(b) processor unit for converting the at least one digital sequence to a plurality of bioencrypted oligonucleotide sequences; (c) a synthesizer unit for receiving machine instructions from the processor unit for synthesizing the plurality of bioencrypted oligonucleotide sequences; and (d) a storage unit for receiving the plurality of oligonucleotides deposited from the synthesizer unit.

[0018] Provided herein are systems for retrieving information, the method comprising: (a) a storage unit comprising a plurality of oligonucleotides on a surface; (b) a deposition unit for applying at least one form of biodecryption to the plurality of oligonucleotides; (c) a sequencing unit for sequencing the plurality of oligonucleotides to obtain nucleic acid sequence; and (d) a processor unit for converting the nucleic acid sequences to at least one digital sequence, wherein the at least one digital sequence encodes for at least one item of information.

[0019] Provided herein are systems for retrieving information, the method comprising: (a) a storage unit comprising a plurality of oligonucleotides on a surface; (b) a deposition unit for applying at least an enzymatic, electromagnetic, chemical, or affinity based bioencryption to the plurality of oligonucleotides; (c) a sequencing unit for sequencing the plurality of oligonucleotides to obtain nucleic acid sequence; and (d) a processor unit for converting the nucleic acid sequences to at least one digital sequence, wherein the at least one digital sequence encodes for at least one item of information.

[0020] Provided herein are systems for retrieving information, the method comprising: (a) a storage unit comprising a plurality of oligonucleotides on a surface; (b) a deposition unit for applying CRISPR/Cas complex to the plurality of oligonucleotides; (c) a sequencing unit for sequencing the plurality of oligonucleotides to obtain nucleic acid sequence; and (d) a processor unit for converting the nucleic acid sequences to at least one digital sequence, wherein the at least one digital sequence encodes for at least one item of information.

[0020a] Provided herein are methods for storing information, the method comprising: a) receiving, by a computing system, at least one item of information in a form of at least one digital sequence; b) receiving, by the computing system, instructions for enzymatic bioencryption; c) converting, by the computing system, the at least one digital sequence to digital sequences of a plurality of oligonucleotides based on the instructions, wherein the digital sequences of the plurality of oligonucleotides are configured for decryption by exposure of the plurality of oligonucleotides to a nuclease complex; d) synthesizing the plurality of oligonucleotides in a synthesizer; and e) storing the plurality of oligonucleotides.

[0020b] Provided herein are platforms for storing information, the platform comprising: a) a computing system comprising at least one processor and instructions executable by the at least one processor to perform operations comprising: (i) receiving at least one item of information in a form of at least one digital sequence; (ii) receiving instructions for enzymatic bioencryption; and (iii) converting the at least one digital sequence to digital sequences of a plurality of oligonucleotides based on the instructions, wherein the digital sequences of the plurality of oligonucleotides are configured for decryption by exposure of the plurality of oligonucleotides to a nuclease complex; and b) a material deposition system for deposition and storage of oligonucleotides comprising: (i) a synthesizer for receiving instructions from the computing system for synthesizing the plurality of oligonucleotides, wherein the synthesizer comprises a substrate for storing the plurality of oligonucleotides.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0022] **Figure 1** illustrates an exemplary workflow for nucleic acid-based data storage.

[0023] **Figure 2** illustrates an exemplary workflow for storage for bioencryption.

[0024] **Figure 3** illustrates an exemplary workflow for retrieval following bioencryption.

[0025] **Figures 4A-4B** depict a bioencryption method using a Cas enzyme.

[0026] **Figures 5A-5C** depict various oligonucleotide sequence design schemes.

[0027] **Figures 6A-6C** depict various oligonucleotide sequence design schemes.

CLAIMS

WHAT IS CLAIMED IS:

1. A method for storing information, the method comprising:
    a) receiving, by a computing system, at least one item of information in a form of at least one digital sequence;
    b) receiving, by the computing system, instructions for enzymatic bioencryption;
    c) converting, by the computing system, the at least one digital sequence to digital sequences of a plurality of oligonucleotides based on the instructions, wherein the digital sequences of the plurality of oligonucleotides are configured for decryption by exposure of the plurality of oligonucleotides to a nuclease complex;
    d) synthesizing the plurality of oligonucleotides in a synthesizer; and
    e) storing the plurality of oligonucleotides.

