universe of Discourse

Mon, 02 Nov 2015

A message to the aliens, part 18/23 (cell respiration and division)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics) Page 17 (DNA chemistry)

This is page 18 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

This page depicts the best way to fry eggs. The optimal fried egg is shown at left. Ha ha, just kidding. The left half of the page explains cellular respiration. The fried egg is actually a cell, with a DNA molecule in its nucleus. Will the aliens be

familiar enough with the structure of DNA to recognize that the highly abbreviated picture of the DNA molecule is related to the nucleobases on the previous page? Perhaps, if their genetic biochemistry is similar to ours, but we really have no reason to think that it is.

The illustration of the DNA molecule is subtly wrong. It shows a symmetric molecule. In reality, one of the two grooves between the strands is about twice as big as the other, as shown at right.

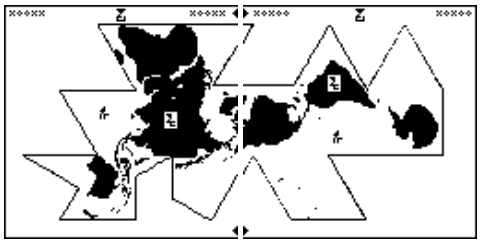
The top formula says that $C_6H_{12}O_6$ and O_2 go into the cell; the bottom formula says that CO_2 comes out. (Energy comes out also; I wonder why this wasn't mentioned.) The notation for chemical compounds here is different from that used on page 14: there, O_2 was written as  ; here it is written as  (“2×O”).

The glyph near the left margin  does not appear elsewhere, but I think it is supposed to mean “cell”. Supposing that is correct, the text at the bottom says that the number of cells in a man or woman is !!10^{13}!!. The number of cells in a human is not known, except very approximately, but !!10^{13}!! is probably the right order of magnitude. (A 2013 paper from *Annals of Human Biology* estimates !!3.72\cdot 10^{13}!!.)

Next to the cell is a ruler labeled !!10^{-5}!! meters, which is a typical size for a eukaryotic cell.

The illustration on the right of the page, annotated with the glyphs for the four nucleobases from the previous page   , depicts the duplication of genetic material during cellular division. The DNA molecule splits down the middle like a zipper. The cell then constructs a new mate for each half of the zipper, and when it divides, each daughter cell gets one complete zipper.

The next article will discuss pages 19 and 20, shown at right. (Click to enlarge.) Try to figure it out before then.



