The 1999 and 2003 messages explained

by S.Dumas

for more information visit our web site:
http://www.activeseti.qc.tc

Background

In 1999, an interstellar message was broadcasted in direction of 4 stars. This transmission took place at the Evpatoria installations in Ukraine. With its 70 meters dish and a 150kW transmitter at 6cm, Evpatoria is one of the most powerful deep space radar. Arecibo and Goldstone were not available for the project at the time.

Four years later another broadcast was performed from Evpatoria in the direction of 5 others stars.

The concept of both messages was based on the work on two Canadian physicists: Stephane Dumas and Dr. Yvan Dutil. An American company called Team Encounter 2001 orchestrated the whole adventure under the name of Cosmic Call.

SETI is a hobby for both of them.

Dr. Dutil is a Canadian astrophysicist and has worked at the Space Telescope Science Institute, with the Canadian government, and at the Universitat Polytecnica de Catalunya, Barcelona,Spain. He his now a scientist for ABB in Quebec City, where he work on the development of remote sensing instrument for ground and space applications. He is widely published, especially in the French Canadian press. His printed works have appeared in everything from astronomy magazines to academic journals, including books chapters. He has appeared in numerous television and radio programs where he has discussed his work in creating interstellar messages for extraterrestrials, as well as the effect of city lights on the nighttime sky and other topic related to astronomy.

Stephane Dumas is a physicist working for the Canadian Government in the field of Modeling and Simulation. He has worked in the field of simulated integrated optical devices in the private sector. His main personnel interests include cryptography, the theory of information, SETI and astronomy. He has published in collaboration with Yvan some papers related to this project and had reviewed a book on SETI. He also appears, from time to time, on a radio show to talk about science discoveries and phenomena.

In 1998, both were involved in a few simulations on the Internet concerning possible messages from an extraterrestrial source. During one of those simulations, they entered in contact with the people of Team Encounter who at that time were planning to send their first message to the stars. They agreed to let the supervision of the whole message to those Dutil and Dumas.

The ideas behind the content

The whole concept behind the message was based in part on the work of Hans Frendenthal (ref.1).

The beginning of both messages is centered on mathematics. There is a simple reason for that choice. Any civilization capable of building a device to receive radio waves from

outer space needs mathematics and physics to accomplish that task. Also any kind of society needs some form of mathematics for taxes and commerce. So mathematics is a truly a common language.

Later on in the message some knowledge of physics is introduced. Physic is needed to be able to describe our surrounding and establish further common ground. In order to describe our surrounding, some units of measurement have to be presented. We use the hydrogen spectrum for the length and time. Anyone who is familiar with spectrum will recognize those lines and relations. The hydrogen and helium atoms are used to introduce the mass.

With length, time and mass, others units of measurement can be derived (eg. force, pressure, power). It does not matter whether or not ET uses the Newton as a unit of force its definition is based on the same.

A detailed look of both messages is found in the annexes B and D.

The 2003 message is an improvement over the 1999. It no longer divided into 23 pages but rather into a very long page. The format has been changed to facilitate the detection and decoding.

The alphabet

There are many ways to format an interstellar message. The image format was selected for its many advantages: mainly the possibility of using small diagrams to increase the level of information.

The major problem of the transmission would be to overcome possible errors due to noise. The information presented in two dimensions gives some extra security against it. For a 1D message, the noise will generate a lot of error in the decoding. Image style messages offers more redundancy but not without problems too. Simply recall the Drake message of 1976. By changing a bit, the whole structure collapsed. The Evpatoria message avoids this by using a frame of pixel around the image. Thus given a larger structure to look for. This structure reflects in a Fourier transform by the display of strait line. This is quite particular and not natural.

Special symbols had to be created to maintain the level of information as high as possible even in a noisy reception. The whole set of characters is made by small bitmaps of 5x7 pixels. Each is different from any other in the set in respect to rotation and mirroring. This difference is of several bits (ie 7 bits for the 2003 message). Situations where regular letters such as p, q, d and b could be mix-up do not happen with this set of symbols.

In the message, each symbol represents an idea. They are not characters, as we know them. Some of those ideoglyphs are equivalent to digit (e.g. 1,2) and other to concept (e.g. hydrogen, kg). Diagrams and pictures complement them.

New symbols were created for the 2003 message with a more resistant pattern. Digits (ie numbers) are represented with a 4x7 pattern while the other symbols keep the 5x7 format. The digits appear more often so they could be smaller, the repetition will compensate for the possible noise. The height of both symbols is kept the same for decoding purpose.

The targets

In 1999, we had just enough allocated time to transmit in the direction of four stars (the message was repeated three times for each star). In order to keep a descent signal to noise ratio with our transmission rate (100 bit/s), target stars needed to be nearer than 100 light-years, even if our correspondent was listening with an antenna of one kilometer in diameter. From the list compiled by the SETI Institute, we picked up the stars, which can be observed easily from Ukraine. We focused our selection on stars near the galactic plane, simply because basic calculation shows than the signal will reach an additional ten sun-like stars (plus many more cooler ones) beyond our primary targets. In fact, the signal may still be detected as far as 10,000 light-years by a 1 km antenna. We also choose a region of the sky where the interstellar scintillation is minimal, between 60 and 90 degrees of the galactic center. The final selection was made using spectral type, metallicity and age as criteria (Kevin Apps, University of Sussex, gave us a crucial help for this final step). We even managed to get a star in bonus, since our target star 16 Cygni A has a widely separated companion 16 Cygni B, which is know to possess an extrasolar planet.

Those are the stars from the 1999 broadcast:

Star name	**HD178428**	**HD186408**	**HD1900360**	**HD190040**
Visual mag	6.08	5.99	5.73	5.08
Spectral type	G5V	G2V	G6IV+	G1V
Distance (lyr)	68.3	70.5	51.8	57.6
R.A., J2000	19h07m57s	19h41m49s	20h03m27s	20h04m06s
Dec, J2000	16d51m12s	50d31m30s	29d53m48s	17d04m13s

For the 2003 broadcast, a new set of targets was selected. The message was sent by the Evpatoria installation on July 6th (from 02:00 to 07:39) and by Roswell, New Mexico on the same day (05:00 to 10:39 MST).

Those are the stars from the 2003 broadcast:

Star name	**Hip 26335 (Orion)**	**Hip 43587 (55 Cnc) for Cancer**	**Hip 4872 for Cassiopeia**	**Hip 52721 (47 UMa) for Ursa Major**	**Hip 7918 for Andromeda**
Visual mag	8.78	5.96	9.56	5.03	4.96
Spectral type	K7	G8V	K5V	G0V	G2V
Distance (lyr)	37.1	40.9	32.8	45.9	41.2
R.A., J2000	05:36:30.991	08:52:35:811	01:02:38.867	10:59:27.974	01:41:47.15
Dec, J2000	+11 19 40.32	+28 19 50.95	+62 20 42.18	+40 25 48.88	+42 36 48.5

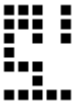
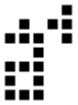
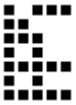
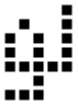
References

1. Freudenthal, H. (1960). Lincos: Design of a language for cosmic intercourse. Amsterdam: North-Holland Publishing, Company.

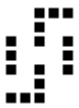
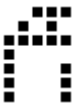
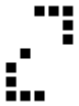
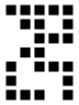
Annex A: 1999 alphabet

The alphabet used in the 1999 message is presented here. All the symbols are built using a 5x7 bitmap.

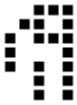
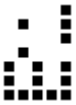
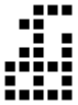
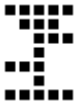
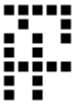
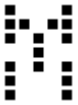
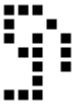
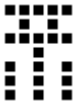
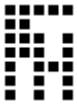
Numbers

	1		2		3
	4		5		6
	7		8		9
	0				

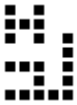
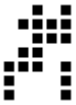
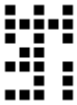
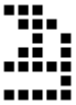
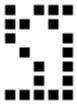
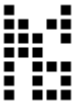
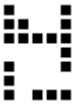
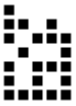
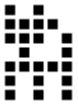
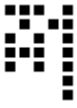
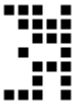
Mathematics

	plus(+)		minus (-)		multiplication (*)
	division (/)		equal		undetermined
	negation		pi (π)		union
	dot (.)		delta		math
	radius				

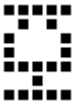
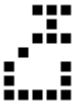
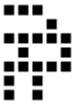
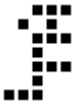
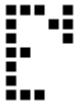
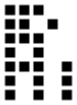
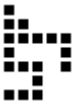
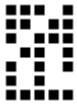
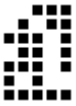
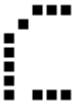
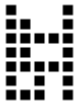
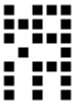
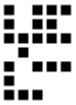
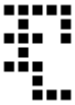
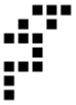
Units

	kilogram		meter		second
	newton		joule		pascal
	watt		hertz		kelvin
	year				

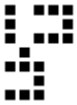
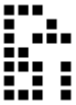
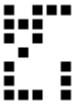
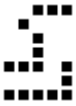
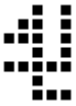
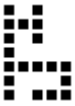
Chemical elements

	hydrogen		helium		carbon
	nitrogen		oxygen		aluminium
	silicium		iron		sodium
	chlorine		argon		E112
	gold		silver		sulfur
	uranium		zinc		

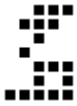
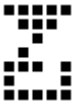
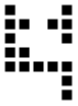
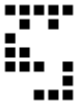
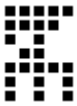
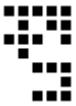
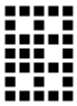
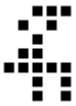
Physical concepts

	proton		neutron		electron
	mass		wavelength		time
	frequency		velocity		force
	energy		pressure		power
	Planck (h) Constant		G Constant		distance
	Hubble Constant		density		Cosmological constant
	acceleration		charge		length
	physics		photon		temperature

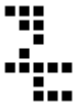
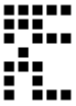
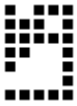
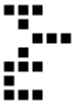
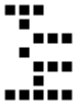
Biological

	thymidine		adenosine		cytidine
	guanosine		cell		biology
	male		female		people

Astronomy

	Jupiter		Earth		Moon
	Sun		Mars		Mercury
	Neptune		Pluto		Saturn
	univers		Uranus		Venus

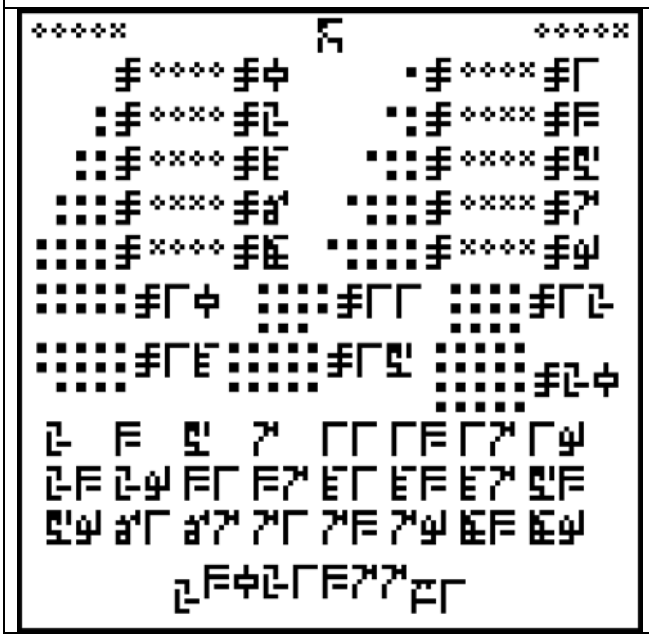
Others

	etc.		question		land
	ocean		sky		target
	age		var a		var b
	var c				

Annex B : 1999 message

The 1999 message is made of 23 images (or pages) of 127x127 pixels.

page 1 - numbers

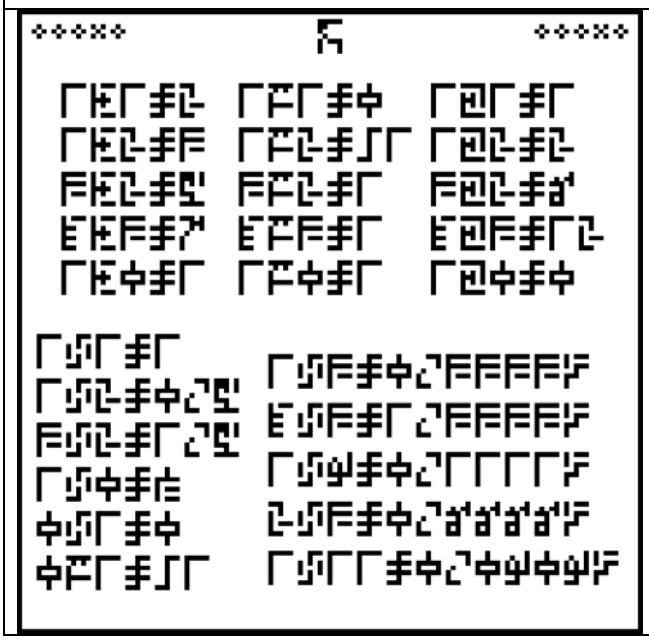


0000 = 0 0001 = 1
0010 = 2 0011 = 3
0100 = 4 0101 = 5
0110 = 6 0111 = 7
1000 = 8 1001 = 9

10 11 12
13 15 20

- **Introduction to numbers**
  - Why 10-based digits? Mostly it ease the task of proof reading for the human reader. There are two ways of introducing the symbols: binary and dots. Also, the way to use the position of the digits (base 10) is illustrated.
  - List of prime from 2 to 89 with the largest prime discovered in 1999
  - Binary representation is used through all the message.
  - Both binary values at the top (left and right) of the image are the page number. Once again, it is for redundancy.

page 2 - operators



1+1=2	1-1=0	1*1=1
1+2=3	1-2=-1	1*2=2
3+2=5	3-2=1	3*2=6
4+3=7	4-3=1	4*3=12
1+0=1	1-0=1	1*0=0

1/1=1	1/3=0.3333…
1/2=0.5	4/3=1.3333...
3/2=1.5	1/9=0.1111...
1/0=undetermine	2/3=0.6666...
0/1=1	1/11=0.0909...
0-1=-1	

- **Introduction to mathematical operators** such as addition, subtraction, multiplication and division.
- **Introduction of continuity symbol (eg. "...")**

page 3 - exponents

$1^1=1$ $2^1=2$ $3^1=3$ $4^2=16$
$1^2=1$ $2^2=4$ $3^2=9$ $5^3=125$
$1^3=1$ $2^3=8$ $3^3=27$

