MadHatter: A toy cipher that conceals two plaintexts in the same ciphertext

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Abstract

We present a toy cipher that has two novel features: Two plaintexts are concealed by the same ciphertext in different schemes, and the enumeration of the permutations of ciphertext symbols (not the permutations of plaintext symbols, as used in transposition ciphers) forms the basis of one of the schemes. The other scheme uses mixed-radix numbers as substitutes for plaintext symbols. Both schemes use the same symbols, but with different interpretations, and this allows two plaintexts to be encrypted in the same ciphertext.

Keywords: MadHatter, mixed-radix number, permutation, toy cipher

Introduction

In this article we present a new toy cipher. As any toy model, it is not meant to be used in any real-life scenario. Rather, its purpose is merely to display novel features that may someday be useful in serious cryptography, or as an aid in teaching. This cipher has two new features worthy of mention. First, it uses two different schemes for decrypting the same block of ciphertext symbols to recover two corresponding plaintext symbols. This feature allows it to conceal two plaintexts in the same ciphertext. Second, one of the encryption schemes maps plaintext symbols to permutations of ciphertext symbols. The other scheme is not as new; it uses mixed-radix numbers as the images of plaintext symbols. Because these numbers must be unambiguously decipherable after a permutation, we cannot rely on a positional number system. Therefore, we will have to expand our set of ciphertext symbols so that digits can retain their values when their positions change. How the two encryption schemes work should become clearer in the next section.

The structure of the cipher is explained in more detail in the next section. Following that, we will explain its cryptanalysis with an example.

Structure of the cipher

To explain the structure of the cipher, we will work through a simple example. We will use a keyed plaintext alphabet, and replace the digits of the mixed-radix numbers with letters `A` through `I`. Letters from the first plaintext will be mapped to mixed-radix numbers. The digits of those numbers will be replaced with the symbols that we have chosen (`A`,...,`I`). Finally, those symbols will be permuted according to the letters of the second plaintext in order to obtain the ciphertext.

We begin with the set of plaintext symbols. Our cipher encrypts 24 symbols, so we will start with the English alphabet of 26 letters and remove two of the least frequent letters, for example, by replacing all occurrences of ‘J’ with ‘I’ and ‘Z’ with ‘S’. We can key the cipher by rearranging the order of the alphabet with the same or different orderings for the two encryption schemes. For example, the alphabet could be keyed with the keyword MADHATTER to obtain MADHTERBCFGIKLNOPQSUVWXY.

For each letter in the first plaintext, we map it to a four-digit mixed-radix number. The radices of these numbers are 2, 2, 2, and 3. For our example keyed alphabet, the mapping could be

M → 0000	R → 0100	K → 1000	S → 1100
A → 0001	B → 0101	L → 1001	U → 1101
D → 0002	C → 0102	N → 1002	V → 1102
H → 0010	F → 0110	O → 1010	W → 1110
T → 0011	G → 0111	P → 1011	X → 1111
E → 0012	I → 0112	Q → 1012	Y → 1112

so that, if we want to encrypt the message

“Why is a raven like a writing-desk?”

we obtain this intermediate ciphertext:

1110 0010 1112 0112 1100 0001 0100 0001 1102

0012 1002 1001 0112 1000 0012 0001 1110 0100

0112 0011 0112 1002 0111 0002 0012 1100 1000

Since the second encryption scheme will permute these digits, we need to replace them with characters that are unique to their initial positions. The first digit can be replaced by A=0 and B=1, the second by C=0 and D=1, the third by E=0 and F=1, and the last by G=0, H=1, and I=2. Our initial mapping becomes this updated mapping:

M → ACEG	R → ADEG	K → BCEG	S → BDEG
A → ACEH	B → ADEH	L → BCEH	U → BDEH
D → ACEI	C → ADEI	N → BCEI	V → BDEI
H → ACFG	F → ADFG	O → BCFG	W → BDFG
T → ACFH	G → ADFH	P → BCFH	X → BDFH
E → ACFI	I → ADFI	Q → BCFI	Y → BDFI

and the intermediate ciphertext is now

BDFG ACFG BDFH ADFI BDEG ACEH ADEG ACEH BDEI

ACFI BCEI BCEH ADFI BCEG ACFI ACEH BDFG ADEG

ADFI ACFH ADFI BCEI ADFH ACEI ACFI BDEG BCEG

The second encryption scheme enumerates the permutations of four objects. We can again assign them to the letters of the plaintext alphabet with a mapping like this:

