Beyond The Genome 2012 Informatics Challenge

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The Prize

Oxford NANOPORE Technologies®

Computing

The Challenge

Reads were generated by taking a portion of an organism's reference sequence and inserting a “DNA-encoded” famous quote into the sequence. Your challenge is to identify the inserted sequence, decode the quote, and identify its speaker. The first person to send the correct quote and its speaker to btg2012info@gmail.com wins.

The Response

The winner will be announce on Twitter @ddgenome

The Data

http://goo.gl/3Zwkk

http://genome.wustl.edu/pub/user/ddooling/BeyondTheGenome2012InformaticsChallenge.tar.gz

ftp://genome.wustl.edu/pub/user/ddooling/BeyondTheGenome2012InformaticsChallenge.tar.gz

To the **bold**

You are free to proceed

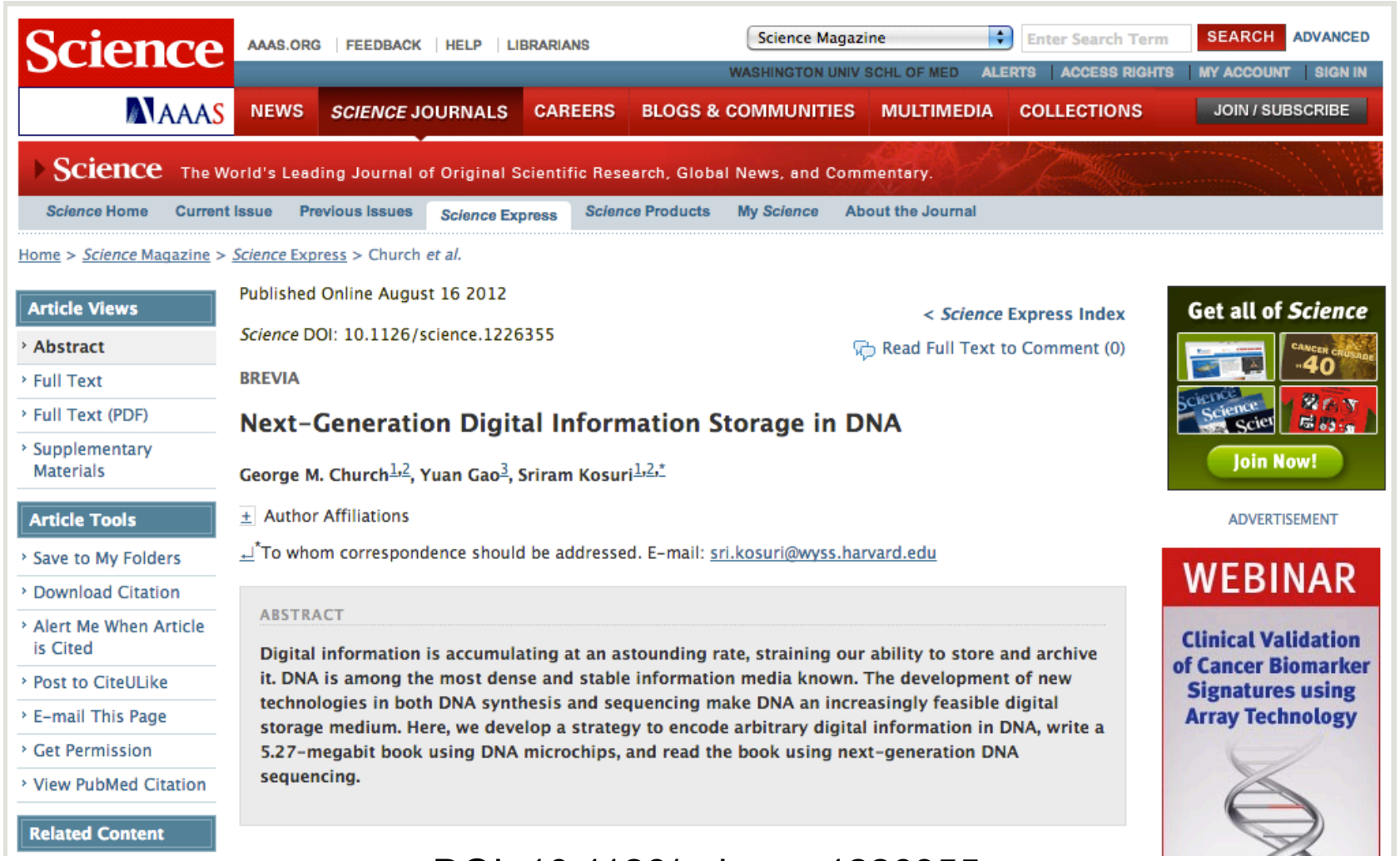
To the brave

We will present more information about the challenge

To the bewildered

We will pause, then discuss possible approaches

DNA Encoding



DOI: 10.1126/science.1226355
https://www.sciencemag.org/content/early/2012/08/15/science.1226355.full

DNA Encoding

Text `Hello, world!`

ASCII

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040	&#32;	Space	64	40	100	&#64;	@	96	60	140	&#96;	`
1	1	001	SOH (start of heading)	33	21	041	&#33;	!	65	41	101	&#65;	A	97	61	141	&#97;	a
2	2	002	STX (start of text)	34	22	042	&#34;	"	66	42	102	&#66;	B	98	62	142	&#98;	b
3	3	003	ETX (end of text)	35	23	043	&#35;	#	67	43	103	&#67;	C	99	63	143	&#99;	c
4	4	004	EOT (end of transmission)	36	24	044	&#36;	$	68	44	104	&#68;	D	100	64	144	&#100;	d
5	5	005	ENQ (enquiry)	37	25	045	&#37;	%	69	45	105	&#69;	E	101	65	145	&#101;	e
6	6	006	ACK (acknowledge)	38	26	046	&#38;	&	70	46	106	&#70;	F	102	66	146	&#102;	f
7	7	007	BEL (bell)	39	27	047	&#39;	'	71	47	107	&#71;	G	103	67	147	&#103;	g
8	8	010	BS (backspace)	40	28	050	&#40;	(	72	48	110	&#72;	H	104	68	150	&#104;	h
9	9	011	TAB (horizontal tab)	41	29	051	&#41;	)	73	49	111	&#73;	I	105	69	151	&#105;	i