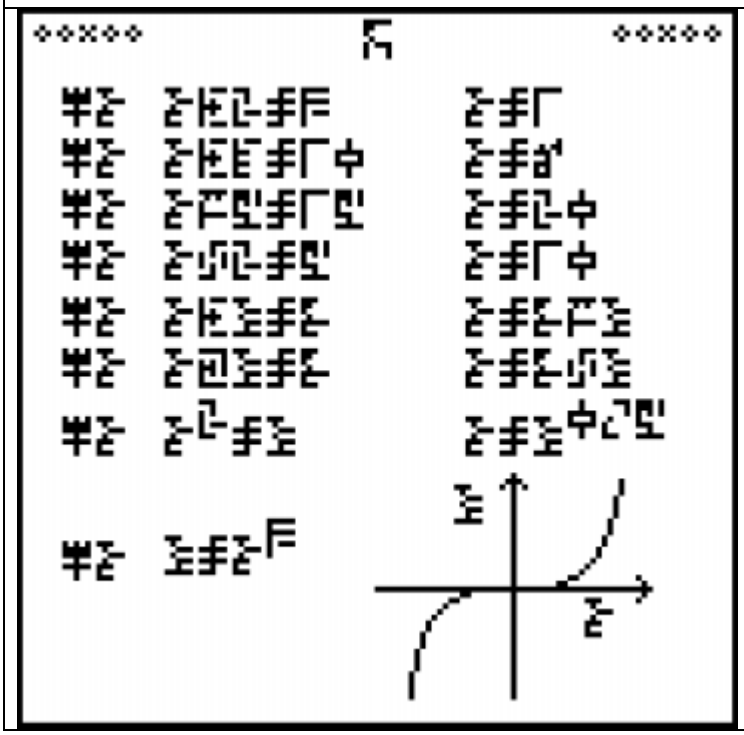
$10^1=10$ $10^2=100$
$10^3=1000$ $10^{-2}=0.01$

$1.23*10^2=123$ $8^{1/3}=2$
$45*10^{-2}=0.45$ $4^{1/2}=2$

$2^{1/2}=1.4142356...$

- **Introduction to exponent notation** for representing large numbers. The choice of using the upper position as opposed to another symbol (ie. ^) is to save place. Furthermore, it avoids the use of parenthesizes (e.g. 10^(-2)+5 vs. 10^{-2}+5). This approach requires fewer symbols to introduce. Further in the message, the subscribe will be used to attach an attribute to a concept (ex. "Mass of proton" is be written as "M_{proton}")

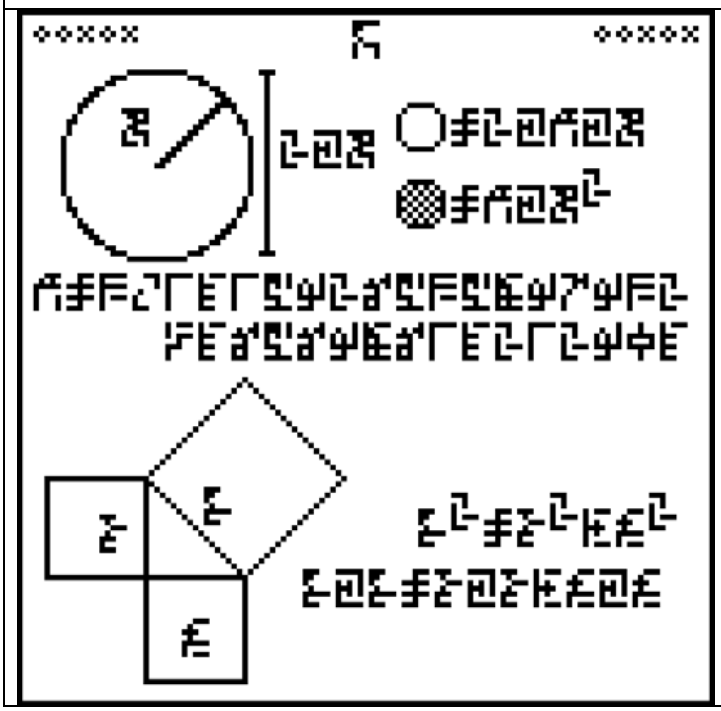
page 4 - variables & questions



?a	a+2=3	a=1
?a	a+4=10	a=6
?a	a-5=15	a=20
?a	a/2=5	a=10
?a	a+b=c	a=c-b
?a	a*b=c	a=c/b
?a	a^2=b	a=$b^{0.5}$
?a	b=a^3	

- **Introduction of the notion of question**. This is a difficult topic to introduce. The choice of using equations and searching the unknown is a way to do it while expanding Mathematics notions. The concept of "question" will be used at the end of the message.

page 5 - geometry



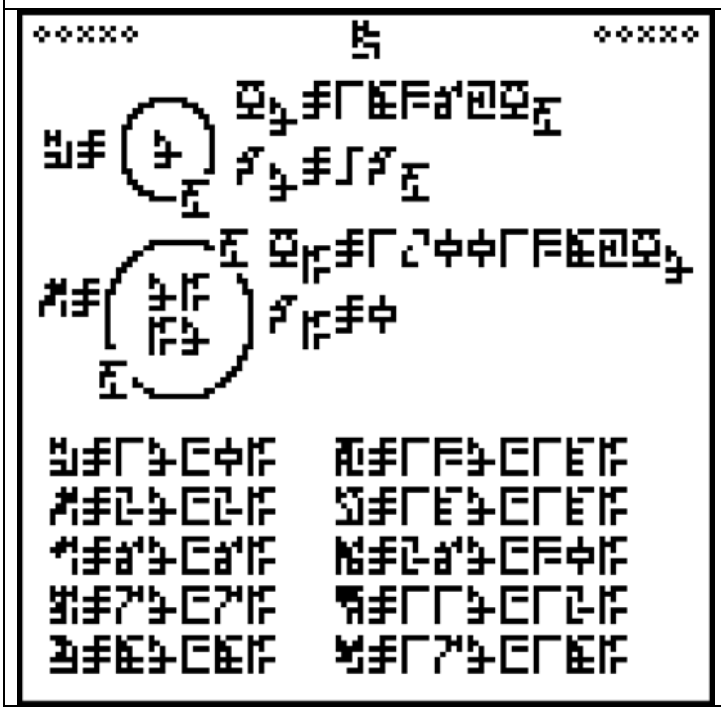
Radius
Circumference
Area

π = 3.1415927…465698614212904

$c^2 = a^2 + b^2$
c*c = a*a + b*b

- **Introduction to some geometric notions** such as radius and area. The value of π is displayed with 51,539,600,000 digits. However, it is clear that so many digits would have required too mush space. A simple solution was used to solve that particular problem. The first few digits are written followed by "…" and the last 15 digits of the sequence. The probability of such a sequence to appear with 52 billions digits is too low to considered. The use of Pythagoras's theorem is helpful to reinforce the notion of exponent.

page 6 - chemical elements



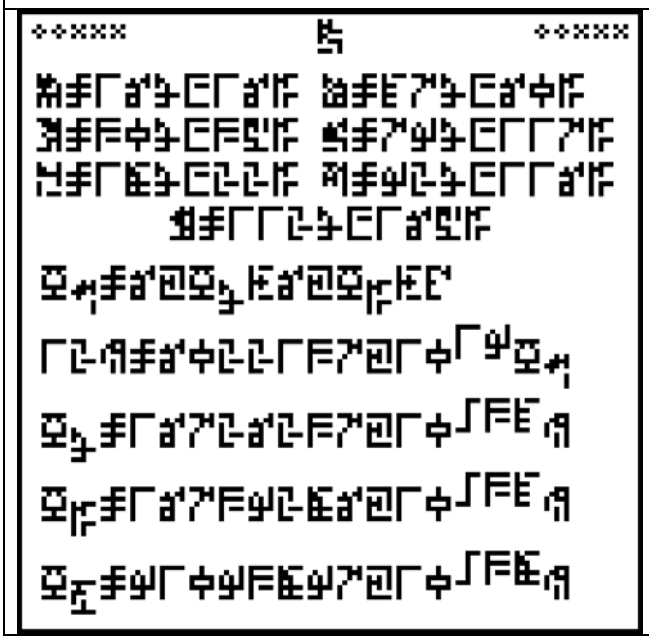
Hydrogen
$Mass_{proton} = 1836 \times Mass_{electron}$.
$Charge_{proton} = -Charge_{electron}$

Helium
$Mass_{neutron} = 1.00138 \times Mass_{proton}$
$Charge_{neutron} = 0$

H = 1p ∪ 0n Al = 13p ∪ 14n
He = 2p ∪ 2n Si = 14p ∪ 14n
C = 6p ∪ 6n Fe = 26p ∪ 30n
N = 7p ∪ 7n Na = 11p ∪ 12n
O = 8p ∪ 8n Cl = 17p U 18n

- **Introduction of basic elements** such as hydrogen and helium. Proton, neutron and electron are introduced also. The graphical representation of a nucleus may not be understood but the ratio of electron and proton mass will. Whatever the unit of mass used, the ratio between the proton and electron mass is always around 1836.
- A list of other elements based on their number of protons and neutrons.
- **Introduction of the notion of mass**

page 7 - mass



S = 16p U 16n Ag = 47p U 60n
Zn = 30p U 35n Au = 79p U 117n
Ar = 18p U 22n U = 92p U 116n

E112 = 112p U 165n

$M_C = 6 * M_P + 6 * M_n + E$

12kg of Carbon = 6.0221367×10^{23} M_{Carbon}

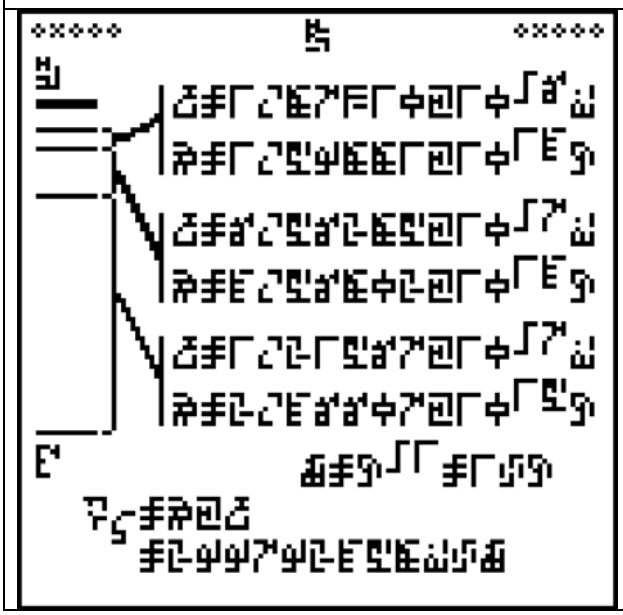
$M_{proton} = 1.6726231 \times 10^{-27}$ kg

$M_{neutron} = 1.6749286 \times 10^{-27}$ kg

$M_{electron} = 9.1093897 \times 10^{-31}$ kg

- This is an expansion of the notion of mass. The carbon 12 is used with the Avogadro number (eg. the number of atom in a mole) to further develop the idea of mass. Here the exponent notation comes handy since the proton, neutron and electron respective masses are listed.
- More elements from the periodic table are introduced.

page 8 - hydrogen



$l = 1.87310 \times 10^{-6}$ m
$f = 1.59881 \times 10^{14}$ Hz

$l = 6.56285 \times 10^{-7}$ m
$f = 4.56802 \times 10^{14}$ Hz

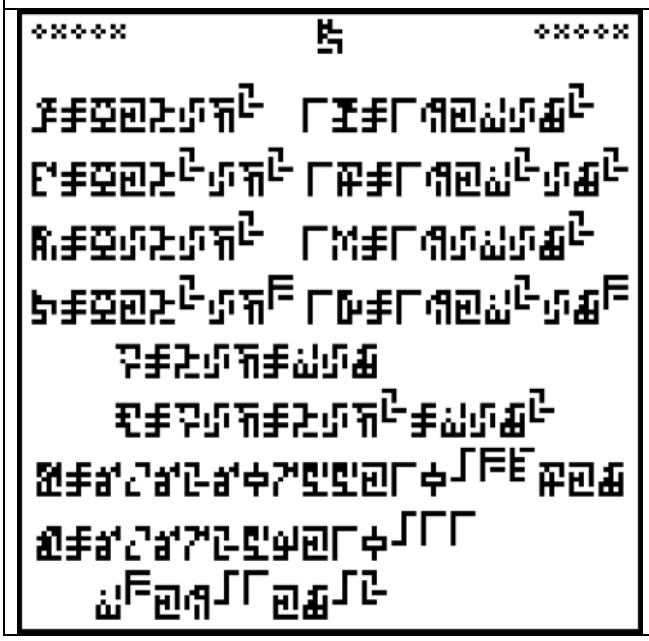
$l = 1.21567 \times 10^{-7}$ m
$f = 2.46607 \times 10^{15}$ Hz

second = Hz^{-1} = 1/Hz

$speed_{photon}$ = frequency * wavelength
= 299792458 m/s

- The spectrum of the hydrogen atom is used to **introduce wavelength** and ultimately the length notion. The speed of light is also displayed relating the wavelength and the frequency.
- The hertz is introduced as the unit of frequency.
- The notion of time is shown using the frequency.

page 9 - units or measurement



Force = M x L ÷ T^2

1 Newton = 1 kg x m ÷ s^2

Energy = M x L^2 ÷ T^2

1 Joule = 1 kg x m^2 ÷ s^2

Pression = M ÷ L ÷ T^2

1 Pascal = 1 kg ÷ m ÷ s^2

Power = M x L^2 ÷ T^3

1 Watt = 1 kg x m^2 ÷ s^3

speed = L ÷ T = m ÷ s

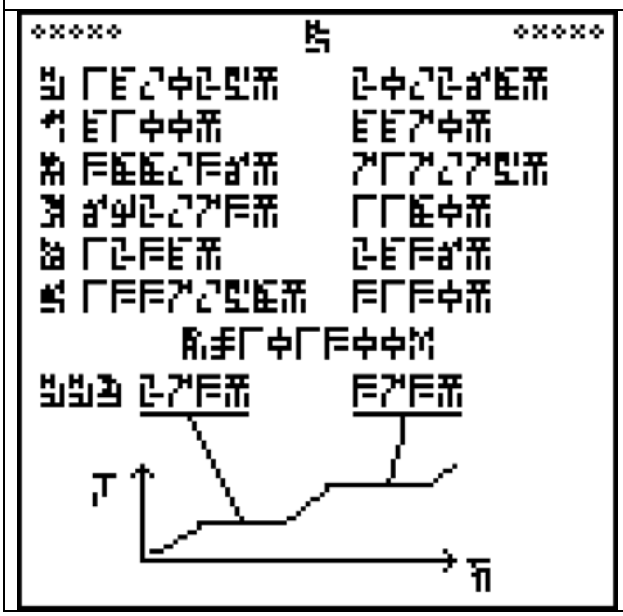
acceleration = speed ÷ T = L ÷ T2 = m ÷ s^2

h = 6.6260755x10-34 J s

G = 6.67259×10^{-11} $m^3 kg^{-1} s^{-2}$

- Those are the units of measurement in Physics. They are defined using two approaches. The first definition implicates the meter, second and kg. The second implicates the notion of length, time and mass. This has the effect of reinforcing the definition of those notions. Even if the reader does not use Pascal as the unit of pressure, he will recognize its definition using length, mass and time.
- The last items of this page are the gravitational constant G and Planck constant h.