M → 1234	R → 2134	K → 3124	S → 4123
A → 1243	B → 2143	L → 3142	U → 4132
D → 1324	C → 2314	N → 3214	V → 4213
H → 1342	F → 2341	O → 3241	W → 4231
T → 1423	G → 2413	P → 3412	X → 4312
E → 1432	I → 2431	Q → 3421	Y → 4321

(We do not necessarily have to use the same keyed alphabet, but could use another keyword to reorder the plaintext letters.) So now, if we want to encrypt a second message such as

“I haven’t the slightest idea.” “Nor I.”

then the permutations that we will need are

```
2431 1342 1243 4213 1432 3214 1423 1423 1342
1432 4123 3142 2431 2413 1342 1423 1432 4123
1423 2431 1324 1432 1243 3214 3241 2134 2431
```

We must apply these permutations to the blocks of four symbols in the intermediate ciphertext above. So, the first block, `BDFG`, is reordered with the first permutation, 2431, to become `DGFB`. The second block is reordered with the second permutation to become `AFGC`. This continues until we obtain the final ciphertext:

```
DGFB AFGC BDIF IDAF BGED ECAH AGDE AHCE BEID
AIFC IBCE EBHC DIFA CGBE AFIC AHCE BGFD GADE
AIDF CHFA AFDI BIEC ADHF ECAI FCIA DBEG CGEB
```

Decipherment requires that one knows the alphabet key(s), the choice of symbols for the digits of the mixed-radix numbers, and which digit of those numbers is the ternary digit. However, this is not a particularly difficult cipher to cryptanalyze, as we shall see in the next section.

Cryptanalysis

Analyzing this toy cipher is not difficult. First, we break the ciphertext into blocks of four symbols. Then, by noting which symbols do not occur in the same block as others, we can assign them to groups, each of which represents the first, second, third, or fourth digit of the mixed-radix numbers. We can then assign a mapping from those numbers to the 24-letter alphabet. The resulting text can be analyzed as a monoalphabetic substitution cipher, which can be broken by hand or with an automated system like the hill-climbing stochastic that maximizes textual fitness described by Jakobsen (1995). The orderings of the digit symbols (i.e., the permutations) can also be mapped to the 24-letter alphabet. The resulting text can again be analyzed as a monoalphabetic cipher. Finally, it is possible to recover the keywords (if any) that were used to reorder the keyed alphabets.

Let us work through an example. Suppose we are presented with this ciphertext, and all we know is that it is encrypted with the MadHatter toy cipher.

```
XSZTXTYRVYXSZTUXYWTRTYWSTZXUTWZUTZSXWTSZWTYSVZXRVUWZXSTZXRYT
WYTSXZTRWVZUVZXSUYXVTUXYRVZWTYXRWYTUTZUWUYWTTYWUXUZVTUXZXRTY
XRYTXZTRTSWYSYVXSZTXVZSWTXZSVUWYXZTRYXTRRZXTSYWTVZWRWRTYXYVU
STYWTRXYYRXTXRZTWTYSTYXRTXUYTXZSTUXZTUZWTYWRTYUWXVSZWTYSVYWU
TRXZWSTYXRYTXZTRWTYUVZWUXYVUXRZTTYRXUZTXVZXSWRYTXTZRTZXUXSZV
TRWYXUTYWUYTWZVUVSXZTWYRRTYXXRZTTYSWTYUXTWSYWRZTXTYUTYWSUYWV
RTXZSYVXTYWSVSXZTXYRVUWYYWRVVRWYYRWV
```

Our first step is to break the ciphertext into blocks of four symbols:

```
XSZT XTYR VYXS ZTUX YWTR TYWS TZXU TWZU TZSX WTSZ ...
```

Then we tabulate the occurrences of symbols in the same block. In this grid we see an X when two symbols appear together in at least one four-symbol block.