[*Other articles in category /aliens/dd*] *permanent link*

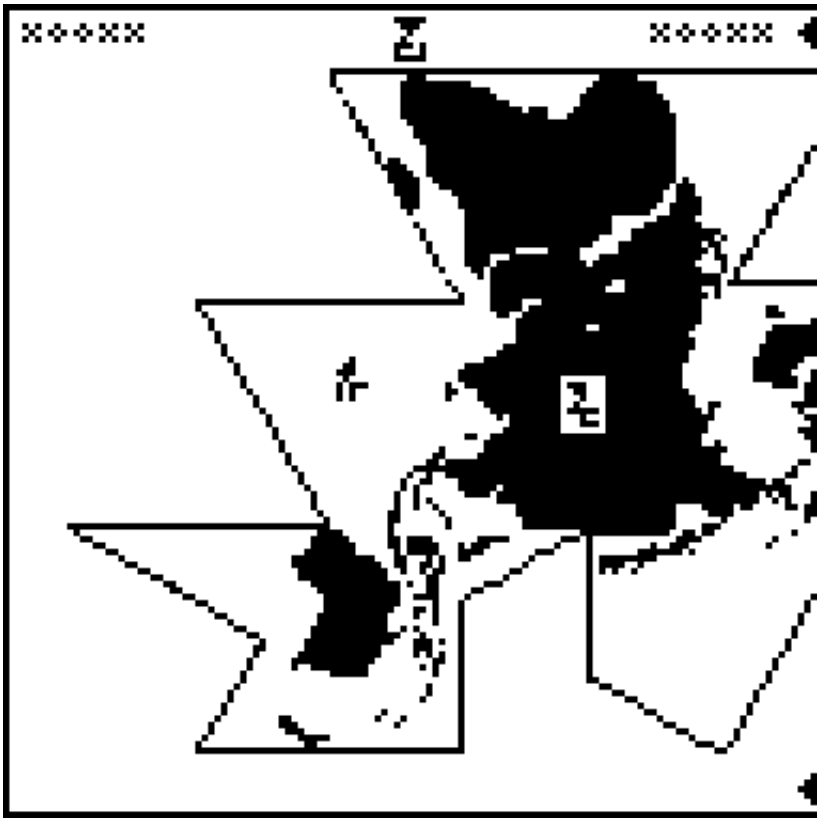
The Universe of Discourse

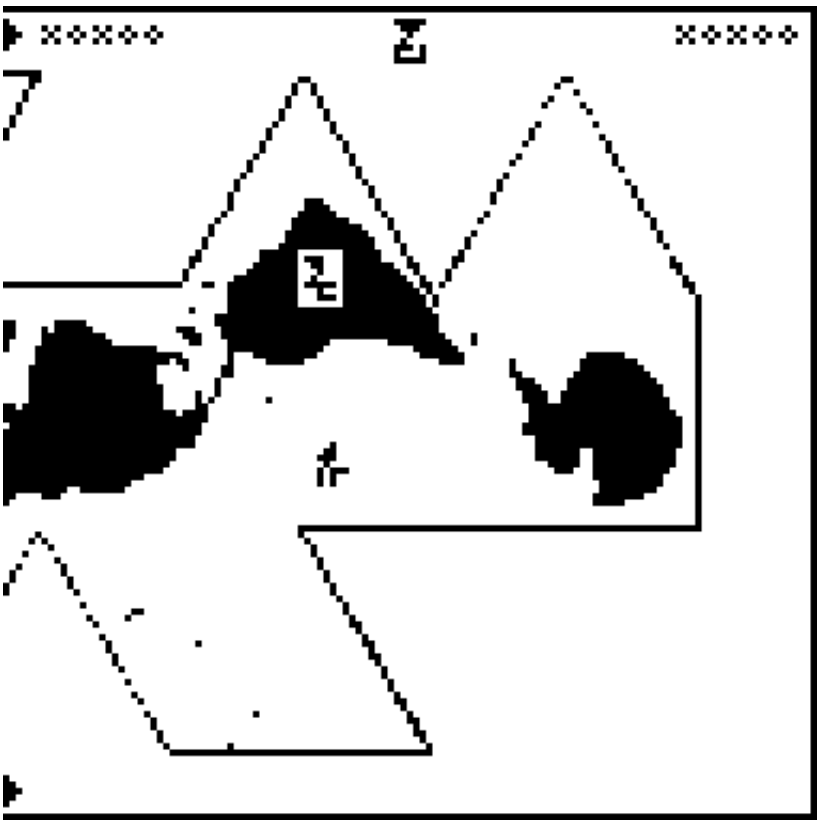
Sat, 28 Nov 2015

A message to the aliens, part 19/23 (map of the Earth)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics) Page 17 (DNA chemistry) Page 18 (cell respiration and division)

These are pages 19–20 of the *Cosmic Call* message. An explanation follows.



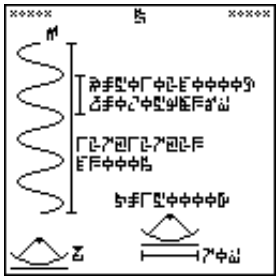


These two pages are a map of the surface of the Earth. Every other page in the document is surrounded by a one-pixel-wide frame, to separate the page from its neighbors, but the two pages that comprise the map are missing part of their borders to show that the the two pages are part of a whole. Assembled correctly, the two pages are surrounded by a single border. The matching sides of the map pages have diamond-shaped registration marks to show how to align the two pages.

The map projection used here is R. Buckminster Fuller's Dymaxion projection, in which the spherical surface of the Earth is first projected onto a regular icosahedron, which is then unfolded into a flat net. This offers a good compromise between directional distortion and size distortion. Each twentieth of the map is distorted only enough to turn it into a triangle, and the interruptions between the triangles can be arranged to occur at uninteresting parts of the map.

Both pages are labeled with the glyph for "Earth". On each page, the land parts of the map are labeled with and the water parts with , as on page 14, since the recipients wouldn't otherwise be able to tell which was which.