page 10 - temperature



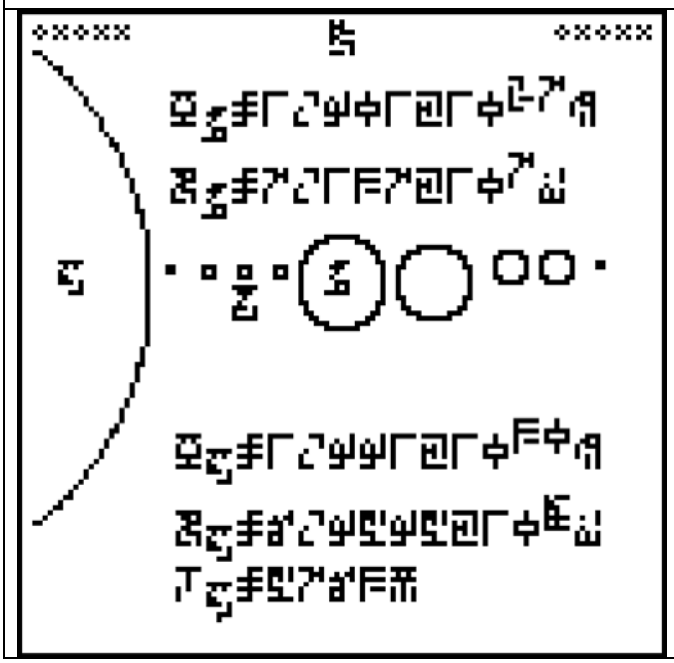
H	14.025K	20.268K
C	4100K	4470K
S	388.36K	717.75K
Zn	692.73K	1180K
Ag	1234K	2436K
Au	1337.58K	3130K

Pression = 101300 pascal

HHO	273K	373K

- The temperature is defined in this page. The boiling and melting temperatures of chemical elements are listed.
- Pressure at which the temperature is expected is also written.
- The graphic at the bottom is an attempt to show the phases of the water.

page 11 - solar system



$Mass_{Jupiter} = 1.901x10^{27}$ kg
$Radius_{Jupiter} = 7.137x10^{7}$ m

$Mass_{Sun} = 1.991x10^{30}$ kg
$Radius_{Sun} = 6.9595x10^{8}$ m
$Temperature_{Sun} = 5763$ K

- We have the capability to see planets surrounding other stars. Given ET has the same possibility; this page is a representation of the solar system. The Sun, Jupiter and Earth are the only objects identified. Jupiter's and Sun's size and mass are listed.

page 12 - earth (part 1)

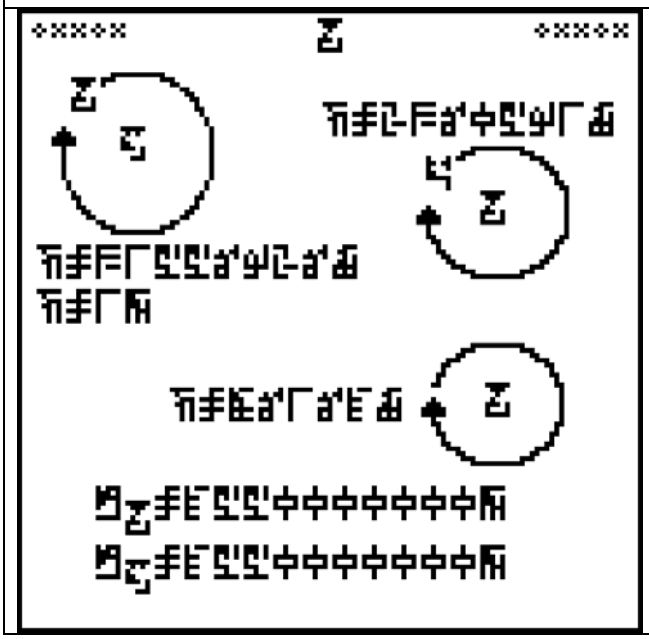
$Distance_{Earth\text{-}Moon} = 3844x10^{5}$ m

$Mass_{Moon} = 7.35x10^{22}$ kg
$Radius_{Moon} = 1.74x10^{6}$ m

$Mass_{Earth} = 5.977x10^{24}$ kg
$Radius_{Earth} = 6.378x10^{6}$ m

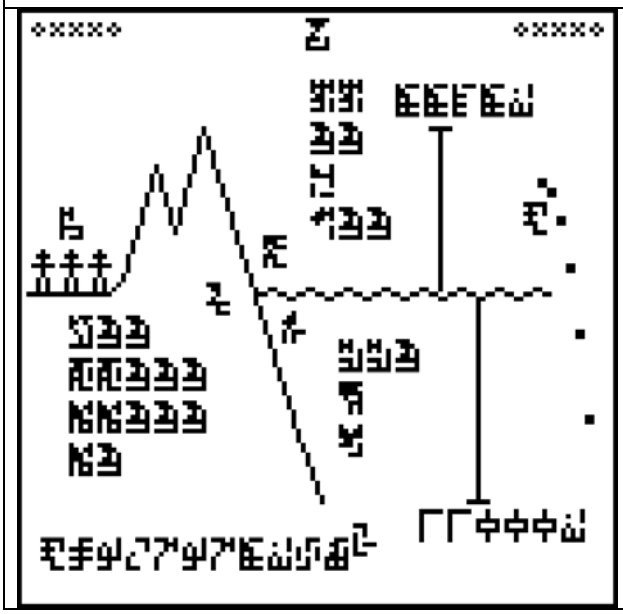
$Distance_{Earth\text{-}Sun} = 1.4957x10^{11}$ m

- This is a little bit more on the Earth-Moon system.

page 13 - earth (part 2)	
	time = 2360591 seconds time = 31556926 seconds time = 1 year time = 86163 seconds Age_{Earth} = 4550000000 years Age_{Sun} = 4550000000 years

- More on the Earth-Moon system. Giving information about the dimensions and distance of Earth and Moon.

page 14 - earth (part 3)



NN
OO
Ar
COO

8848 m (altitude of Mt Everest)

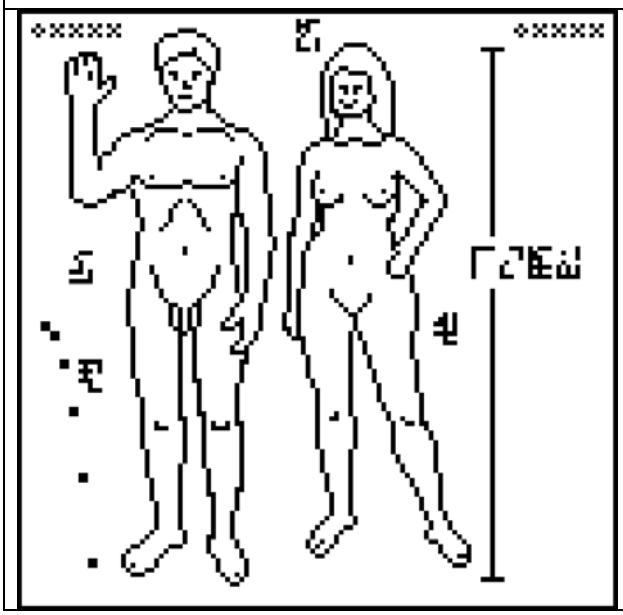
HHo
Na
Cl

SiOO
AlAlOOO
FeFeOOO
FeO

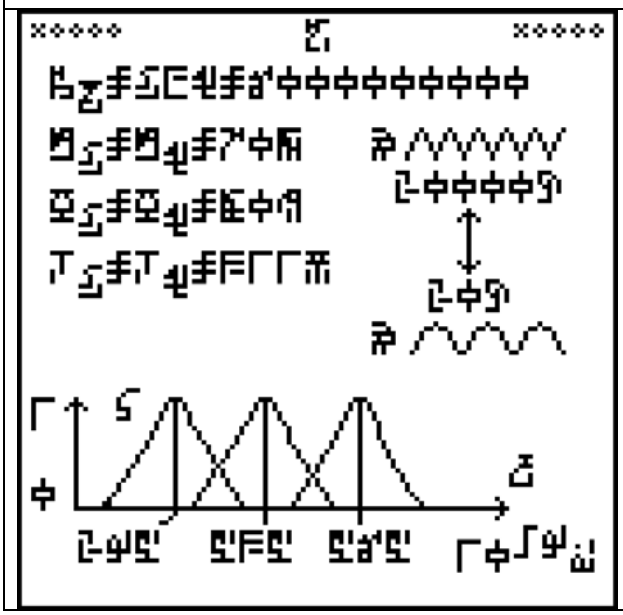
11000 m (depth of Marian Trench)

$g = 9.7978\ m/s^2$

- This is some information about the ecosystem on Earth and a brief composition of air, land and ocean.

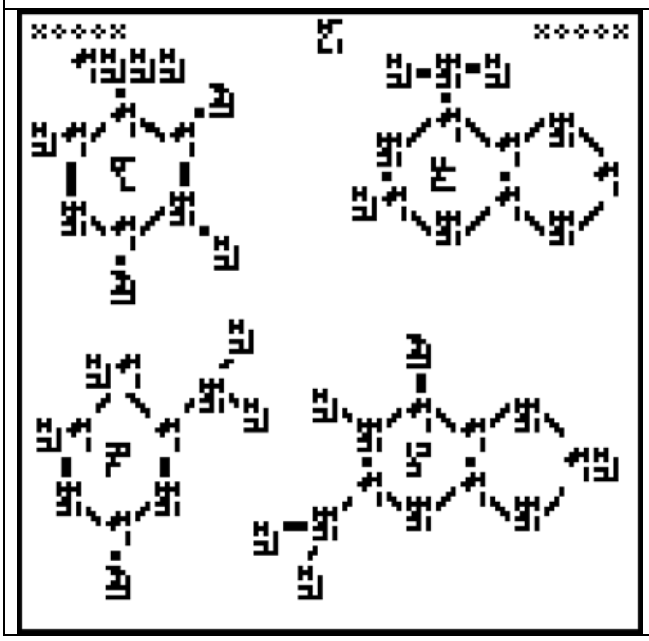
page 15 - humans (part 1)	
	1.8m

- This is a representation of 2 humans: a male and a female. The dotted line at the left is a representation of a free fall, giving the up and down of the picture.

page 16 - humans (part 2)	
	$People_{Earth}$ = Male ∪ Female = 6,000,000,000 Age_{Male} = Age_{Female} = 70 years $Mass_{Male}$ = $Mass_{Female}$ = 80 kg $Temperature_{Male}$ = $Temperature_{Female}$ = 311K audition: 20Hz to 20000Hz Visual: 295, 535 and 565 x10^{-9} m

- More information about humans: population, acoustic and visual range, age, mass, temperature.

page 17 - DNA (part 1)

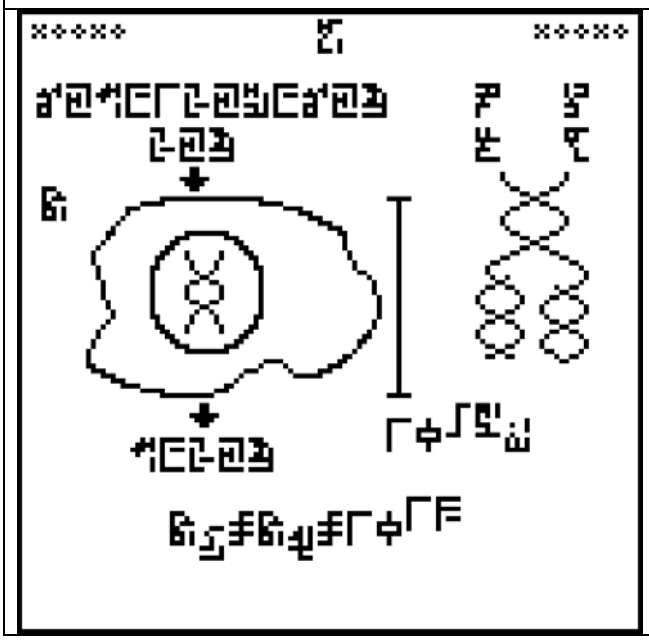


thymidine adenosine

cytidine guanosine

- This is building block of DNA: the 4 nucleic acids. This information tells we are carbon-based life form.

page 18 - DNA (part 2)



$6xC \cup 12xH \cup 6xO$
$2xO$

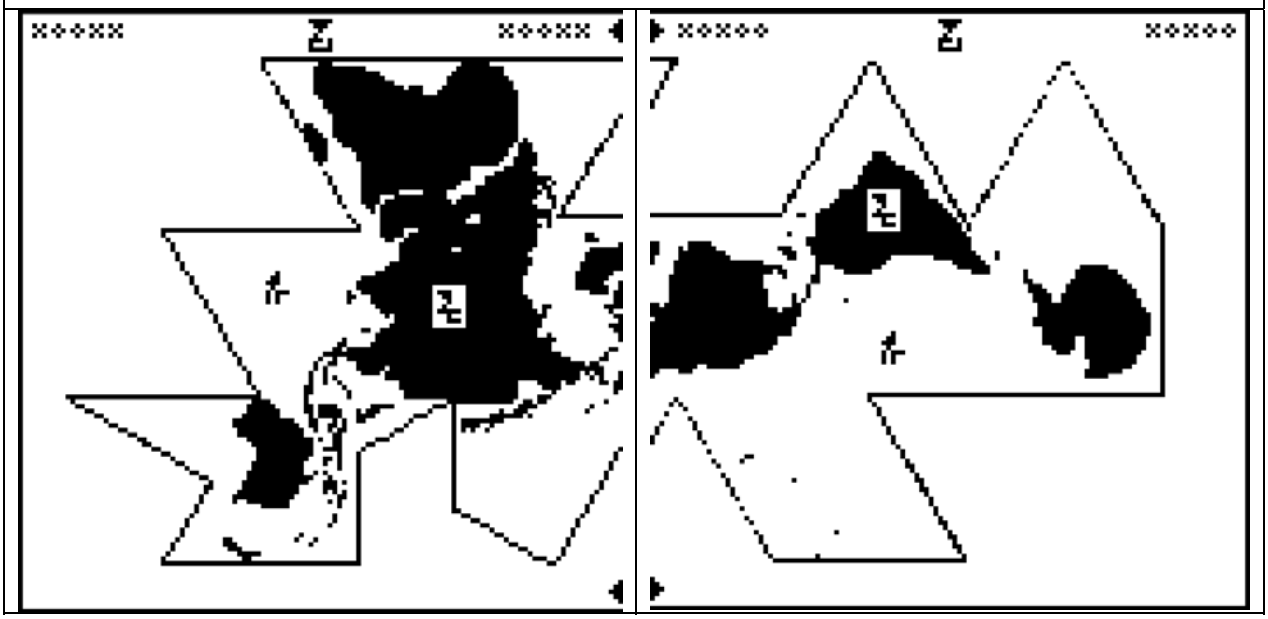
$C \cup 2xO$

cell size = 10^{-5} m

$Cell_{Male} = Cell_{Female} = 10^{13}$ cells

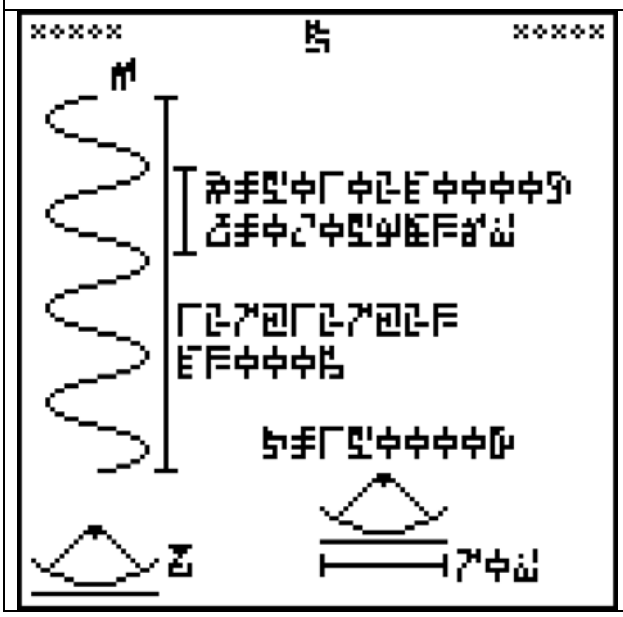
- This is a crude representation of a cell and the DNA molecule.