10	A	012	LF (NL line feed, new line)	42	2A	052	&#42;	*	74	4A	112	&#74;	J	106	6A	152	&#106;	j
11	B	013	VT (vertical tab)	43	2B	053	&#43;	+	75	4B	113	&#75;	K	107	6B	153	&#107;	k
12	C	014	FF (NP form feed, new page)	44	2C	054	&#44;	,	76	4C	114	&#76;	L	108	6C	154	&#108;	l
13	D	015	CR (carriage return)	45	2D	055	&#45;	-	77	4D	115	&#77;	M	109	6D	155	&#109;	m
14	E	016	SO (shift out)	46	2E	056	&#46;	.	78	4E	116	&#78;	N	110	6E	156	&#110;	n
15	F	017	SI (shift in)	47	2F	057	&#47;	/	79	4F	117	&#79;	O	111	6F	157	&#111;	o
16	10	020	DLE (data link escape)	48	30	060	&#48;	0	80	50	120	&#80;	P	112	70	160	&#112;	p
17	11	021	DC1 (device control 1)	49	31	061	&#49;	1	81	51	121	&#81;	Q	113	71	161	&#113;	q
18	12	022	DC2 (device control 2)	50	32	062	&#50;	2	82	52	122	&#82;	R	114	72	162	&#114;	r
19	13	023	DC3 (device control 3)	51	33	063	&#51;	3	83	53	123	&#83;	S	115	73	163	&#115;	s
20	14	024	DC4 (device control 4)	52	34	064	&#52;	4	84	54	124	&#84;	T	116	74	164	&#116;	t
21	15	025	NAK (negative acknowledge)	53	35	065	&#53;	5	85	55	125	&#85;	U	117	75	165	&#117;	u
22	16	026	SYN (synchronous idle)	54	36	066	&#54;	6	86	56	126	&#86;	V	118	76	166	&#118;	v
23	17	027	ETB (end of trans. block)	55	37	067	&#55;	7	87	57	127	&#87;	W	119	77	167	&#119;	w
24	18	030	CAN (cancel)	56	38	070	&#56;	8	88	58	130	&#88;	X	120	78	170	&#120;	x
25	19	031	EM (end of medium)	57	39	071	&#57;	9	89	59	131	&#89;	Y	121	79	171	&#121;	y
26	1A	032	SUB (substitute)	58	3A	072	&#58;	:	90	5A	132	&#90;	Z	122	7A	172	&#122;	z
27	1B	033	ESC (escape)	59	3B	073	&#59;	;	91	5B	133	&#91;	[	123	7B	173	&#123;	{
28	1C	034	FS (file separator)	60	3C	074	&#60;	<	92	5C	134	&#92;	\	124	7C	174	&#124;	|
29	1D	035	GS (group separator)	61	3D	075	&#61;	=	93	5D	135	&#93;	]	125	7D	175	&#125;	}
30	1E	036	RS (record separator)	62	3E	076	&#62;	>	94	5E	136	&#94;	^	126	7E	176	&#126;	~
31	1F	037	US (unit separator)	63	3F	077	&#63;	?	95	5F	137	&#95;	_	127	7F	177	&#127;	DEL