The next article will discuss page 21, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

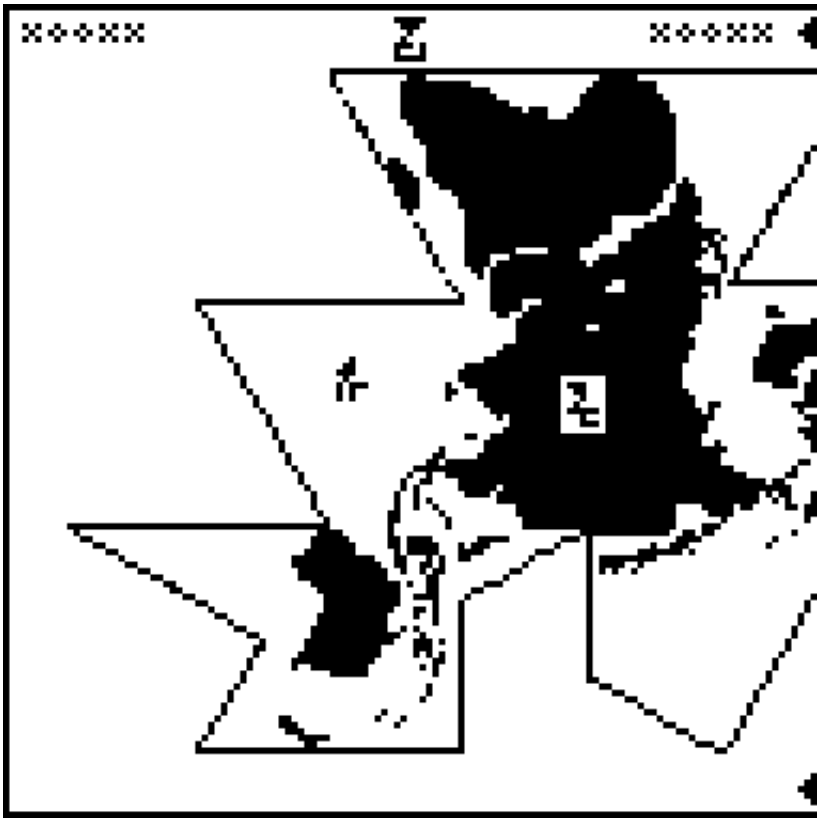
The Universe of Discourse

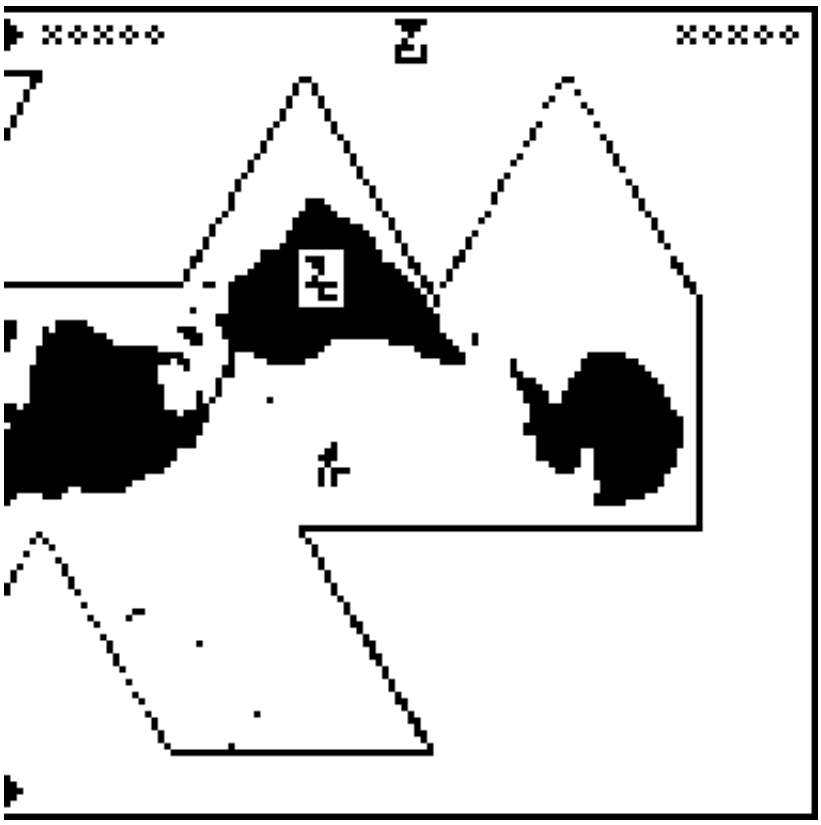
Sun, 09 Sep 2001

A message to the aliens, part 20/23 (map of the Earth)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics) Page 17 (DNA chemistry) Page 18 (cell respiration and division)

These are pages 19–20 of the *Cosmic Call* message.





They are explained here.