pages 19 & 20 - land



- This is a Fuller representation of the earth.

page 21 - radiotelescope



Frequency = 5,010,240,000 Hz
Wavelength = 0.059836 m

127x127x23
43,000 peoples

Power = 150,000 Watts

70 meters

- Here is some information about the transmitter. The carrier wave frequency is 5,010,240,000 Hz, given a wavelength of 0.059836m.
- The message size is 127x127x23 and 43,000 people were part of the project. In fact, there own messages were broadcasted after this one.
- The power of the antenna is 150,000 watts and the dish has 70m in diameter.
- In its own right this information does not mean much. But if the reader has understood the previous parts, then the units attached to the numbers will means something.

page 22 - cosmology

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

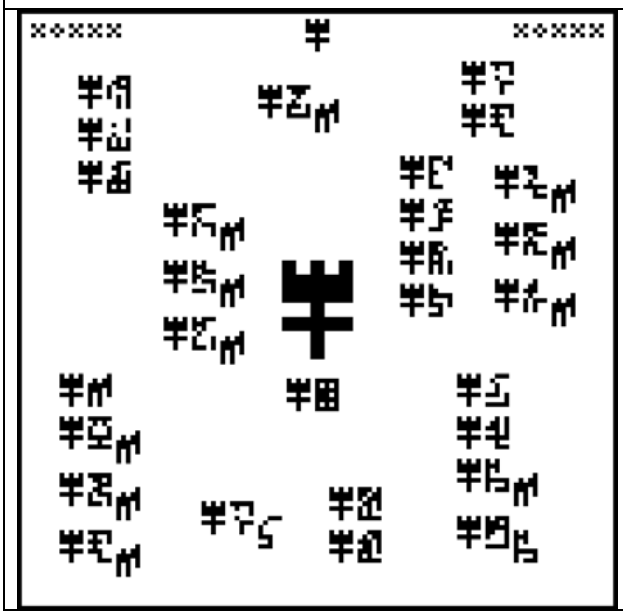
$\rho = 2.76 \times 10^{-27}$ [kg m^{-3}]

$\Lambda = 1.08 \times 10^{-35}$ [s^{-2}]

Hubble = 1/14000000000 year^{-1}
$T_{universe}$ = 2.736 Kelvins

- After telling a little about human, the message now tells the reader about our understanding of the universe. We are talking about general relativity and cosmology.
- The age of the Universe, as we understand it, is 14 billions years old and it current temperature is 2.736 Kelvin.

page 23 - questions

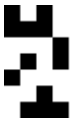
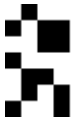


- This is the last page of the message. Now that we have divulged information about us, we would like those questions to be answered.
- The questions are based on the same kind of information presented through the entire message.

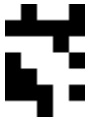
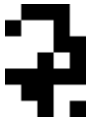
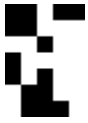
Annex C: 2003 alphabet

Those are the symbols use in the 2003 message. Symbols representing numbers are 4x7 bitmaps and others symbols are 5x7 bitmaps.

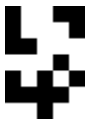
Numbers (4x7)

	0		1		2
	3		4		5
	6		7		8
	9				

Units

	joule		kelvin		kilogram
	meter		newton		pascal
	second		watt		year
	hertz				

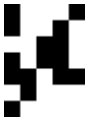
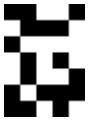
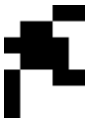
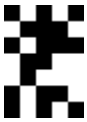
Chemical elements

	aluminum		argon		carbon
	chlore		gold		hydrogen
	iron		nitrogen		oxygen
	silicium		silver		sodium
	sulfur		uranium		zinc
	E114		helium		

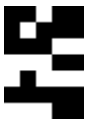
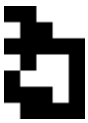
Mathematics

	equal		mathematics		minus (-)
	multiplication (*)		negation		pi (π)
	plus (+)		power (^)		radius
	undetermined		division (/)		dot (.)

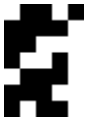
Physical concepts

	acceleration		charge		electron
	energy		force		frequency
	gravity		length		mass
	neutron		photon		physics
	pressure		proton		density
	velocity		temperature		time
	wavelength		distance		Constant of Hubble

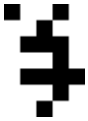
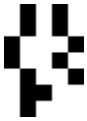
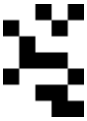
Biological

	adenosine		cell		cytidine
	female		male		thymidine
	guanosine				

Astronomy

	Jupiter		Moon		Sun
	Earth				

Others

	age		delta		E.T.
	etc		land		ocean
	question		sky		variable a
	variable b		variable c		

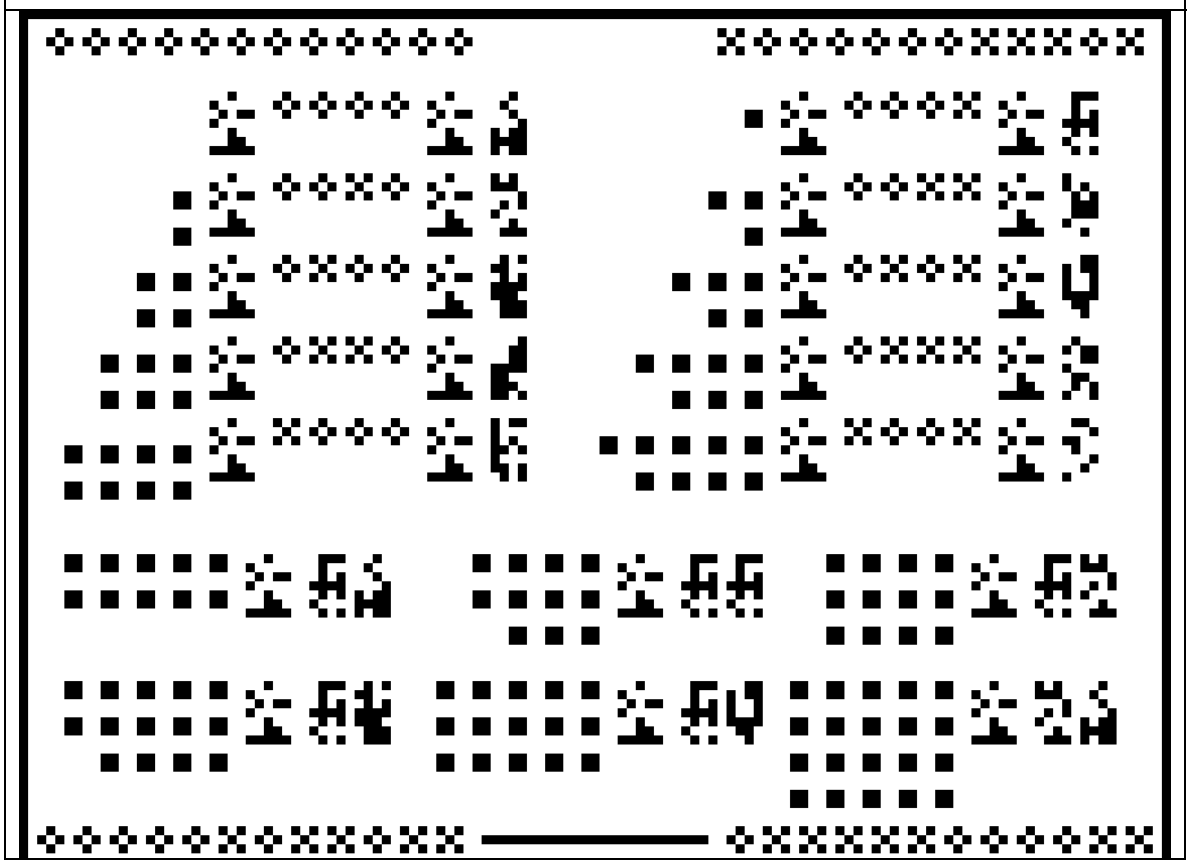
Annex D: 2003 message

The 2003 message have essentially the content as in the 1999 message. However, there have been some changes and here a brief list:

- The format has changed from a 23 pages to a single page. Analysis showed that vertical lines are more important for decoding than horizontal ones. The single page structure is more efficient (ie better use of the space) for writing the message.
- The whole set of symbols has been rebuilt to be more noise resistant. Digits are no longer represented by 5x7 symbols but by 4x7. They appear more often and therefore could bear to be smaller.
- Some information from the 1999 has been dropped (ie some graphics) and some information updates (ie largest prime number)
- The symbol for union was replaced by the addition.
- The separation between each section consists of 2 binary numbers and a line. The value at the left is line number from the top and the value at the right is the remaining lines until the end of the message.

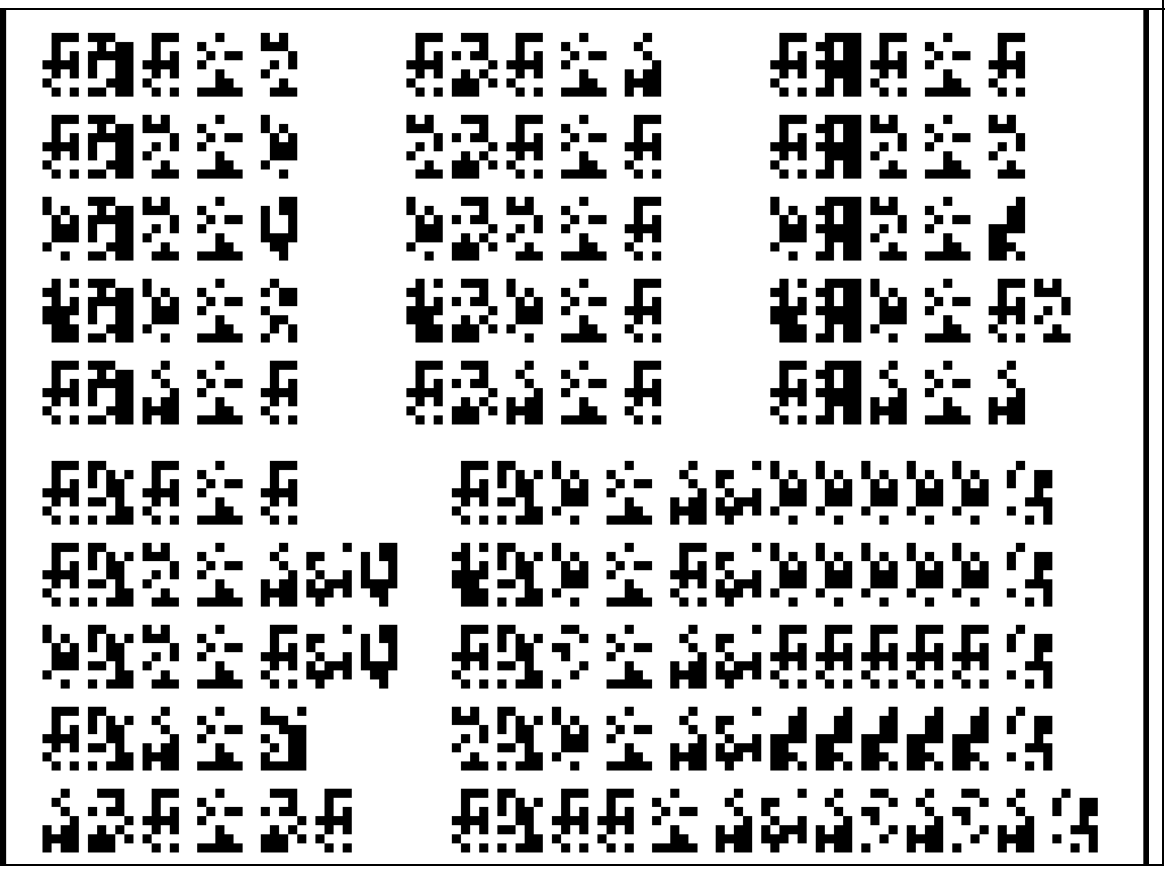
The notes related to each section only addressed difference from the 1999 message.

section 1 - numbers



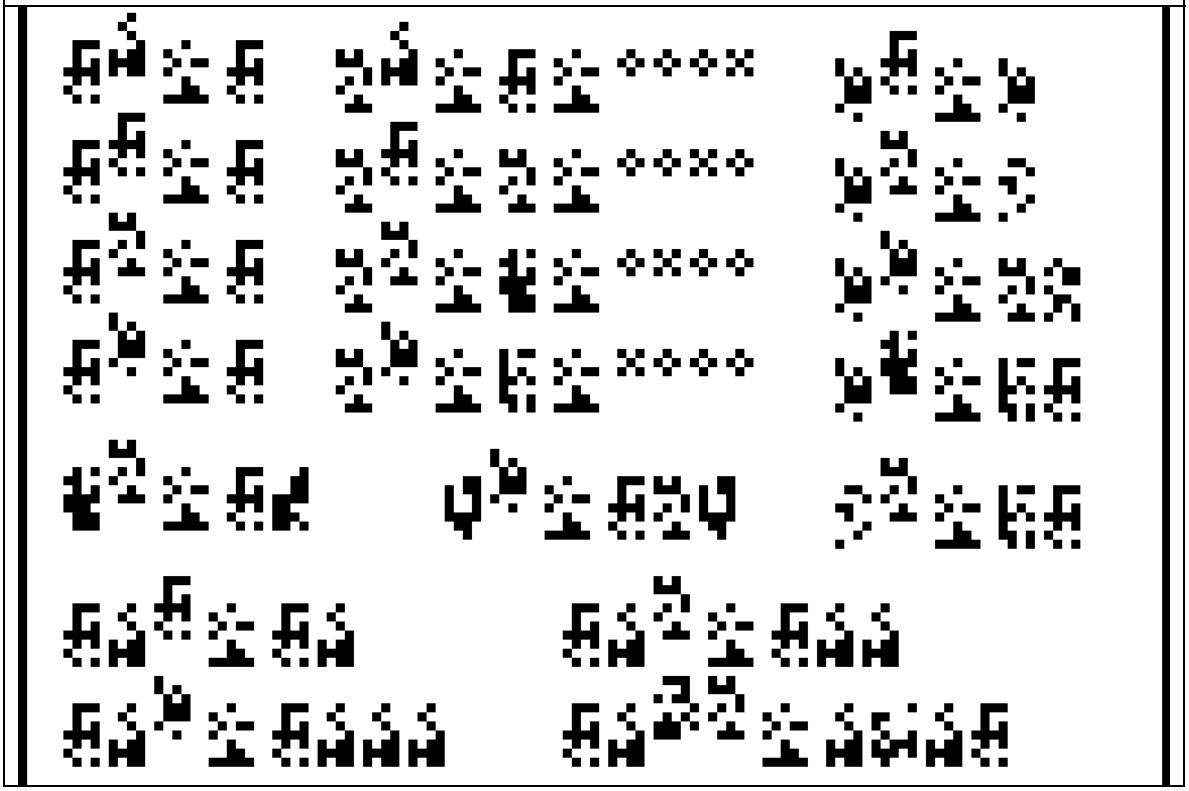
- **Introduction to numbers**: similar to page 1 of 1999.