2. The method of claim 1, wherein the enzymatic bioencryption comprises CRISPR/Cas-based bioencryption.

3. The method of claim 1, wherein the nuclease complex comprises an enzyme as set out in Table 1:

Recognition Sequence	**Enzyme**
AA/CGTT	AclI
A/AGCTT	HindIII HindIII sold under the trademark HindIII-HF ®
AAT/ATT	SspI SspI sold under the trademark SspI-HF®
/AATT	MluCI Tsp509I
A/CATGT	PciI
A/CCGGT	AgeI AgeI sold under the trademark AgeI-HF®
ACCTGC(4/8)	BspMI BfuAI
A/CCWGGT	SexAI
A/CGCGT	MluI MluI sold under the trademark MluI-HF®
ACGGC(12/14)	BceAI
A/CGT	HpyCH4IV

ACN/GT	HpyCH4III
(10/15)ACNNNNGTAYC(12/7) (SEQ ID NO: 5)	BaeI
(9/12)ACNNNNNCTCC(10/7) (SEQ ID NO: 6)	BsaXI
A/CRYGT	AflIII
A/CTAGT	SpeI SpeI sold under the trademark SpeI-HF®
ACTGG(1/-1)	BsrI
ACTGGG(5/4)	BmrI
A/GATCT	BglII
AGC/GCT	AfeI
AG/CT	AluI
AGG/CCT	StuI
AGT/ACT	ScaI ScaI sold under the trademark ScaI-HF®
AT/CGAT	ClaI BspDI
ATCTATGTCGGGTGCGGAGAAAGAGGTAAT(-15/-19) (SEQ ID NO: 7)	PI-SceI
ATGCA/T	NsiI NsiI sold under the trademark NsiI-HF®
AT/TAAT	AseI
ATTT/AAAT	SwaI
(11/13)CAANNNNNGTGG(12/10) (SEQ ID NO: 8)	CspCI
C/AATTG	MfeI MfeI sold under the trademark MfeI-HF®
CACGAG(-5/-1)	BssSI BssSαI
CACGAG	Nb.BssSI
CACGTC(-3/-3)	BmgBI
CAC/GTG	PmlI
CACNNN/GTG	DraIII DraIII sold under the trademark DraIII-HF®
CACNN/NNGTG (SEQ ID NO: 9)	AleI
CAGCAG(25/27)	EcoP15I
CAG/CTG	PvuII PvuII sold under the trademark PvuII-HF®
CAGNNN/CTG	AlwNI
CAGTG(2/0)	BtsIMutI
NNCASTGNN/	TspRI

CA/TATG	NdeI
CATG/	NlaIII
C/ATG	CviAII
/CATG	FatI
CAYNN/NNRTG (SEQ ID NO: 10)	MslI
CC(12/16)	FspEI
CCANNNNN/NNNNTGG (SEQ ID NO: 11)	XcmI
CCANNNNN/NTGG (SEQ ID NO: 12)	BstXI
CCANNNN/NTGG (SEQ ID NO: 13)	PflMI
CCATC(4/5)	BccI
C/CATGG	NcoI NcoI sold under the trademark NcoI-HF®
CCCAGC(-5/-1)	BseYI
CCCGC(4/6)	FauI
CCC/GGG	SmaI
C/CCGGG	XmaI TspMI
(0/-1)CCD	Nt.CviPII
CCDG(10/14)	LpnPI
CCGC(-3/-1)	AciI
CCGC/GG	SacII
CCGCTC(-3/-3)	BsrBI
C/CGG	MspI HpaII
CC/NGG	ScrFI
/CCNGG	BssKI StyD4I
C/CNNGG	BsaJI
CCNNNNN/NNGG (SEQ ID NO: 14)	BslI
C/CRYGG	BtgI
CC/SGG	NciI
C/CTAGG	AvrII
CCTC(7/6)	MnlI
CCTCAGC(-5/-2)	BbvCI
CCTCAGC	Nb.BbvCI
CCTCAGC(-5/-7)	Nt.BbvCI
CCTGCA/GG	SbfI SbfI sold under the trademark SbfI-HF®
CCTNAGC(-5/-2)	Bpu10I
CC/TNAGG	Bsu36I
CCTNN/NNNAGG (SEQ ID NO: 15)	EcoNI
CCTTC(6/5)	HpyAV