[Other articles in category /aliens/dd] permanent link

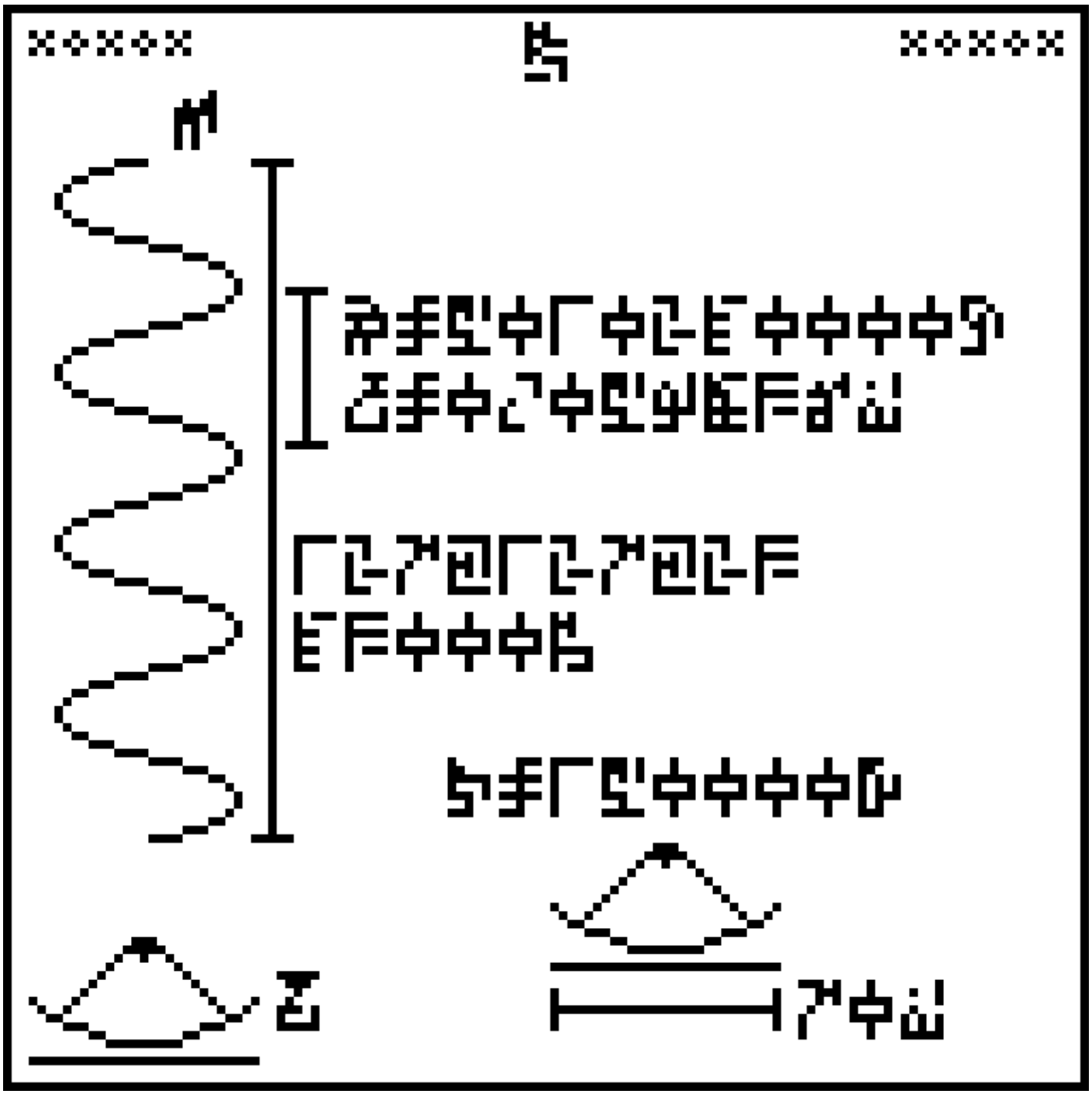
The Universe of Discourse

Sun, 06 Dec 2015

A message to the aliens, part 21/23 (the message)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics) Page 17 (DNA chemistry) Page 18 (cell respiration and division) Pages 19-20 (map of the Earth)

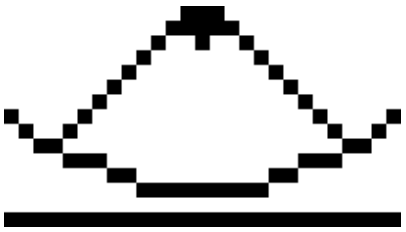
This is page 21 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

This page discusses the message itself. It is headed with the glyph for "physics" .