	R	S	T	U	V	W	X	Y	Z
R	-		x		x	x	x	x	x
S		-	x		x	x	x	x	x
T	x	x	-	x		x	x	x	x
U			x	-	x	x	x	x	x
V	x	x		x	-	x	x	x	x
W	x	x	x	x	x	-		x	x
X	x	x	x	x	x		-	x	x
Y	x	x	x	x	x	x	x	-	
Z	x	x	x	x	x	x	x		-

We can see that R, S, and U never appear in the same block. Therefore, they must be the symbols for the ternary digit. Likewise, T and V do not appear together, so must represent one of the binary digits. The complete set of sets is

{T, V}, {W, X}, {Y, Z}, {R, S, U}

We can now map combinations of these symbols to the 24-letter alphabet. The choice of mapping is irrelevant, since we will be analyzing the result as a monoalphabetic substitution later. So, without loss of generality, let us use this mapping:

TWYR → A	TXYR → G	VWYR → N	VXYR → T
TWYS → B	TXYS → H	VWYS → O	VXYS → U
TWYU → C	TXYU → I	VWYU → P	VXYU → V
TWZR → D	TXZR → K	VWZR → Q	VXZR → W
TWZS → E	TXZS → L	VWZS → R	VXZS → X
TWZU → F	TXZU → M	VWZU → S	VXZU → Y

With this mapping, we obtain this intermediate ciphertext:

```
LGUMABMFLEBWSLGBKSXVIQGCFCCYMGGKBULRLPKGKBQAVBGGKB
GILMFACXBPKBGKCSVKGMXAKMXAICSXAGKBIBDIBPKUBXGPNNN
```

Passing this through a monoalphabetic substitution analyzer returns the first plaintext (clearly, the trailing XXX is padding):

```
IT MADE ALICE QUITE HUNGRY TO LOOK AT THEM. I WISH
THEY'D GET THE TRIAL DONE, SHE THOUGHT, AND HAND ROUND
THE REFRESHMENTS. XXX
```

The substitution key is E?TUCH?G??BXYAD?OLIMPFQ?S?, where "?" again denotes unknown parts of the key because the plaintext does not contain B, G, I, J, P, X, or Z.

To decrypt the second plaintext, we need to identify the permutations used to reorder the symbols in each four-character block of the ciphertext. To that end, it is useful to replace all the members of each group with the same symbol. So, whereas earlier we found that {T, V} represent one of the binary digits, we will replace both T and V with a 1. Similarly, we will replace the members of the other sets with 2, 3, and 4. We obtain

2431 2134 1324 3142 3214 1324 1324 1234 1342 2143 2134 1324 1423 2413
2431 2314 2314 2134 1324 4321 1423 4132 1324 2314 1342 4321 1324 2431
1423 2413 2431 2314 1423 4312 4312 1342 1234 1423 2314 3214 4321 4321
1324 2413 2314 4132 1423 3421 2431 2134 1324 1243 1234 1423 1432 1324
1342 2143 2134 1324 1423 2413 2431 2314 2134 1324 2314 2431 1342 4312
1324 2431 2134 1324 2431 1423 2413 2431 2314 1423 1234 4132 2431 1342
1342 1243 2431 2134 1324 4321 4123 4312 1324 1423 1234 1423 3241 1423
3421

The mapping of these permutations to the 24-letter alphabet is arbitrary. Let us take a canonical one.