section 2a - mathematical operators



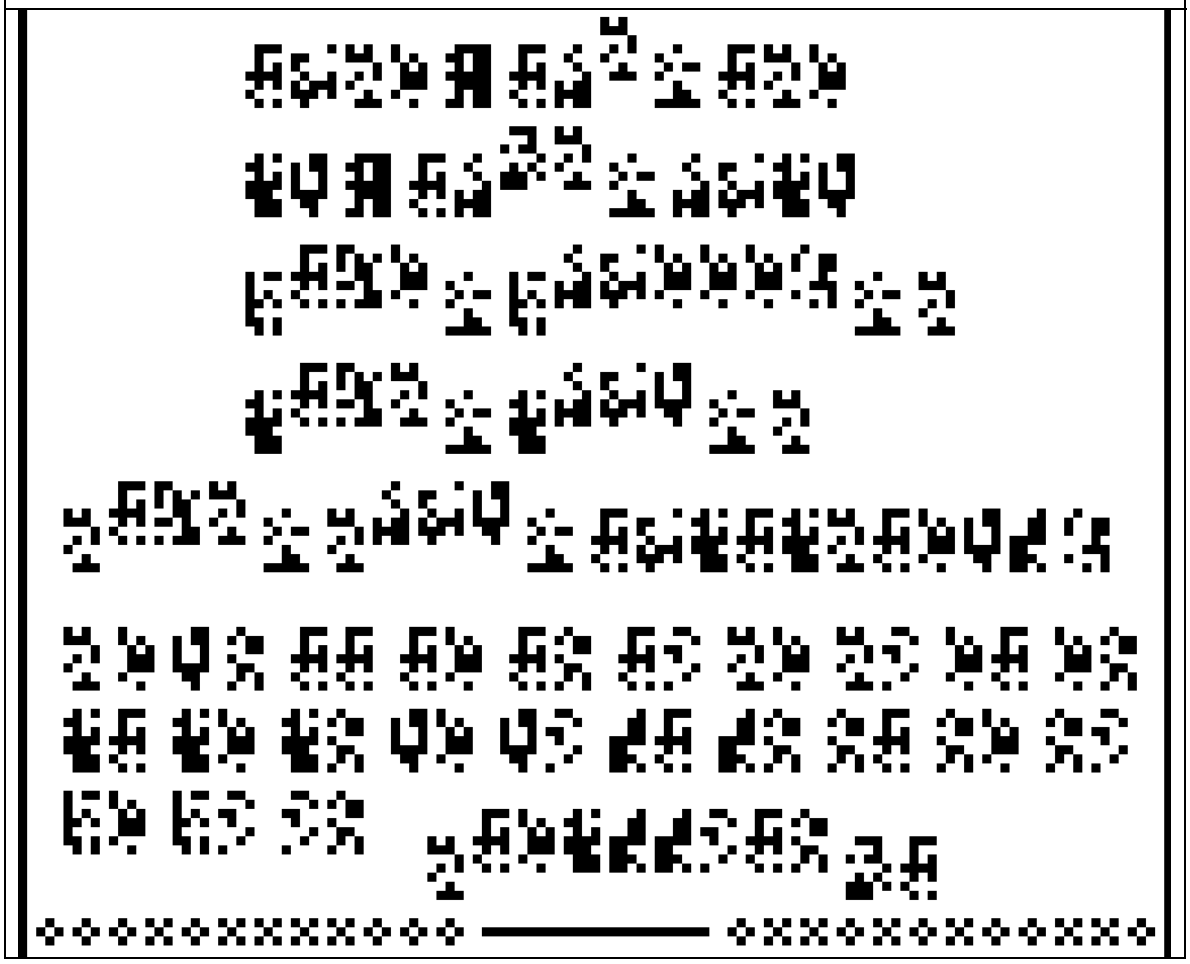
- **Introduction to operators**: same as page 2 of 1999.

section 2b - mathematical operators



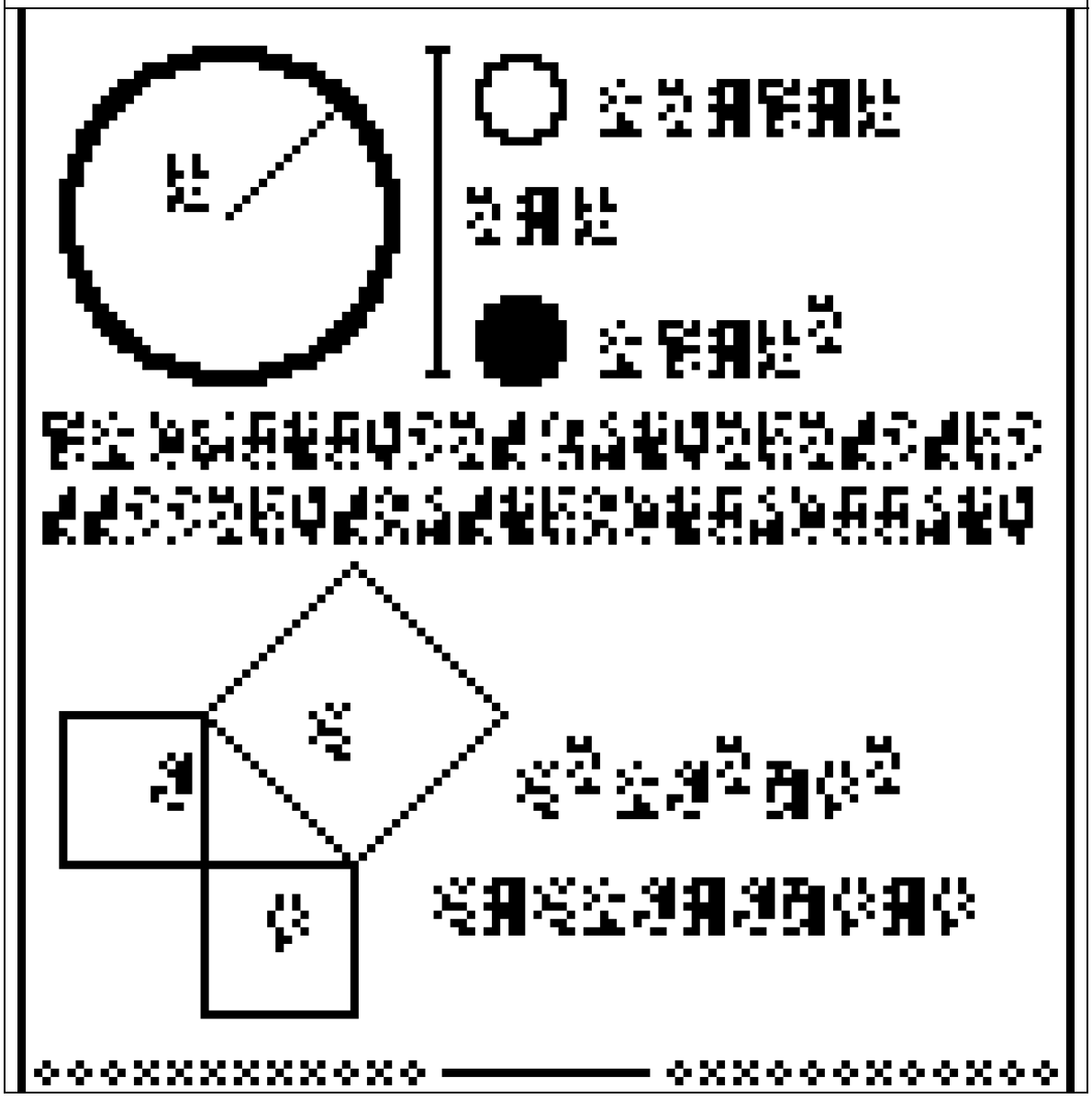
- **Introduction to exponent notation**: similar to page 3 of 1999.

section 2c - operators and primes



- list of prime from 2 to 89 and the largest prime discovered in 1999 (previously in page 1).

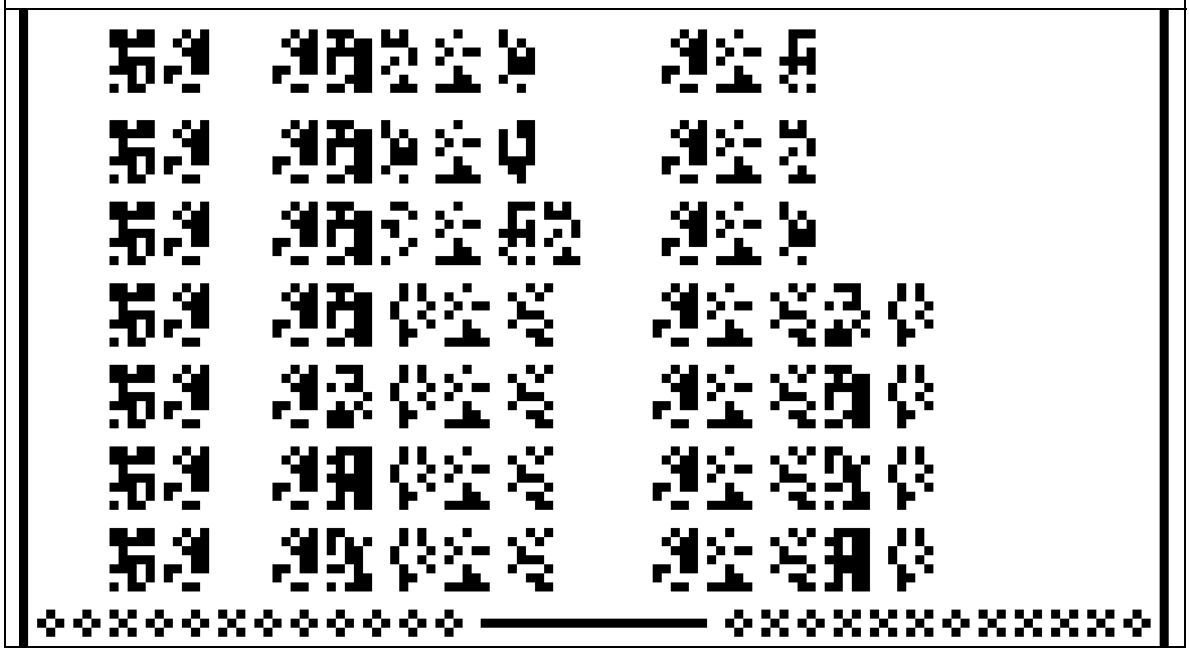
section 3 - notion of geometry



- Introduction to some geometric notions such as radius and area
- PI is displayed with 1,241,100,000,000 digits. The last 36 digits (045282696896699285670648734103110 45) are actually written preceding by 3.1415926
- The use of Pythagoras's theorem to reinforce the notion of exponent.

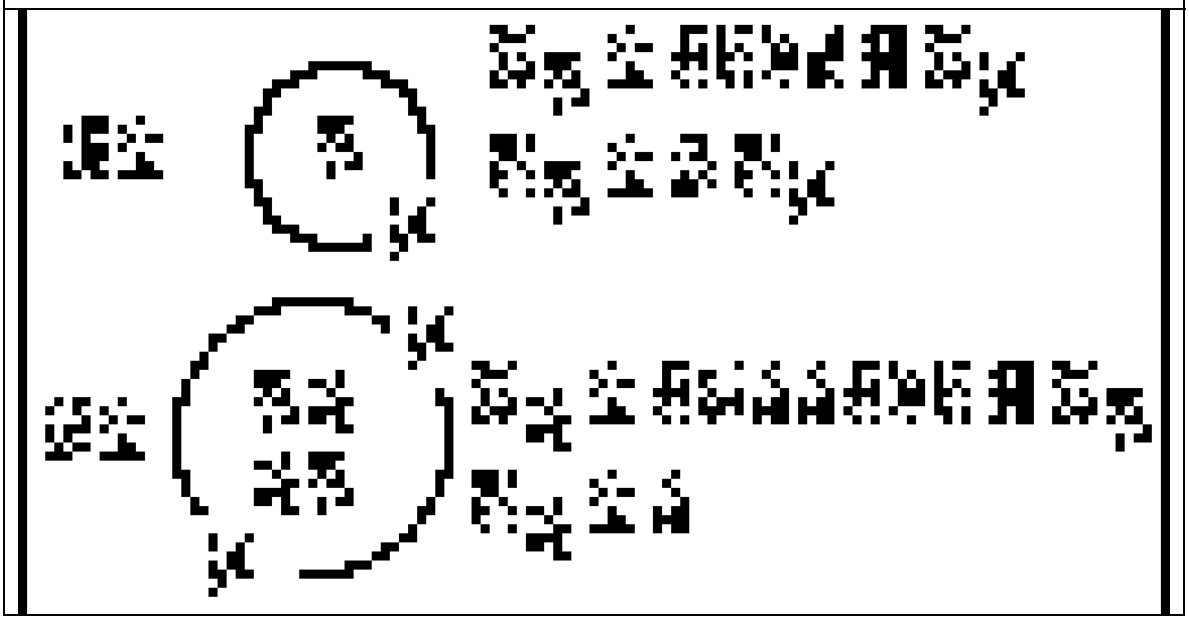
π = 3.1415926 ... 045282696896699285670648734103110 45

section 4 - notion of questions



- This is the same as page 4 of the 1999 message. The graphic has been removed.

section 5a - hydrogen and helium

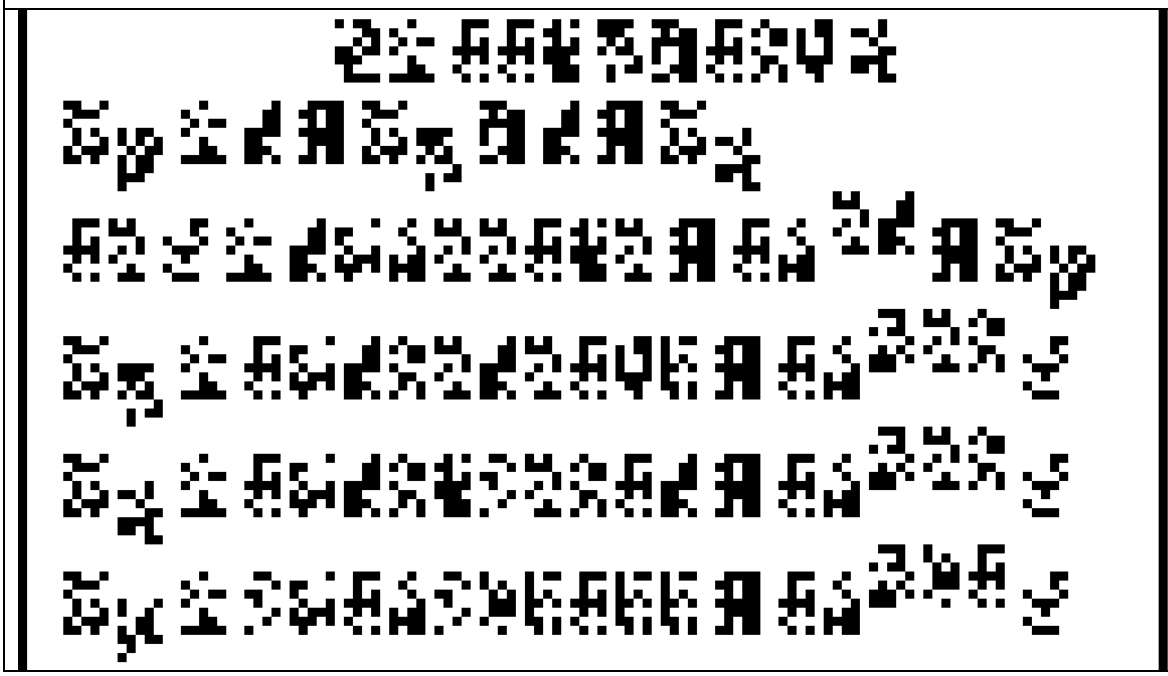


- **Introduction to mass** : same as page 6 of 1999.