The leftmost part of the page has a cartoon of the Yevpatoria RT-70 radio telescope



that was used to send the message, labeled "Earth" . Coming out the the telescope is a stylized depiction of a radio wave. Two rulers measure the radio wave.

The smaller one measures a single wavelength, and is labeled "frequency = 5,010,240,000 Hz " and "wavelength = 0.059836 meters "; these are the frequency and the wavelength of the radio waves used to send the message. The longer ruler has the notation "127×127×23", describing the format of the message itself, 23 pages of 127×127 bitmaps, and also "43000 people ", which I do not understand at all. Were 43,000 people somehow involved with sending the message? That seems far too many. Were there 43,000 people in Yevpatoria in 1999? That seems far too few; the current population is over 100,000. I am mystified.

At the other end of the radio wave is the glyph , which is hard to decipher, because it appears only on this page and on the unhelpful page 23. I *guess* it is intended to refer to the recipients of the message.

[Addendum 20151219: Having reviewed page 23, I am still in the dark. References to the mass and radius of suggest that it refers to the recipients' *planet*, but references to the mathematics, physics, and biology of suggests that it refers to the recipients themselves.]

In the lower-right corner of the page is another cartoon of the RT-70, this time with a ruler underneath showing its diameter, 70 meters. Above the cartoon is the power output of the telescope, 150 kilowatts.

The next article will discuss page 22, shown at right. (Click to enlarge.) Try to figure it out before then.