Source: www.LookupTables.com

DNA Encoding

Text	`Hello, world!`
ASCII	`72 101 108 108 111 44 32 119 111 114 108 100 33`

Bits and Bytes

- Bit: off or on, 0 or 1
- Byte: eight bits, 01010101
- Each position represents a power of 2
- All characters in the ASCII set can be repesented by one byte (0 – 127 (= 2^7-1)

DNA Encoding

Text	`Hello, world!`
ASCII	`72 101 108 108 111 44 32 119 111 114 108 100 33`
Binary	`01001000 01100101 01101100 01101100 01101111 00101100 00100000 01110111 01101111 01110010 01101100 01100100`

DNA Encoding

- 0 becomes A or C
- 1 becomes T or G

DNA Encoding

Text	`Hello, world!`
ASCII	`72 101 108 108 111 44 32 119 111 114 108 100 33`
Binary	`01001000 01100101 01101100 01101100 01101111 00101100 00100000 01110111 01101111 01110010 01101100 01100100`
DNA	`AGCAGCCC ATTCCGAT CTTATTAC CTTCTTCC CGGAGGGG AATATGCC ACTACCCA ATGTATTT ATTCTTGT ATTTAATC CTGCGGAA CGTAAGCC`

How we did it

1. Downloaded a reference sequence from NCBI
2. Excised out a chunk
3. Encoded the quote into DNA
4. Randomly inserted the quote-DNA into the excised chunk from the reference
5. Generated simulated reads from the new reference

What you get

dna-encode.pl	Perl script to encode/decode text to/from DNA
i2x100f180.1.fq	Read 1 of Illumina 2x100 reads from 180+/-20 bp fragments
i2x100f180.2.fq	Read 2 of Illumina 2x100 reads from 180+/-20 bp fragments
i2x50f2000.1.fq	Read 1 of Illumina 2x50 reads from 2+/-0.2 kbp fragments
i2x50f2000.2.fq	Read 2 of Illumina 2x50 reads from 2+/-0.2 kbp fragments
i2x250f700.fq	Interleaved reads 1 and 2 of Illumina 2x250 reads from 700+/-50 bp fragments

dna-encode.pl

NAME

dna-encode - encode and decode ASCII text into DNA

SYNOPSIS

dna-encode [OPTIONS]... [FILE]...

DESCRIPTION

This script encodes a string of characters first into big endian (network order) binary and then into DNA where zero become A or C and one becomes G or T.

This implementation is based on the algorithm described in George M. Church, Yuan Gao, and Sriram Kosuri. Next-Generation Digital Information Storage in DNA. Science 2012. DOI: 10.1126/science.1226355.

dna-encode.pl

OPTIONS

```
-d, --decode
    Decode a DNA sequence into a message rather than the default of
    encoding a message into DNA.

-l, --little-endian
    Encode/decode characters using little endian byte order rather than
    the default big endian byte order.

-r, --reverse-complement
    Reverse complement the DNA after encoding (or before decoding).

--verbose
    Output intermediate binary when encoding/decoding.
```

Pause for Questions?