section 5b - chemical elements

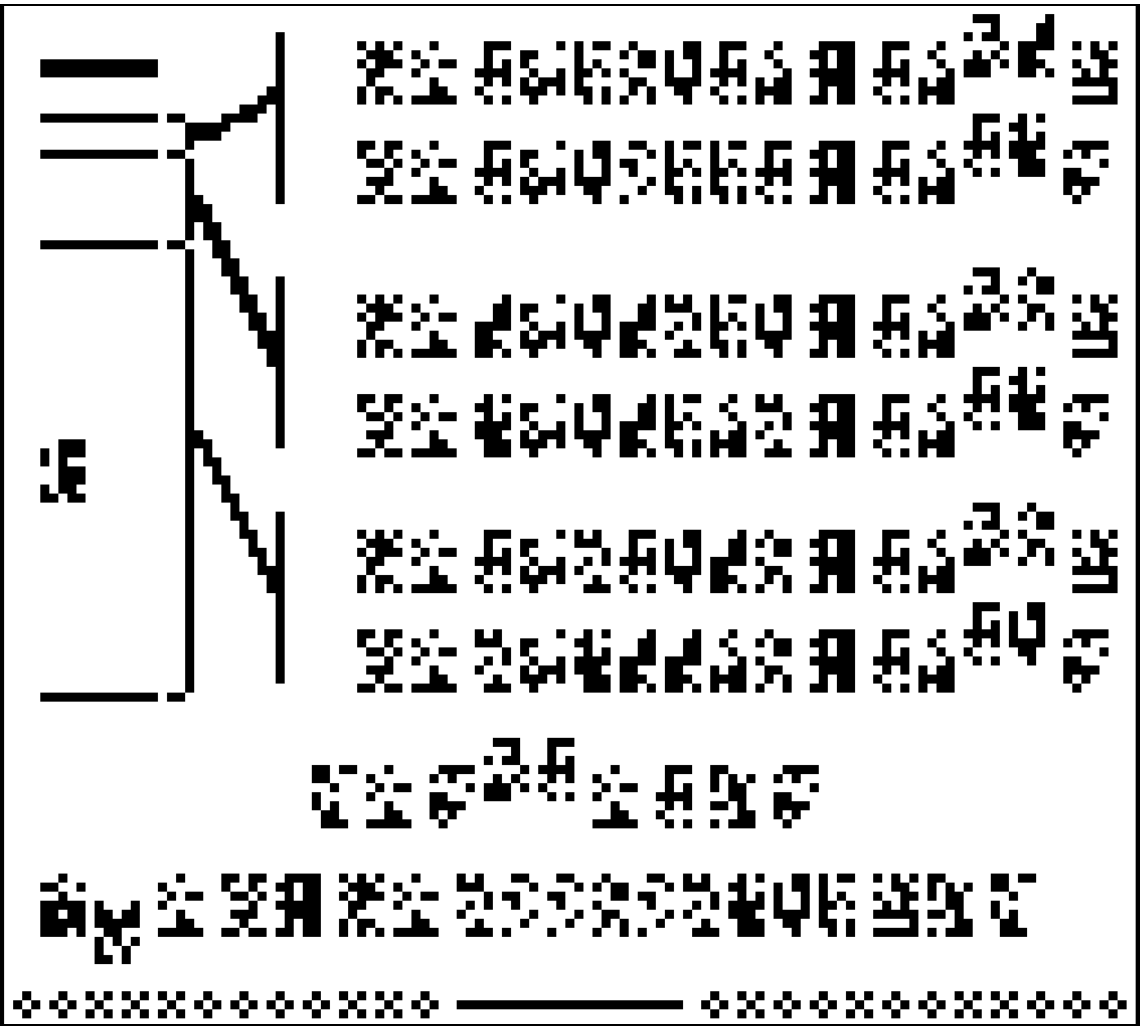
- This is the same as pages 6 and 7 of 1999.

section 5c - mass



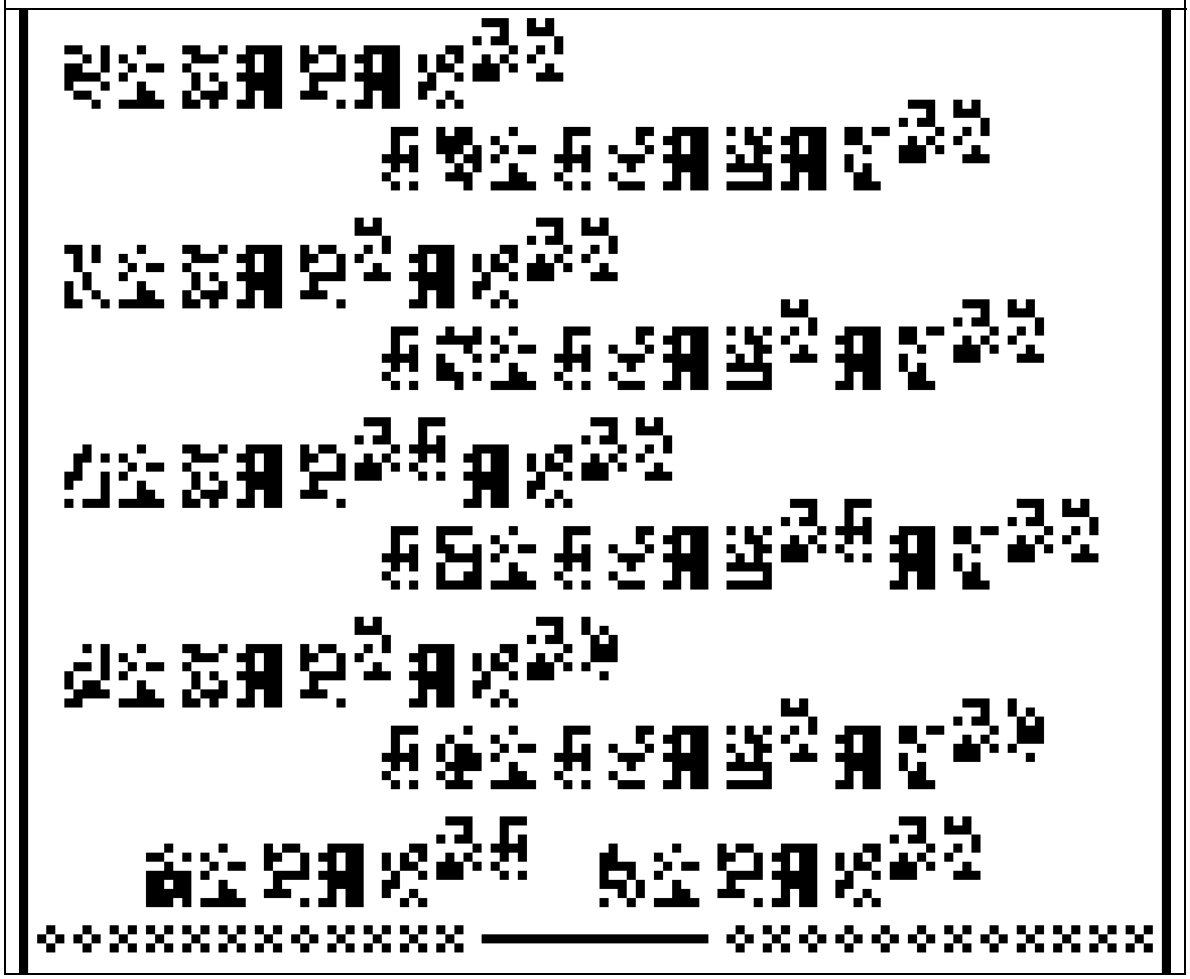
- Here the exponent notation comes handy since the proton, neutron and electron masses are listed

section 5d - spectrum of hydrogen



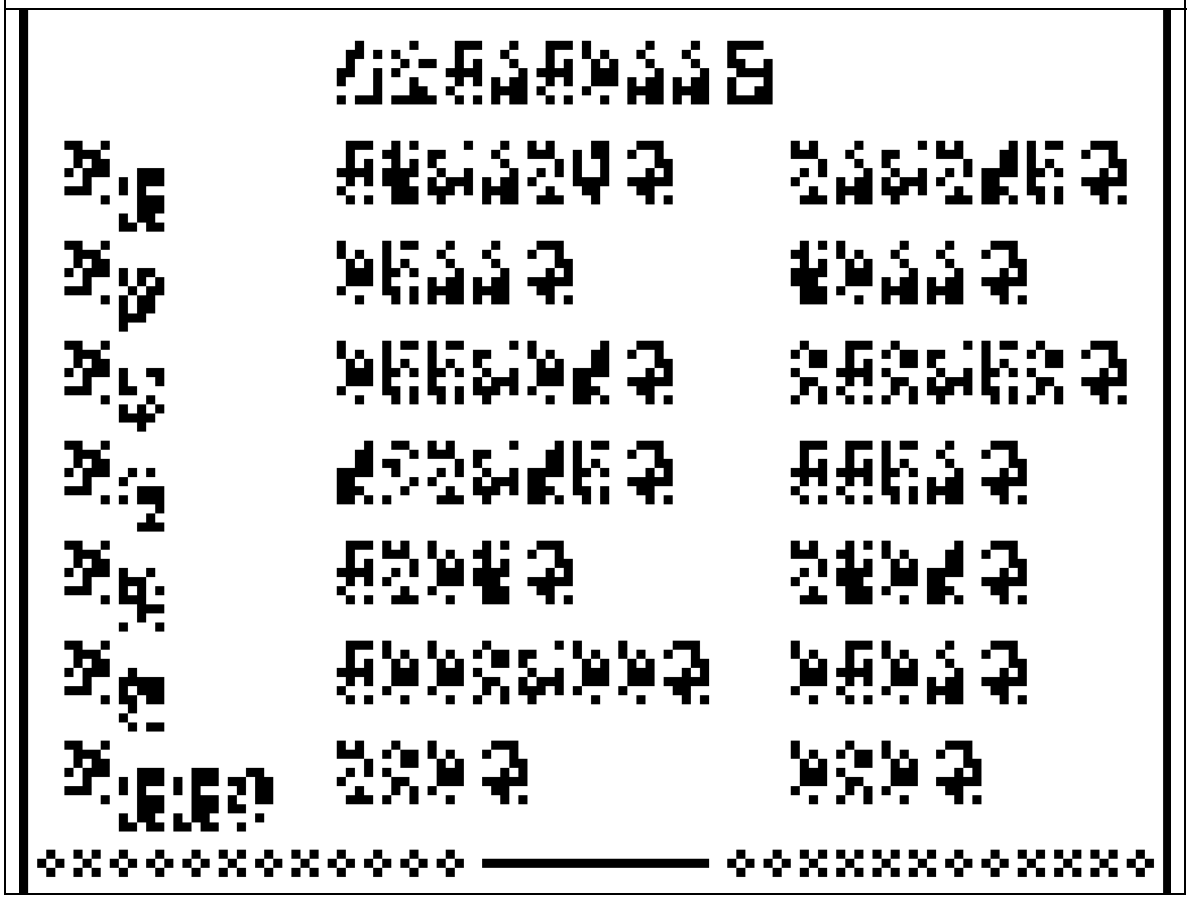
- The hydrogen atom is used to introduce wavelength and ultimately the length notion. The speed of light is also displayed relating the wavelength and the frequency.
- The hertz is introduced as the unit of frequency.
- The notion of time is shown using the frequency.