[Other articles in category /aliens/dd] permanent link

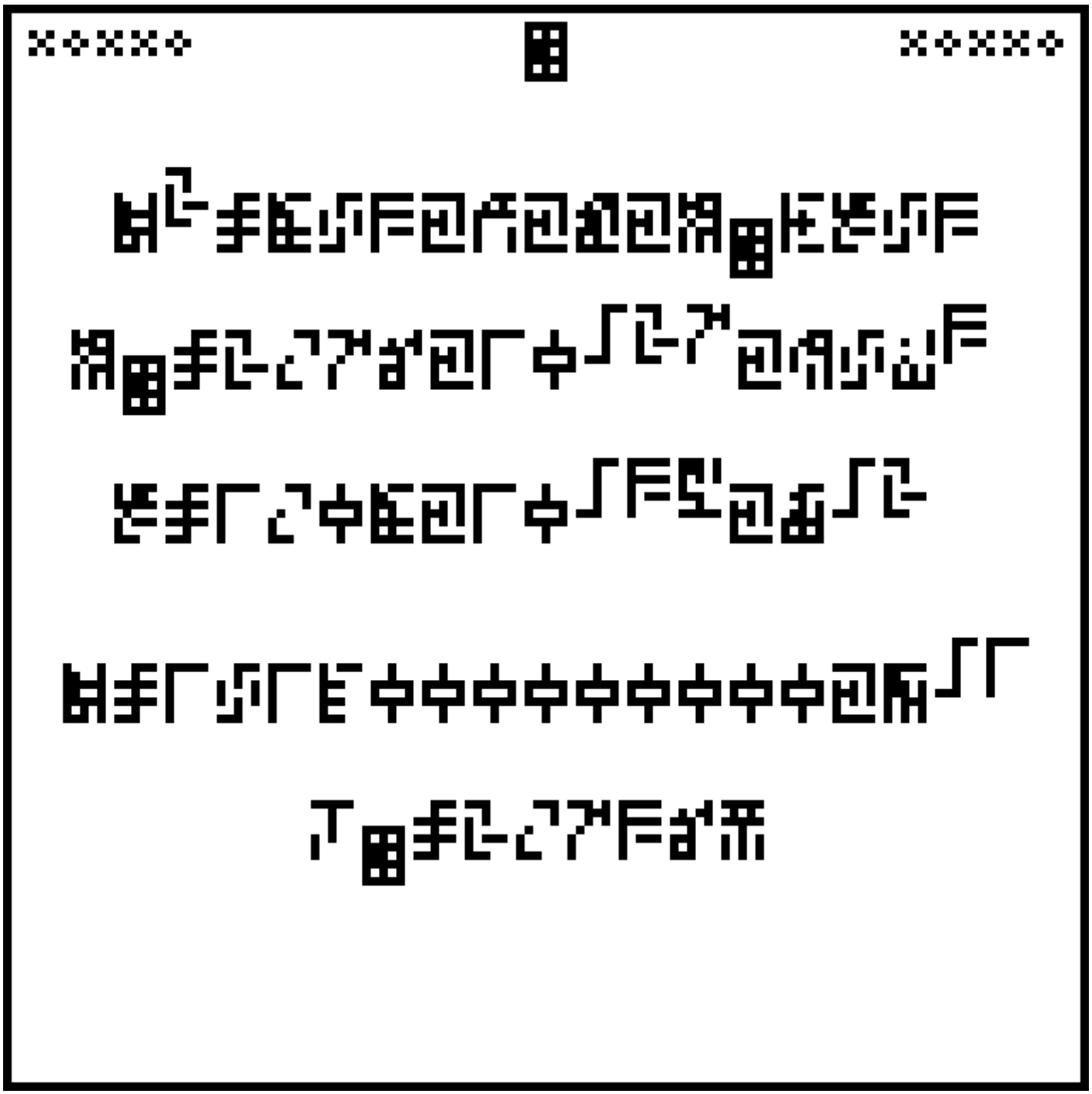
The Universe of Discourse

Sat, 12 Dec 2015

A message to the aliens, part 22/23 (cosmology)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics) Page 17 (DNA chemistry) Page 18 (cell respiration and division) Pages 19-20 (map of the Earth) Page 21 (the message)

This is page 22 of the *Cosmic Call* message. An explanation follows.



The 10 digits are:

This page discusses properties of the entire universe. It is labeled with a new glyph,  , which denotes the universe or the cosmos. On this page I am on uncertain ground, because I know very little about cosmology. My explanation here could be completely wrong without my realizing it.

The page contains only five lines of text. In order, they state:

1. The Friedmann equation which is the current model for the expansion of the universe. This expansion is believed to be uniform everywhere, but even if it isn't, the recipients are so close by that they will see exactly the same expansion we do. If they have noticed the expansion, they may well have come to the same theoretical conclusions about it. The equation is:

$$H^2 = \frac{8\pi G}{3}\rho + \frac{\Lambda c^2}{3}$$

   where H is the Hubble parameter (which describes how quickly the universe is expanding), G is the universal gravitation constant  (introduced on page 9), ρ is the density of the universe  (given on the next line), and Λc^2 () is one of the forms of the cosmological constant (given on the following line).

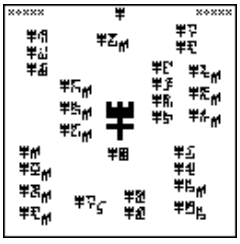
2. The average density  of the universe  , given as $2.76 \times 10^{-27}\mathrm{kg\ m^{-3}}$. The "density" glyph would have been more at home with the other physics definitions of page 9, but it wasn't needed until now, and that page was full.

3. The cosmological constant Λ is about $10^{-52}\mathrm{m^{-2}}$. The related value given here, Λc^2, is $1.08 \cdot 10^{-35}\mathrm{s^{-2}}$.

4. The calculated value of the Hubble parameter H  is given here in the rather strange form $\frac{1}{14000000000}\mathrm{year^{-1}}$. The reason it is phrased this way is that (assuming that H were constant) $\frac{1}{H}$ would be the age of the universe, approximately 14,000,000,000 years. So this line not only communicates our estimate for the current value of the Hubble parameter, it expresses it in units that may make clear our beliefs about the age of the universe. It is regrettable that this wasn't stated more explicitly, using the glyph  that was already used for the age of the Earth on page 13. There was plenty of extra space, so perhaps the senders didn't think of it.

5. The average temperature  of the universe, about 2.736 kelvins. This is based on measurements of the cosmic microwave background radiation, which is the same in every direction, so if the recipients have noticed it at all, they have seen the same CMB that we have.

The next article will discuss the final page, shown at right. (Click to enlarge.) Try to figure it out before then.