1234	→	A	2134	→	G	3124	→	N	4123	→	T
1243	→	B	2143	→	H	3142	→	O	4132	→	U
1324	→	C	2314	→	I	3214	→	P	4213	→	V
1342	→	D	2341	→	K	3241	→	Q	4231	→	W
1423	→	E	2413	→	L	3412	→	R	4312	→	X
1432	→	F	2431	→	M	3421	→	S	4321	→	Y

We get this intermediate ciphertext:

```
MGCOPCCADHGCELMIIGCYEUCIDYCMELMIEXXDAEIPYYCLIUESMG
CBAEFCDHGCELMIGCIMDXCMGCMELMIEAUMDDBMGCYTXCEAEQES
```

Analyzing it as a monoalphabetic cipher yields

```
THE QUEEN OF HEARTS SHE MADE SOME TARTS ALL ON A SUMMERS DAY.
THE KNAVE OF HEARTS HE STOLE THE TARTS AND TOOK THEM CLEAN AWAY.
```

The substitution key is M?EABDVKL?YFUXC?WIPGS?RNQ?, where "?" again denotes unknown parts of the key because the plaintext does not contain B, J, P, V, or Z.

Having recovered both plaintexts, we could stop at this point. However, if we desire, we can try different ways of assigning the symbols R, S, ..., Z to the four mixed-radix digits and search for a recognizably keyed alphabet. It is easier to begin with the second plaintext. If we take the mapping of permutations to letters and apply the substitution key that we found above, we have

1234 → N	2134 → H	3124 → ?	4123 → C
1243 → K	2143 → F	3142 → Q	4132 → D
1324 → E	2314 → S	3214 → U	4213 → ?
1342 → O	2341 → ?	3241 → W	4231 → ?
1423 → A	2413 → R	3412 → ?	4312 → L
1432 → V	2431 → T	3421 → Y	4321 → M

By reassigning the symbols 1, 2, 3, and 4 we can try to find a mapping that corresponds to an easily recognized keyed alphabet. In this case, it is simple: we merely exchang 3 and 4.

1234 → K	2134 → F	3124 → C	4123 → ?
1243 → N	2143 → H	3142 → D	4132 → Q
1324 → A	2314 → R	3214 → ?	4213 → U
1342 → V	2341 → T	3241 → ?	4231 → W
1423 → E	2413 → S	3412 → L	4312 → ?
1432 → O	2431 → ?	3421 → M	4321 → Y

This gives us KNAVEOFHRTS?CD??LM?QUW?Y. The missing letters are obvious at this point, and the keyed alphabet is KNAVEOFHRTSBCDGILMPQUWXY, so that the keyword is KNAVE OF HEARTS. We also learn from this procedure that the ternary digit must come third in the mixed-radix numbers, rather than fourth as we had used earlier.

We now turn to the task of recovering the keyed alphabet that was used on the first plaintext. If we apply the substitution key that we found and exchange the third and fourth symbols that represent mixed-radix digits, we get a new mapping:

TWRY → D	TXRY → T	VWRY → X	VXRY → ?
TWRZ → F	TXRZ → H	VWRZ → Y	VXRZ → Q
TWSY → E	TXSY → ?	VWSY → ?	VXSY → M
TWSZ → C	TXSZ → I	VWSZ → W	VXSZ → N
TWUY → O	TXUY → R	VWUY → S	VXUY → G
TWUZ → L	TXUZ → A	VWUZ → U	VXUZ → K

We now look at various ways in which to assign the values of 0, 1, and 2 to the symbols representing digits. If we take T=0, V=1, X=0, W=1, U=0, S=1, R=2, Y=0, and Z=1, and reorganize the mapping accordingly, we obtain the keyed alphabet RA?ITHOLECDFGKMN?QSU?WXY. Again, the missing letters are obvious, and the full key is RABITHOLECDFGKMNPQSUVWXY, giving a keyword of RABBIT HOLE.

Concluding remarks

Like all toy models, the purpose of a toy cipher is not to provide a useful and secure algorithm for encryption, but rather to showcase novel features that may in the future become useful, or to aid in teaching concepts of cryptography, or to occupy one's time with mental exercise. The MadHatter cipher has two such new features. It encrypts two plaintexts into the same ciphertext. This is accomplished through the use of two ways of encoding information into the same block of ciphertext symbols. One method is with mixed-radix numbers. The other method is the second novel feature of the cipher: It enumerates the permutations of the ciphertext symbols and maps plaintext symbols to them.