section 6 - units of measurement



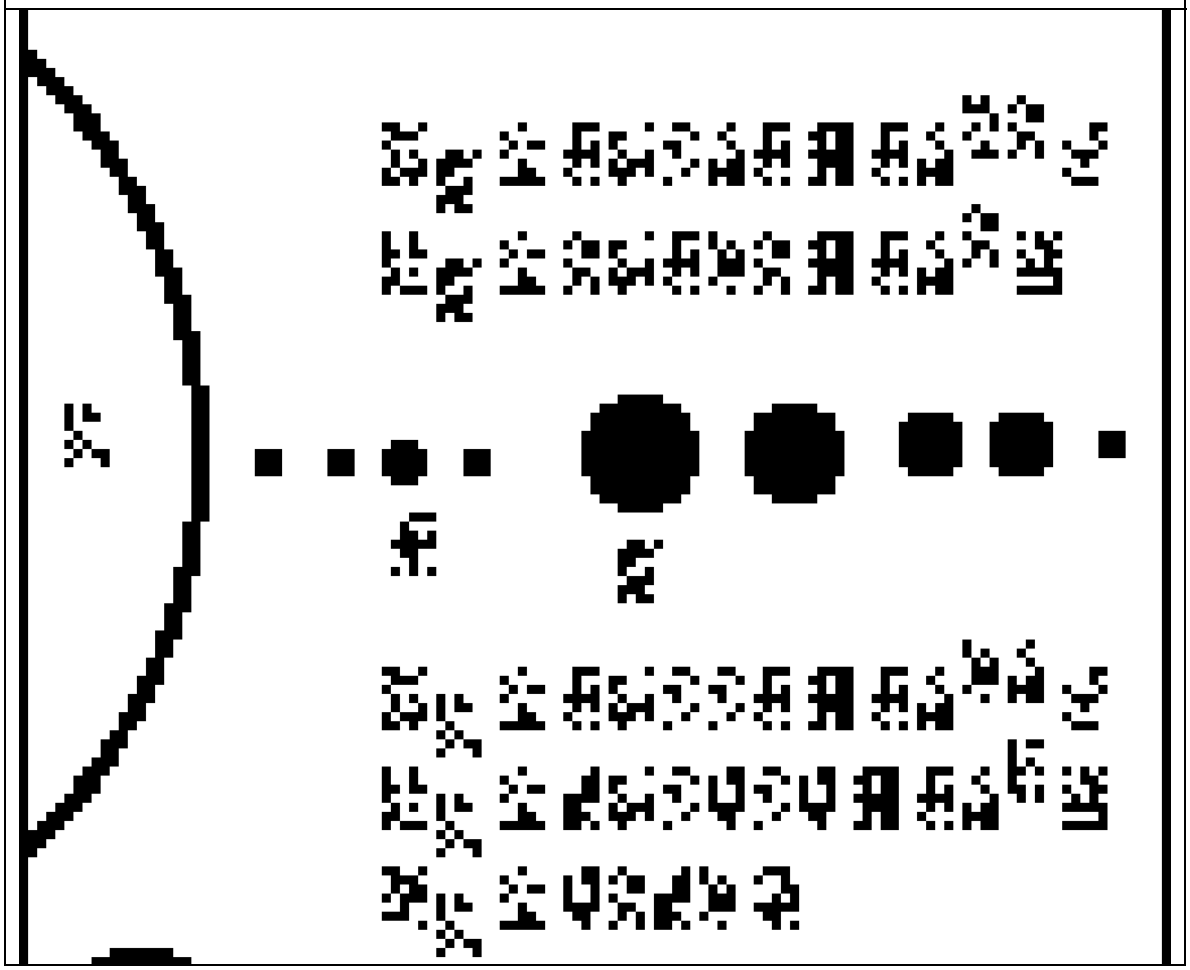
- Same as page 9 of 1999 message

section 7 - temperature



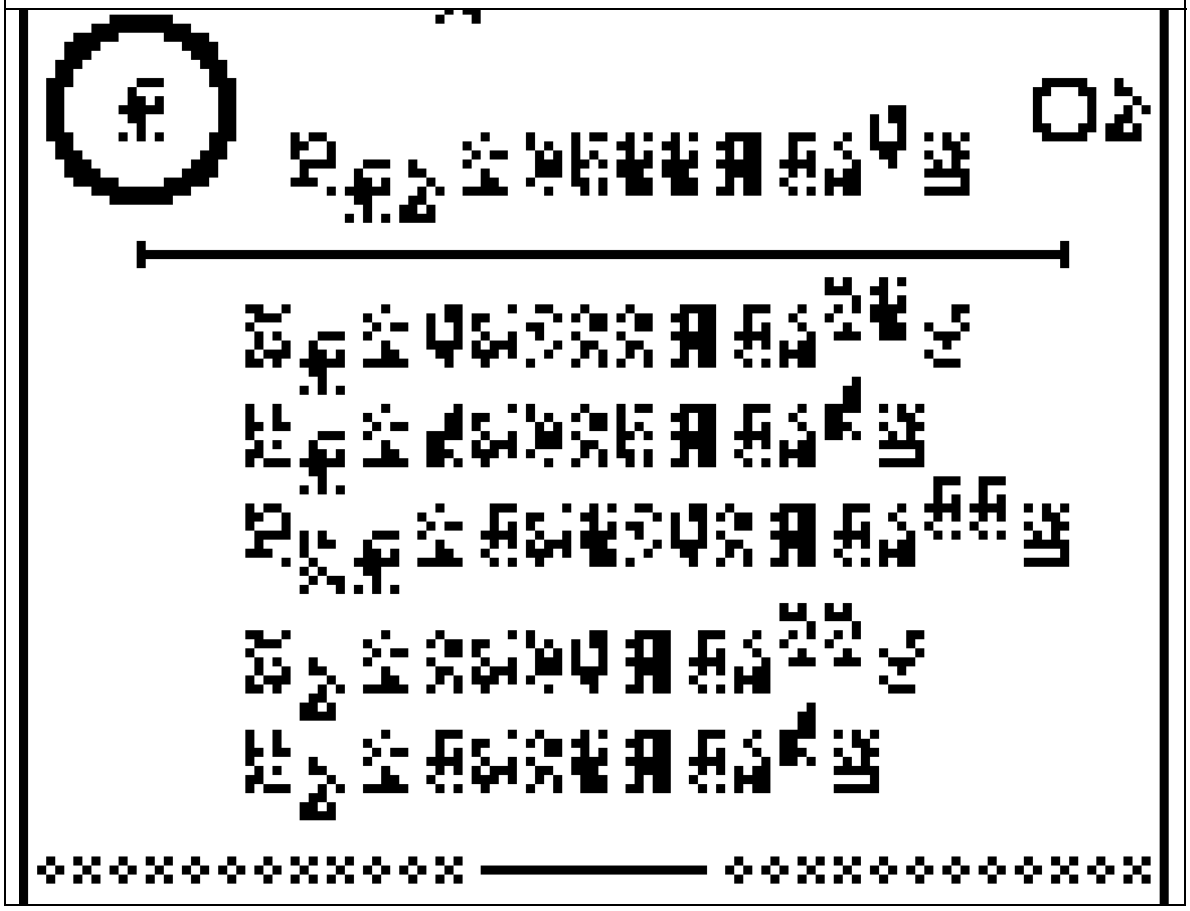
- The temperature is defined in this page. The boiling and melting temperatures are of already introduced elements are listed.
- Pressure at which the temperature is expected is also written.
- The graphic from the 1999 message has been removed.

section 8a - solar system



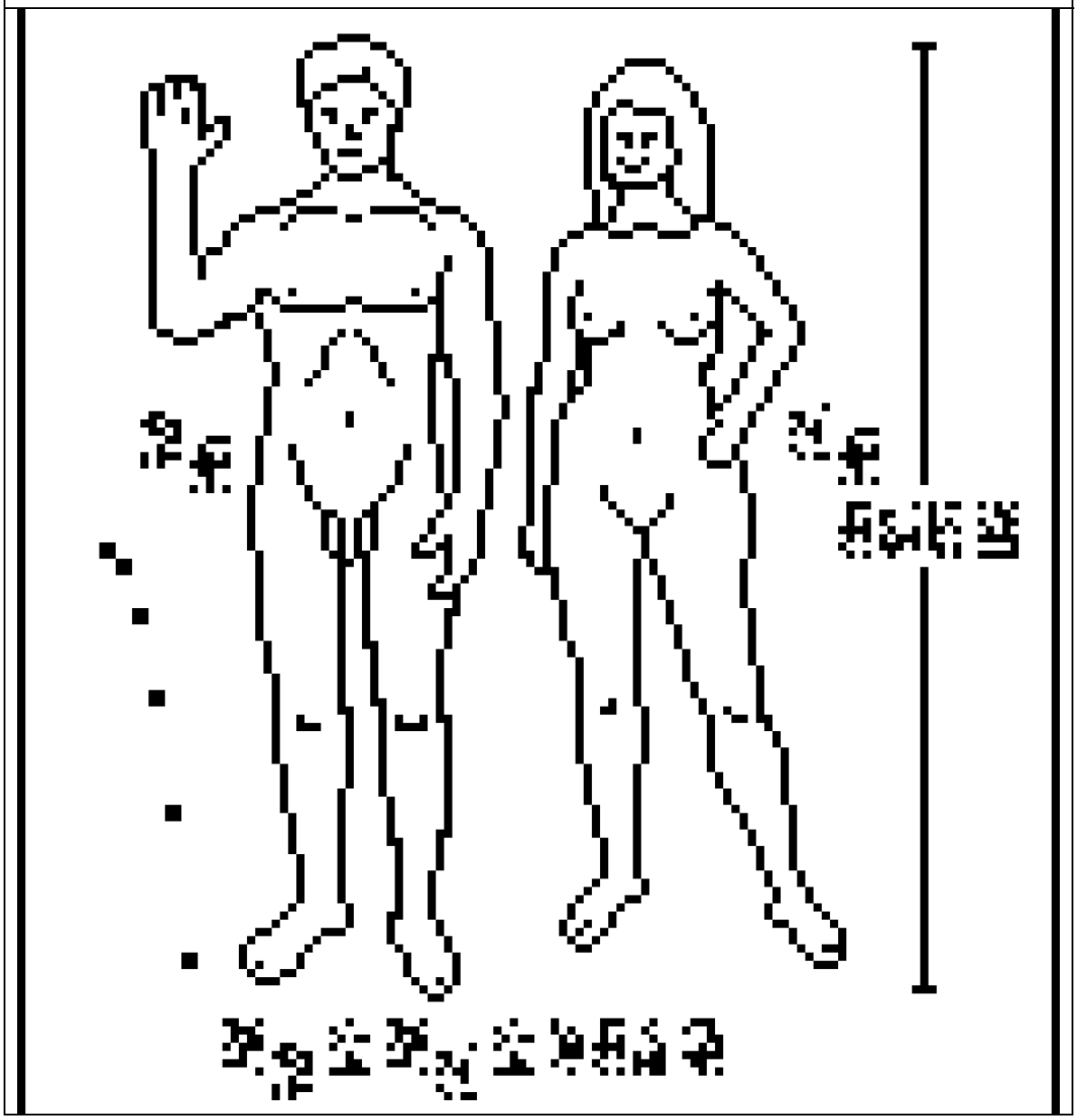
- same as page 11 of 1999
- We have the capability to see planets surrounding other stars. Given ET has the same possibility; this page is a representation of the solar system. The Sun, Jupiter and Earth are the only objects identified. Jupiter's and Sun's size and mass are listed.

section 8b - Earth and Moon



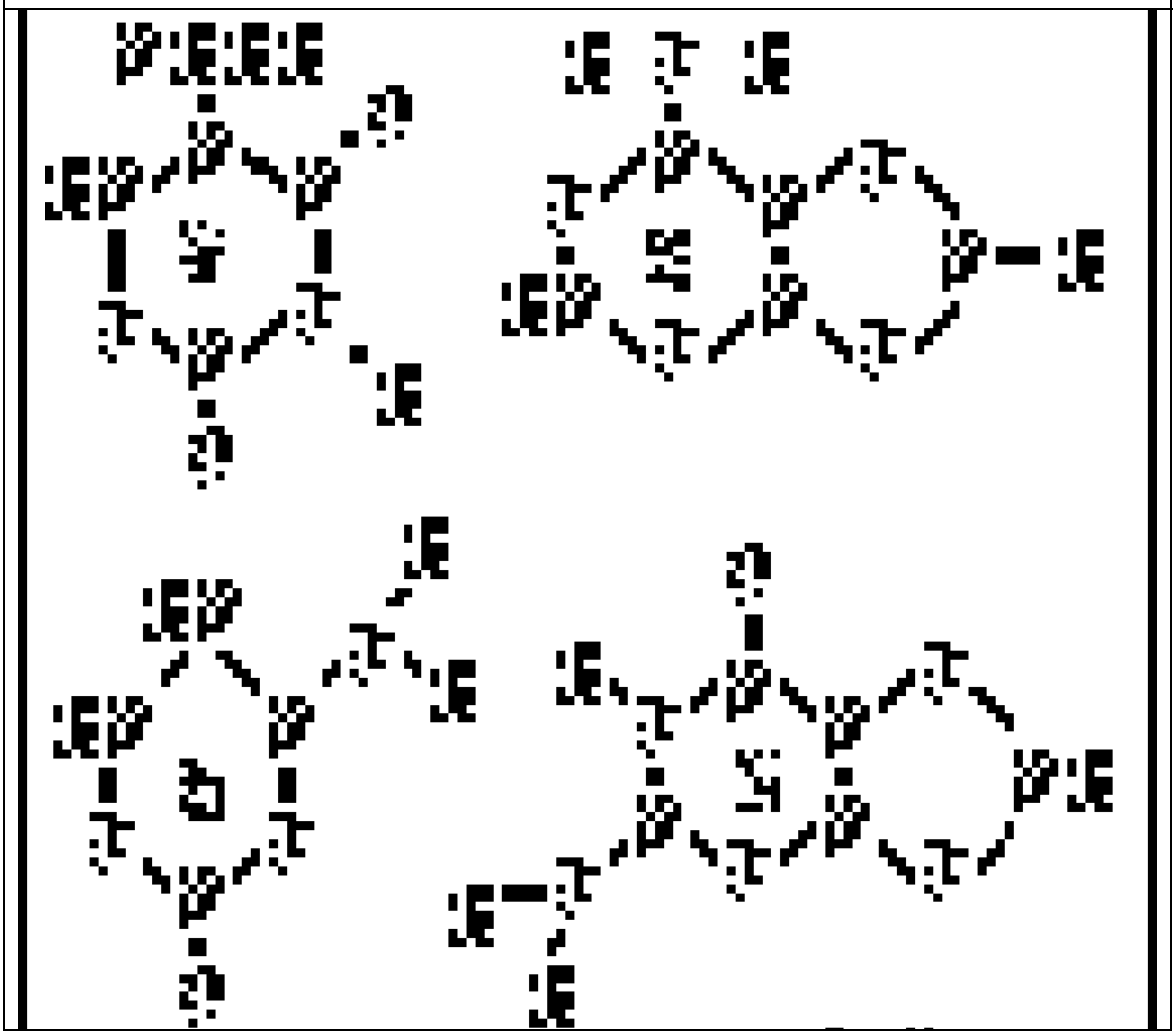
- Same as page 12 of 1999.
- This is a little bit more on the Earth-Moon system.
- The information of page 13 and 14 has been dropped. It was too confusing and did not give much information after all. Some of the information contains in page 14 has been moved to section 10.