CC/WGG	BstNI
/CCWGG	PspGI
C/CWWGG	StyI StyI sold under the trademark StyI-HF®
(10/12)CGANNNNNNTGC(12/10) (SEQ ID NO: 16)	BcgI
CGAT/CG	PvuI PvuI sold under the trademark PvuI-HF®
CG/CG	BstUI
C/GGCCG	EagI EagI sold under the trademark EagI-HF®
CG/GWCCG	RsrII
CGRY/CG	BsiEI
C/GTACG	BsiWI BsiWI sold under the trademark BsiWI-HF®
CGTCTC(1/5)	BsmBI
CGWCG/	Hpy99I
CMG/CKG	MspA1I
CNNR(9/13)	MspJI
CR/CCGGYG	SgrAI
C/TAG	BfaI
CTCAG(9/7)	BspCNI
C/TCGAG	XhoI PaeR7I TliI
CTCTTC(1/4)	EarI
CTGAAG(16/14)	AcuI
CTGCA/G	PstI PstI sold under the trademark PstI-HF®
CTGGAG(16/14)	BpmI
C/TNAG	DdeI
C/TRYAG	SfcI
C/TTAAG	AflII
CTTGAG(16/14)	BpuEI
C/TYRAG	SmlI
C/YCGRG	AvaI BsoBI
GAAGA(8/7)	MboII
GAAGAC(2/6)	BbsI BbsI sold under the trademark BbsI-HF®

GAANN/NNTTC (SEQ ID NO: 17)	XmnI
GAATGC(1/-1)	BsmI
GAATGC	Nb.BsmI
G/AATTC	EcoRI EcoRI sold under the trademark EcoRI-HF®
GACGC(5/10)	HgaI
GACGT/C	AatII
GAC/GTC	ZraI
GACN/NNGTC	Tth111I PflFI
GACNN/NNGTC (SEQ ID NO: 18)	PshAI
GACNNN/NNGTC (SEQ ID NO: 19)	AhdI
GACNNNN/NNGTC (SEQ ID NO: 20)	DrdI
GAG/CTC	Eco53kI
GAGCT/C	SacI SacI sold under the trademark SacI-HF®
GAGGAG(10/8)	BseRI
GAGTC(4/5)	PleI
GAGTC(4/-5)	Nt.BstNBI
GAGTC(5/5)	MlyI
G/ANTC	HinfI
GAT/ATC	EcoRV EcoRV sold under the trademark EcoRV-HF®
/GATC	MboI Sau3AI DpnII BfuCI
GA/TC	DpnI
GATNN/NNATC (SEQ ID NO: 21)	BsaBI
G/AWTC	TfiI
GCAATG(2/0)	BsrDI
GCAATG	Nb.BsrDI
GCAGC(8/12)	BbvI
GCAGTG(2/0)	BtsI BtsαI
GCAGTG	Nb.BtsI
GCANNNN/NTGC (SEQ ID NO: 22)	BstAPI
GCATC(5/9)	SfaNI
GCATG/C	SphI SphI sold under the trademark SphI-HF®
GCCC/GGGC	SrfI

GCCGAG(21/19)	NmeAIII
GCC/GGC	NaeI
G/CCGGC	NgoMIV
GCCNNNN/NGGC (SEQ ID NO: 23)	BglI
GCGAT/CGC	AsiSI
GCGATG(10/14)	BtgZI
G/CGC	HinP1I
GCG/C	HhaI
G/CGCGC	BssHII
GC/GGCCGC	NotI NotI sold under the trademark NotI-HF®
GC/NGC	Fnu4HI
GCN/NGC	Cac8I
GCNNNNN/NNGC (SEQ ID NO: 24)	MwoI
G/CTAGC	NheI NheI sold under the trademark NheI-HF®
GCTAG/C	BmtI BmtI sold under the trademark BmtI-HF®
GCTCTTC(1/4)	SapI BspQI
GCTCTTC(1/-7)	Nt.BspQI
GC/TNAGC	BlpI
G/CWGC	TseI ApeKI
GDGCH/C	Bsp1286I
GGATC(4/5)	AlwI
GGATC(4/-5)	Nt.AlwI
G/GATCC	BamHI BamHI sold under the trademark BamHI-HF®
GGATG(9/13)	FokI
GGATG(2/0)	BtsCI
GG/CC	HaeIII PhoI
GGCCGG/CC	FseI
GGCCNNNN/NGGCC (SEQ ID NO: 25)	SfiI
GG/CGCC	NarI
G/GCGCC	KasI
GGC/GCC	SfoI
GGCGC/C	PluTI
GG/CGCGCC	AscI
GGCGGA(11/9)	EciI