While this cipher used 24 plaintext symbols and represented them as the 24 mixed-radix numbers that can be formed from three binary and one ternary digits or as the 24 permutations of four objects, these choices are arbitrary. It just happens that coincidentally both schemes are able to encode 24 letters. Another cipher could be created with other choices. Not all mixed-radix numbers of a given size and not all permutations of their digits need be used. For example, five binary digits can encode 32 symbols, but we are not required to use more than 26 if we do not wish to do so. And since there are 120 permutations of five objects, we likely would not want to use all of them, either.

A ciphertext encrypted in our toy cipher was used as a bonus challenge in the 2019 season of the British National Cipher Challenge (Niblo 2004). With little *a priori* knowledge about the structure of the cipher, several competitors were able to decrypt it. One is responsible for suggesting the name "MadHatter" for the cipher. For those readers who enjoy solving puzzles, that ciphertext is in the Appendix.

Acknowledgements

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References

Jakobsen, T. 1995. A fast method for cryptanalysis of substitution ciphers. *Cryptologia* 19 (3):265-274. DOI: 10.1080/0161-119591883944.

Niblo, G. A. 2004. The University of Southampton National Cipher Challenge. Cryptologia 28 (3):277-286. DOI: 10.1080/0161-110491892935. The 2019 challenge is at http://www.cipherchallenge.org until September, 2019, when it will be moved to http://2019.cipherchallenge.org to make way for the next season.