[Other articles in category /aliens/dd] permanent link

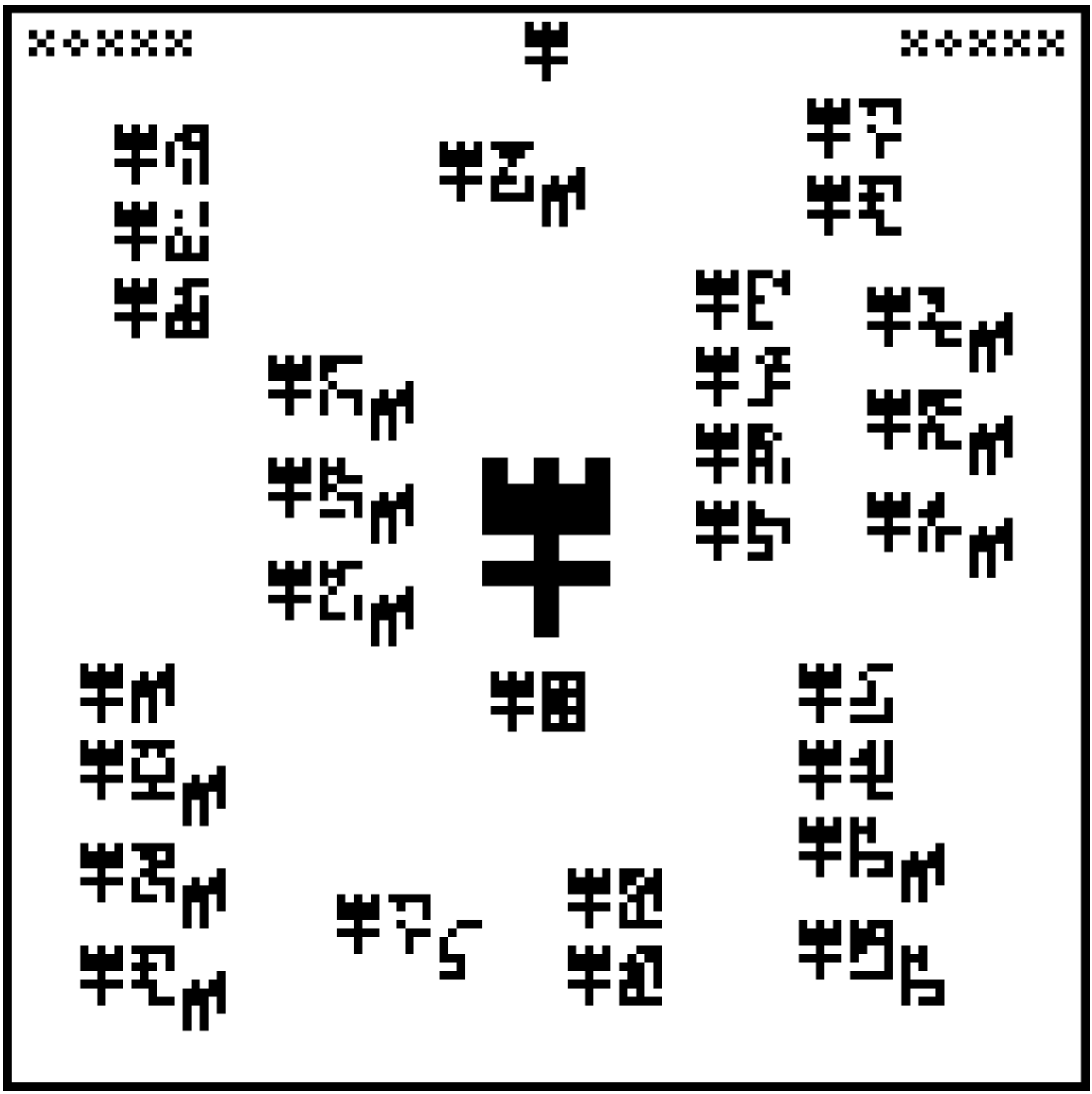
The Universe of Discourse

Mon, 21 Dec 2015

A message to the aliens, part 23/23 (wat)

Earlier articles: Introduction Common features Page 1 (numerals) Page 2 (arithmetic) Page 3 (exponents) Page 4 (algebra) Page 5 (geometry) Page 6 (chemistry) Page 7 (mass) Page 8 (time and space) Page 9 (physical units) Page 10 (temperature) Page 11 (solar system) Page 12 (Earth-Moon system) Page 13 (days, months, and years) Page 14 (terrain) Page 15 (human anatomy) Page 16 (vital statistics) Page 17 (DNA chemistry) Page 18 (cell respiration and division) Pages 19-20 (map of the Earth) Page 21 (the message) Page 22 (cosmology)

This is page 23 (the last) of the *Cosmic Call* message. An explanation follows.