GGGAC(10/14)	BsmFI
GGGCC/C	ApaI
G/GGCCC	PspOMI
G/GNCC	Sau96I
GGN/NCC	NlaIV
GGTAC/C	KpnI KpnI sold under the trademark KpnI-HF®
G/GTACC	Acc65I
GGTCTC(1/5)	BsaI BsaI sold under the trademark BsaI-HF®
GGTGA(8/7)	HphI
G/GTNACC	BstEII BstEII sold under the trademark BstEII-HF®
G/GWCC	AvaII
G/GYRCC	BanI
GKGCM/C	BaeGI
GR/CGYC	BsaHI
GRGCY/C	BanII
GT/AC	RsaI
G/TAC	CviQI
GTA/TAC	BstZ17I BstZ17I sold under the trademark BstZ17I-HF®
GTATCC(6/5)	BciVI
G/TCGAC	SalI SalI sold under the trademark SalI-HF®
GTCTC(1/-5)	Nt.BsmAI
GTCTC(1/5)	BsmAI BcoDI
G/TGCAC	ApaLI
GTGCAG(16/14)	BsgI
GT/MKAC	AccI
GTN/NAC	Hpy166II
/GTSAC	Tsp45I
GTT/AAC	HpaI
GTTT/AAAC	PmeI
GTY/RAC	HincII
GWGCW/C	BsiHKAI
R/AATTY	ApoI ApoI-HF
RCATG/Y	NspI

R/CCGGY	BsrFI BsrFαI
R/GATCY	BstYI
RGCGC/Y	HaeII
RG/CY	CviKI-1
RG/GNCCY	EcoO109I
RG/GWCCY	PpuMI
TAACTATAACGGTCCTAAGGTAGCGAA(-9/-13) (SEQ ID NO: 26)	I-CeuI
TAC/GTA	SnaBI
TAGGGATAACAGGGTAAT(-9/-13) (SEQ ID NO: 27)	I-SceI
T/CATGA	BspHI
T/CCGGA	BspEI
TCCRAC(20/18)	MmeI
T/CGA	TaqαI
TCG/CGA	NruI NruI sold under the trademark NruI-HF®
TCN/GA	Hpy188I
TC/NNGA	Hpy188III
T/CTAGA	XbaI
T/GATCA	BclI
TG/CA	HpyCH4V
TGC/GCA	FspI
TGGCAAACAGCTATTATGGGTATTATGGGT(-13/-17) (SEQ ID NO: 28)	PI-PspI
TGG/CCA	MscI
T/GTACA	BsrGI BsrGI sold under the trademark BsrGI-HF®
T/TAA	MseI
TTAAT/TAA	PacI
TTA/TAA	PsiI
TT/CGAA	BstBI
TTT/AAA	DraI
VC/TCGAGB	PspXI
W/CCGGW	BsaWI
YAC/GTR	BsaAI
Y/GGCCR	EaeI

4. The method of claim 1, wherein the plurality of oligonucleotides comprises at least 100,000 oligonucleotides.

5. The method of claim 1, wherein the plurality of oligonucleotides comprises at least 10 billion oligonucleotides.

6. A platform for storing information, the platform comprising:

a) a computing system comprising at least one processor and instructions executable by the at least one processor to perform operations comprising:

i) receiving at least one item of information in a form of at least one digital sequence;

ii) receiving instructions for enzymatic bioencryption; and

iii) converting the at least one digital sequence to digital sequences of a plurality of oligonucleotides based on the instructions, wherein the digital sequences of the plurality of oligonucleotides are configured for decryption by exposure of the plurality of oligonucleotides to a nuclease complex; and

b) a material deposition system for deposition and storage of oligonucleotides comprising:

i) a synthesizer for receiving instructions from the computing system for synthesizing the plurality of oligonucleotides,

wherein the synthesizer comprises a substrate for storing the plurality of oligonucleotides.

7. The method of claim 1, wherein the decryption comprises contacting the plurality of oligonucleotides with Cas nuclease (CRISPR-associated nuclease), a Zinc Finger Nuclease (ZFN), a Transcription Activator-Like Effector Nuclease, an Argonaute nuclease, S1 Nuclease, a mung bean nuclease, or a DNAse.

8. The method of claim 1, wherein the method further comprises sequencing the plurality of oligonucleotides.

9. The method of claim 1, wherein the plurality of oligonucleotides is stored ex-vivo.

10. The method of claim 1, wherein synthesizing the plurality of oligonucleotides comprises phosphoramidite chemical synthesis.

11. The method of claim 1, wherein the at least one digital sequence comprises at least 1 MB.

12. The platform of claim 6, wherein the decryption comprises contacting the plurality of oligonucleotides with Cas nuclease (CRISPR associated), a Zinc Finger Nuclease (ZFN), a Transcription Activator-Like Effector Nuclease, an Argonaute nuclease, S1 Nuclease, a mung bean nuclease, or a DNAse.

13. The platform of claim 6, wherein the computing system comprises a distributed computing system.