Appendix

This ciphertext was offered as a bonus challenge in the 2019 season of the British National Cipher Challenge. It is encrypted with the toy cipher of this article.

```
JADGGBJDEJGAJGEBJDHADLHBGJDADLGBDBJHJADHDAGKAJEGDKAHAHKDAJEGAKHDKAGDALEG
DKBHDKGAHJDAEAGLLADHHJDADLGAELHBELGAEAGJDGLAHAJDJEHABHKDJBEHGBLDEAGJALEG
EAGLGJEAHDAKGKDABDJHLBHEBKDGDJAHLADGGBLDEJGABDLGLAEGHAJDDLGAHKDBDAKHALEG
DKGBDHJABHDJDAGJAKDHEKAGDAGJADHKAHJEDHKBEJHBBGDKAJDGDLHAJEGAKDHAGAKDAHKD
DHKBGALEKDGBEAGJDAKHKDGAGALEBHKDEHJAHBKDBHKDAKDHEBGJHDAJBDKHGDALELGABLDH
JAEGEGBJDJHADGLBDBGKJAHDDBKGDJGAAEJHAKEHDJHAADJHHAEKJADHHAJEEJGAHDAKGALE
DBHKELAGDKBGJAHDHDBJDKHBHDBKEGAKGKDBADJHAGLDDLBGEJGAGLDBELGADJAHADLGBLDH
GAJDBGLDDALGDHJAADJGAEHJAEGJDAHKGKDADBHJBLEGELAGJAEGGALEDKGBADJGJAEHHAKD
DKHBHKEAEJAGEJGBELGABGLEDALGJAHDGDLBHDKBADLGEBJGDKHBKADHHALDDJHALGDALDBG
DJGAELGAEAGJDHKBHAKDBLGDAEJGKADHJAEGLEGADJGADKHAEJAHBDHLDKGBGJDAAELGJAGE
BLDGELAGDBGKJADHLBEGGBLDDJHADHBKEBHJDGJABHDJBDKHHBDKKAEGGALEDKGBDHKBBELG
ADGKBDGKEAGLGJDADBJGGAJEEJGBDAJHDBHLAGJEELAGKBDGBDKHGBLEELGAHKEAEAJGEJGB
AEGLGBELLADGHAJDDLGBKHDBDALGJBEGBDKHADKHDLAHDAJHADLGDBLGJADGAGLEAEGJBDHK
KADHGBLDDBGLKBDHDBLGGBKDDJHAHLBDJAGDBGLDJBEGDKHBHADKBDLGGJEAAJHEADJHLADG
JAEGHAKDDKGAJGEAKDHADKGBHJDADLGADBHKBDHLAHKDKEBGEJGADAHKAJEHDJAGDBLGHBLD
DJHAJDGBDBGJDAJGBGLDLBGDDBKGJADHBJGEBDKHBGLEBJDGAJHEHJEBBDKHLAGDALEGDKBG
JADHBDKGDBKHELGAEJHAAGJDHBELKBEGGAJDEJHAJDHABDKGHJDADLAGJBEHJDHADJHADJGB
DLAHADHJDLGALEHBDBGLDBJGJDHAHJDAAHKELBEHJADGDKHAAJEHDBGLLAEGLBEGHAKEEJGA
EHAJDBHLDGKBAHDJAELGGBDKDJHADAGLEGLAGBKDDHJAAEKHBDGJADHJDAGJGLDBLEGBGALD
DJHABKDHEBJHGBKEDJGAKEGAEAGJDAKHDAKGJADGEAHJGJDAJAEGBDGLELHBEJBGDGBKJGDA
EAGJKDAHBDLHBHKDEGLBDJGBEHJABDJHHDAJBHLDBKDHALGDGAELGKDBAELGGDBKJADHGALE
DLGABDKHBLEGDJHBGDBJDAHJHKDBBHEJDKGADJAHELAGLAGEGEAJAHKDGADKLGEBAEKHJAGD
KADHHAJEAHKEAJEGBGEJKEGAEJGAHKDADKGALEGADBGKJHADJEHAADJGGJEABGDLEAJGHAJD
DLGBDBLHDBGKAHJDDKAHLGDBBELGJAHEAEJHJAHDAKHDGBJDLBEHJADGBDLHGDKBEAGJLGEA
JHDAADLGJAGDBHDJBJDHAEJGLEGALDHBEAGJLGAEKDGBAEKHGJEAAHDKEAKGJDHAELHBHJDA
DLGBALDGJADGHDAKEBGJDJBGDKHBLBDGADJHDHBJELHBBDGKADJHADLGAGELDKGBDJAHDAGL
JADHHBDLADJGGLDBAKDHBDKHLAEGGBKDAGJEAKDHAKGDBLDGBDKHHALDADJHLDGAEHLBADLG
AJDHKBEGGJDADAGLGKEAAGJDJDHBBGJDDAJHEJGADAHKELAGDKBGDJGAELAGKADHHBKDDLGA
AEJHAJEGEJHAGDAJDBGJGJEABGEJDJHAELAGDKBGEJGADKHAAGKEGAEJLGEABDLGKBHDLADH
HAJDAGLDBLEHBGEKLEGBEJGBGKDBDKHBEBGLAEGLBHKDJEBHELGAKGDBADJHLBHDADJGLBHE
ALGEHBKDKBDGJADHADJGDALGGELADKGBDAHJAGDLAGJDHDBJDBJHJAGEGLEADLGBAGJDHEBL
LEAGDKHBGJEALGEADBLGADJHGJDBHJEBKHDBKDGBEAHJDAJHDAGJADGLBDHKDBGKAEHJAHJD
DGJADLGAEGJABDLGKBGDADGJDJBGDBJGDBHJJHDAGAELBDKHHKDBJBDGGAJDELGAJDHABDLH
GKDBDJAHDAKHBDLGGBDKJADHGALEDKGBBDKHBEGLDKAGDBKGAELGAJEGALGEBHDKDLHAHDJA
LADGGJDABHJEALEGAJHDAGLDBLDHAJGDLADGHAJEGLDBAEJGLAGEBKHDGBJEGBJEELGBGLDA
GALDDJHAEAHJELAGBDHKBGKDAHDJDLGALAEGGBKDDJGALAEGBGLDDGKBAHDJBHKDBLEGAKGD
BDKGGAELEAGLDHKBBDGKADJGDHLAAHDJDBHLBKDHDKAHEAJHHAJDDLGADHJAAEJHJAGDAEGL
ELAGGBKDEAGJGLDBDJBHBEGLLGEAGAJDELGAAEGLGDKBDAJHEAGLJGEABGKEAJDHAJGELAEG
GAJDDJGBGDBJBDLGJAHDJADHBEGKADJHJAHEEKBHLBEGJEGAELGADJHADKAHADGJELGAELBG
LAGDGDAJDBGJBJDHELBGLAEGLDHBDKGBDJHADKAHAEGLDKGBDJAHDLGADJGADBHJBJHDGJEA
ELGADJGAEJBGLAEGBELGGAJDDBGJJDBGELHBEAGLDHBKDBHKKAEGJADGBDHLDJGAGAELBEJG
GKDBKBDHLEGBELGADKHBEJBHAEGJELGADLBGLBHDGDAJEAJGDBGLAGLEEJBGKBDHJDGAELGA
EKHADKBHBEGJEKGADJAHELGADJGAHAKDEAHJDJBGDBKHHDKBAEKGAHJDAEHJDJGAELAGGAJE
AGLEDAJGAKDHAHJEEGLADKGBAJDHDKHAKDGBGLEBDAGLLADGJAEGADHJEJHABHKDKAHDDAJG
JBDGJAEGGBJEDJHABLDGGAELADGJDLGALEGADJAHAEJHLEGABKDHDBGKHDAJADLGBJEHDAJH
JADHGLEABEJHKBHDDALGEGJAGLEABEJHJDGBDAGJDBLGDGBKADHJEAHJDGJABGEJDAGLDBKH
DBGLLBDGDBGKHJDADGALEBGKGJEAHKDAEJHAAEGLKDGBGAJDAGLEDGLBGBKDHADJGKDBAGJD
```