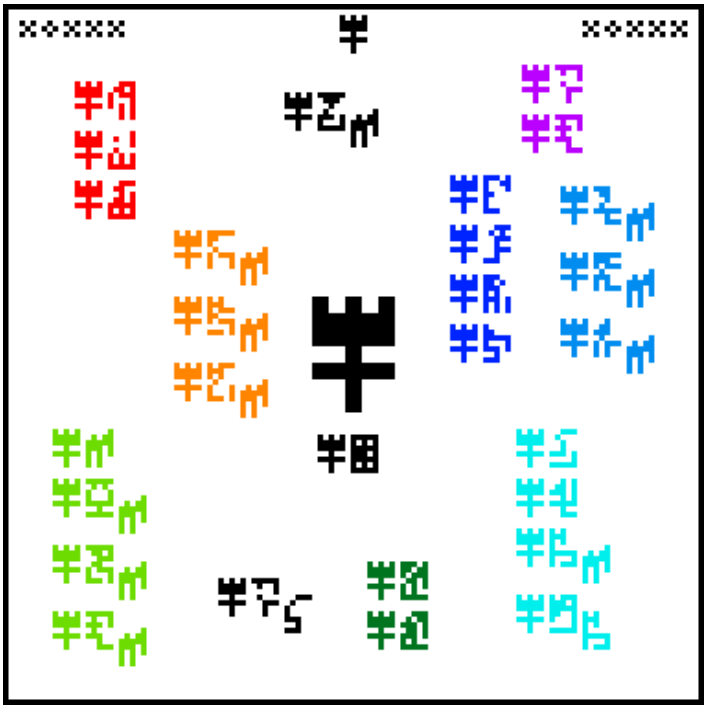


This page is a series of questions for the recipients of the message. It is labeled with the glyph  , which heretofore appeared only on page 4 in the context of solving of algebraic equations. So we might interpret it as meaning a solution or a desire to solve or understand. I have chosen to translate it as "wat".

I find this page irritating in its vagueness and confusion. Its layout is disorganized. Glyphs are used inconsistent with their

uses elsewhere on the page and elsewhere in the message. For example, the mysterious glyph , which has something to do with the recipients of the message, and which appeared only on page 21 is used here to ask about both the recipients themselves and also about their planet.

The questions are arranged in groups. For easy identification, I have color-coded the groups.



Starting from the upper-left corner, and proceeding counterclockwise, we have:

Kilograms, meters, and seconds, wat. I would have used the glyphs for abstract mass, distance, and time, and , since that seems to be closer to the intended meaning.

Alien mathematics, physics, and biology, wat. Note that this asks specifically about the *recipients'* version of the sciences. None of these three glyphs has been subscripted before. Will the meaning be clear to the recipients? One also wonders why the message doesn't express a desire to understand human science, or science generally. One might argue that it does not make sense to ask the recipients about the human versions of mathematics and physics. But a later group expresses a desire to understand males and females, and the recipients don't know anything about that either.

Aliens wat. Alien [planet] mass, radius, acceleration wat. The meaning of shifts here from meaning the recipients themselves to the recipients' planet. "Acceleration" is intended to refer to the planet's gravitational acceleration as on page 14. What if the recipients don't live on a planet? I suppose they will be familiar with planets generally and with the fact that we live on a planet, which explained back on pages 11–13, and will get the idea.

Fucking speed of light, how does it work?

Planck's constant, wat. Universal gravitation constant, wat?

Males and females, wat. Alien people, wat. Age of people, wat. This group seems to be about our desire to understand ourselves, except that the third item relates to the aliens. I'm not quite sure what is going on. Perhaps "males and females" is intended to refer to the recipients? But the glyphs are not subscripted, and there is no strong reason to believe that the aliens have the same sexuality.

The glyph , already used both to mean the age of the Earth and the typical human lifespan, is even less clear here. Does it mean we want to understand the reasons for human life expectancy? Or is it intended to continue the inquiry from the previous line and is asking about the recipients' history or lifespan?

 **Land, water, and atmosphere of the recipients' planet, wat.**

 **Energy, force, pressure, power, wat.** The usage here is inconsistent from the first group, which asked not about mass, distance, and time but about kilograms, meters, and seconds specifically.

 **Velocity and acceleration, wat.** I wonder why these are in a separate group, instead of being clustered with the

 previous group or the first group. I also worry about the equivocation in  acceleration, which is sometimes used to mean the Earth's gravitational acceleration and sometimes acceleration generally. We already said we want to understand mass  , G  , and the size of the Earth. The Earth's surface gravity can be straightforwardly calculated from these, so there's nothing else to understand about that.

 **Alien planet, wat.** The glyph  has heretofore been used only to refer to the planet Earth. It does not mean planets generally, because it was not used in connection with Jupiter  . Here, however, it seems to refer to the recipients' planet.

 **The universe, wat. HUH???**

That was the last page. Thanks for your kind attention.

[Many thanks to Anna Gundlach, without whose timely email I might not have found the motivation to finish this series.]

[Other articles in category /aliens/dd] permanent link