section 9a - humans



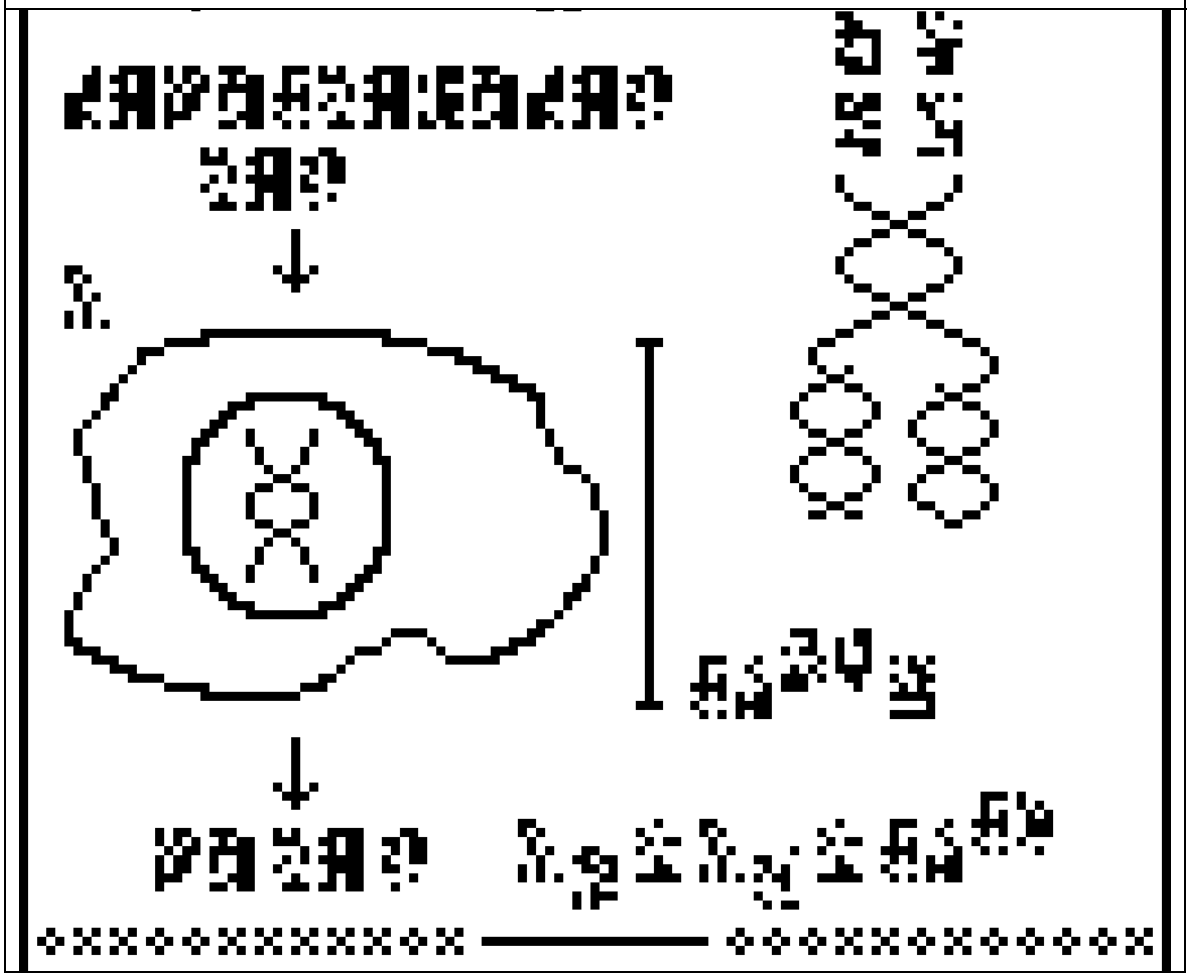
- Same as page 15 of 1999

section 9b - DNA



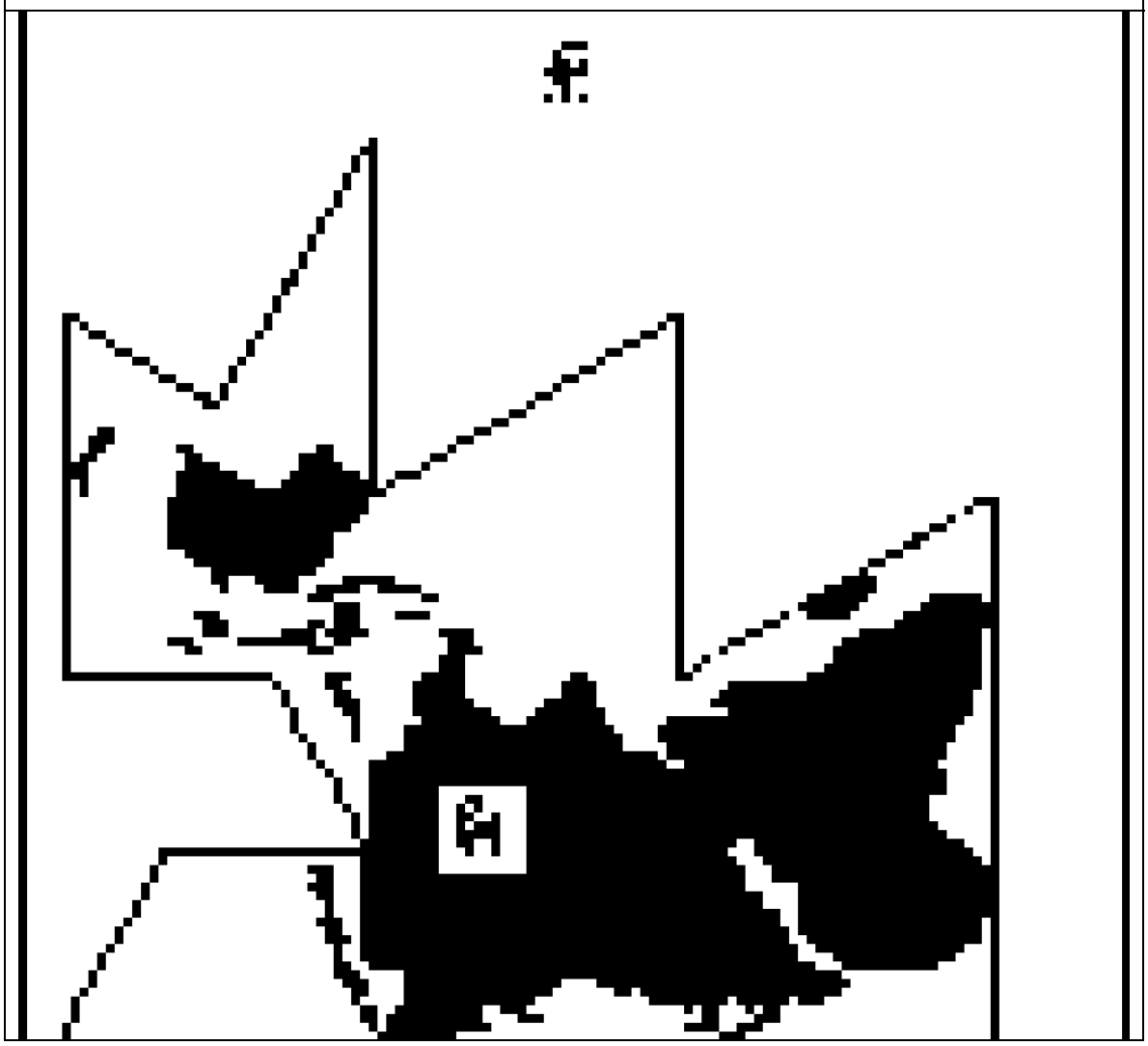
- Same as 17 of 1999.

section 9c - cell



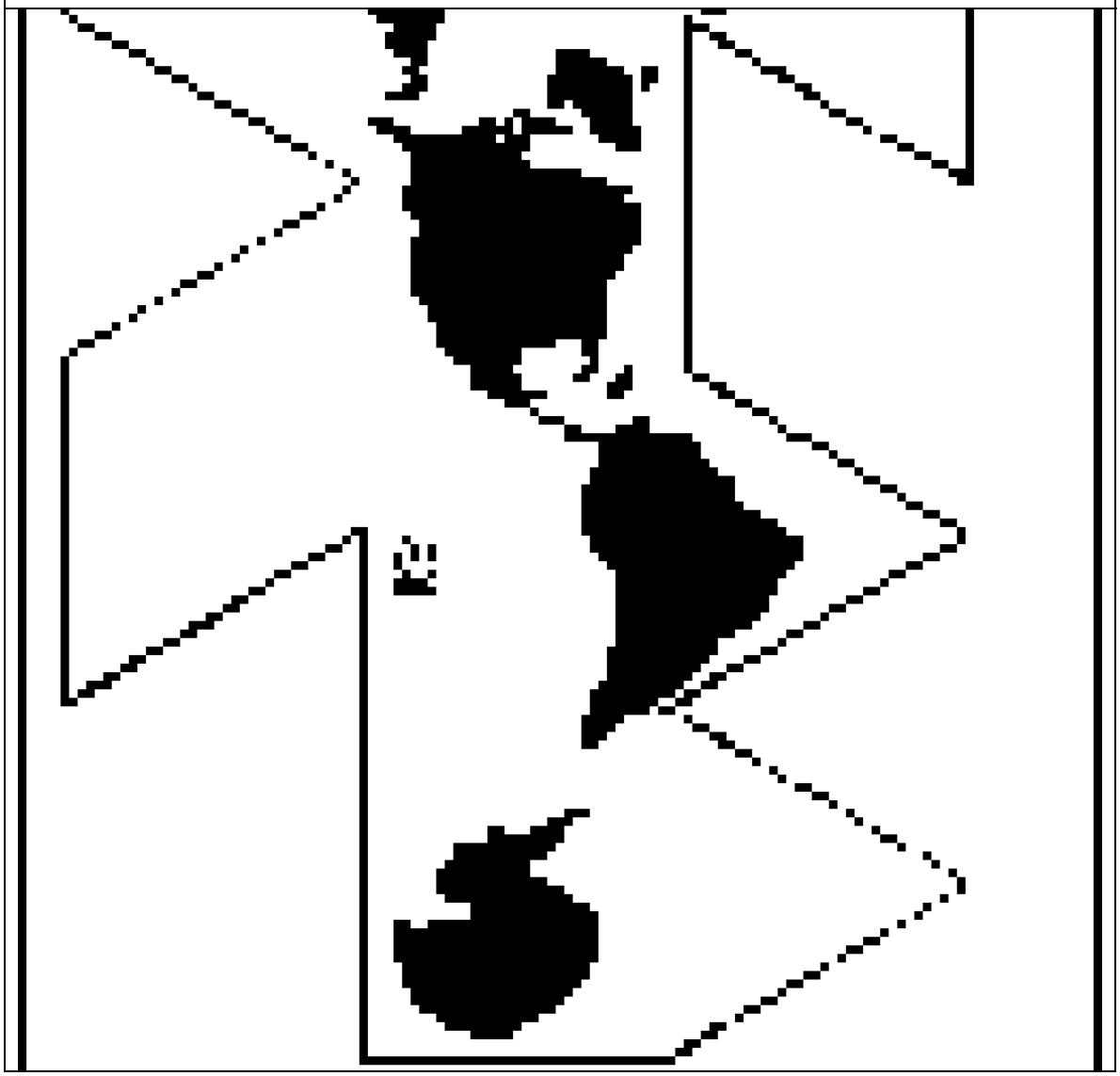
- Same as page 18 of 1999.

section 10a - land and oceans



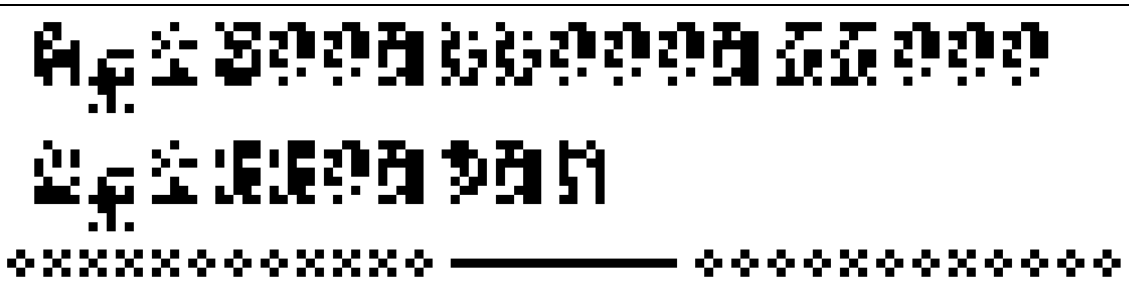
- Same as page 19 of 1999

section 10b - lands and oceans



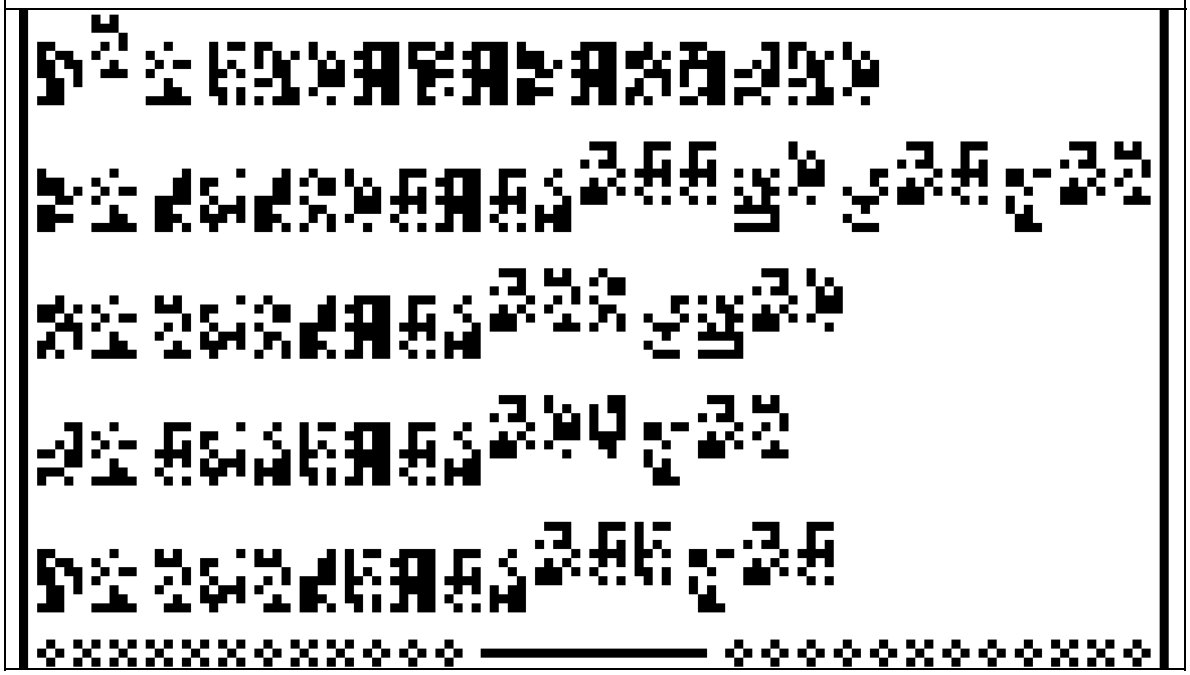
- Same as page 20 of 1999

section 10c - lands and oceans



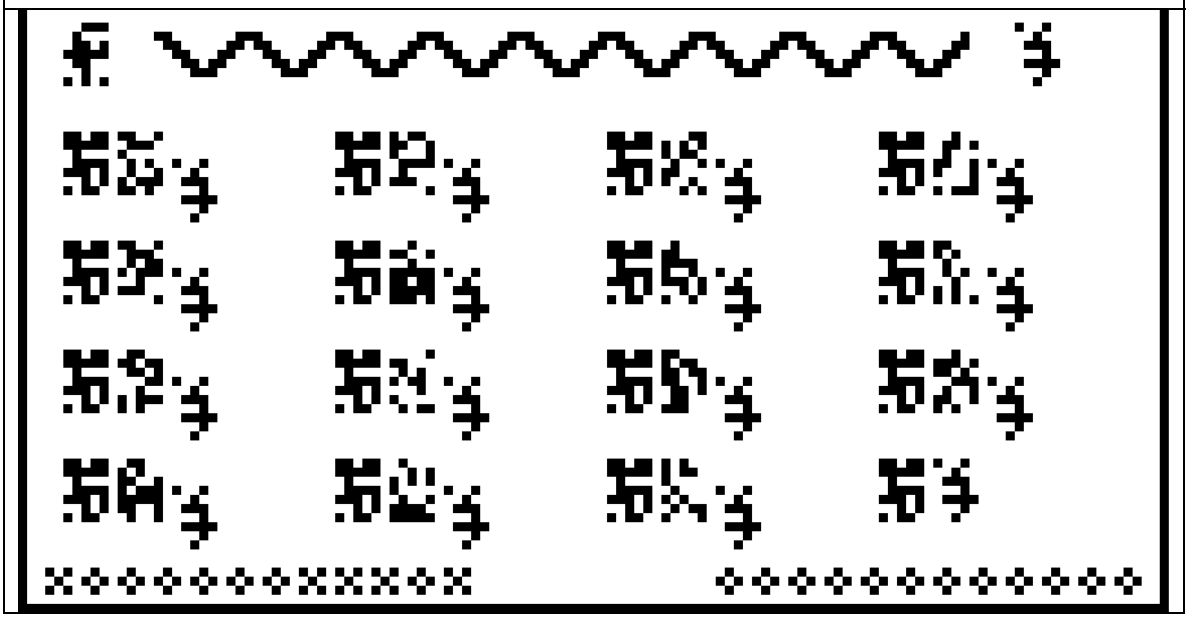
- This is the basis composition of the land (eg. Si O O + Al Al O O O + Fe Fe) and oceans (eg. H H O + Na Cl)

section 11 - cosmology



- This is a brief talk about cosmology. Same as page 22 of 1999.

section 12 - questions



- This is the last section of this message. Some questions we want answered if a respond is sSent back.