AJHEHAKDJADHDLHAAJDHDLGADJBHDHAJBEJHKBDHGALDJADHGBLDDJHAHAJDDKHAGJDAADLG
DJGADBJHDBJHAEJGLAEGHBLDEJGALGEAGKBDJAHDAGJELAEGDKGBHADJADLGGJDABLHDADJG
JAEGLBDGGALEEJGBBHKDGJDAGLAEKAHEDBHKGJEBGKEADJHAAEGLBHKDAGDLAJDGBDLHJDGA
LEGAGBJEDBGKLAEGKHDBAELGJAGDGKEADJHAKBDHGBLEAGLEBKDHBHEJAGJEALEGAJGDDAHK
EHAJBDJHLBGELADGDAKHEAGJAHKDDKAGLBDHJEGAELGADKGBEJBGBEGLDLGAEJAGKBHDGDBL
EGAJLAGELBEHBGLDKBDGAHJDDALGAJDGKADHDAJGBEJGALDGBDKHGBLDBDLGLEGADGKBADJH
BJEHJAEGHJDADBGJHJEAAGJDJEHBAGLEDAJHDLGAEGJAAELGAJDGKADHAHJEBLDHJAGDDLGB
EJAGLBEGLDGBELGAEJGADKAHAEGLEJGAEKBGDJHAELGABHKDGBDLAHJDJADHJEGAEAGLEAKH
DBKHAEKHAHJEKBDHHDBLAHKDAJGDGBJDJADGDGALDKGADAHJALDGDJAGBHJDHBDJAGJELAEG
KDGBDKHBGJDBDJHAEBLGADKHAHJEJADHLDGAAELGKBGDADHJDKBGDHAJEJHADGAKJAHDJAEG
DAHKDAJGAHKDKBDHAGLEDBKGAJDHLADGBGKEKBDHEBGKAHJDAKDHLAEGJAEHHBKDDBHLKADH
DBLHADHJADKHALGEAGJDDGJBAGJEJEGBDAHJDAJGJBEHGALEAHJDALDGAGEJAGLEAKDHAJHD
DAHLADHJAGLDDHKBDKHAEBJGDAHJBGJEDKBHKDAHDLGBGJEAJHEAHDJAADLGAEGJAHKDKADG
DKGBBDHKLHDBJEGAHAKDAGLEDGKBHAJDBHLDDBKHLADGGBJDEJHADGBLDKGBDAJHLBDHJDGA
DBGLLGEABDKHKAGDJADHAELGHBDKLBEGGALEAGJDDAKGJDGAAEJGADKHELAH