translation events are important for information processing with nucleic acids and molecular computing.

SUMMARY

[0006] In accordance with one aspect of the present invention, provided is a composition comprising a first and a second nucleic acid complexes each comprising a first, a second, a third, and a fourth nucleic acid strands, each of the strands comprising, sequentially, a first, a second and a third fragments, wherein the nucleic strands are defined as B-X-D, $\overline{C}$ - $\overline{X}$ - $\overline{A}$, $\overline{D}$ - $\overline{Y}$ - $\overline{E}$ and F-Y-C for the first, second, third and fourth strands of the first complex, respectively, and $\overline{C}$ - $\overline{Y}$ - $\overline{F}$, E-Y-D, F-Z-G, $\overline{H}$ - $\overline{Z}$ - $\overline{E}$ for the first, second, third and fourth strands of the second complex, respectively, wherein each letter denotes a fragment and each string of letters connected by "-" denotes a strand, and wherein: each of the first and the second complexes comprises a first duplex region formed between the second fragments of the first and second strands (X:: $\overline{X}$ and $\overline{Y}$ ::Y, in the first and second complexes, respectively), a second duplex region formed between the second fragments of the third and fourth strands (Y:: $\overline{Y}$ and Z:: $\overline{Z}$), a third duplex region formed between the third fragment of the first strand and the first fragment of the third strand (D:: $\overline{D}$ and $\overline{F}$ ::F), and a fourth duplex region formed between the first fragment of the second strand and the third fragment of the fourth strand ($\overline{C}$ ::C and E:: $\overline{E}$); in each of the first and second complexes, the first fragment (B and $\overline{C}$, in the first and second complexes, respectively) of the first strand, the third fragment ($\overline{A}$ and D) of the second strand, the third fragment ($\overline{E}$ and G) of the third strand and the first fragment (F and $\overline{H}$) of the fourth strand are single-stranded; the third strand of the first complex ($\overline{D}$ - $\overline{Y}$ - $\overline{E}$) has suitable sequence complementarity to the second strand of the second complex (E-Y-D) to allow binding therebetween under hybridizing conditions; and the fourth strand of the first complex (F-Y-C) has suitable sequence complementarity to the first strand of the second complex ($\overline{C}$ - $\overline{Y}$ - $\overline{F}$) to allow binding therebetween under hybridizing conditions.

[0006a] In another aspect, there is provided a composition comprising:

(a) a first nucleic acid complex comprising (i) a first nucleic strand comprising, sequentially, a first, second and third fragments and defined as S-Q-P, wherein each letter denotes a fragment and a string of letters connected by "-" denotes a strand, and (ii) a second strand comprising, sequentially, a first, second, third and fourth fragments and defined as A-$\overline{B}$-$\overline{P}$-$\overline{Q}$, wherein the first complex comprises a duplex region (Q-P::$\overline{P}$-$\overline{Q}$) formed between the second and third fragments of the first strand and the *third and fourth fragments of the second strand; and*

(b) a second nucleic acid complex comprising (i) a first nucleic acid strand comprising, sequentially, a first, second and third fragments and defined as P-B-$\overline{A}$, (ii) a second nucleic acid strand comprising, sequentially, a first, second and third fragments and defined as A-X-C, and (iii) a third strand comprising, sequentially, a first, second and third fragments and defined as $\overline{D}$-$\overline{X}$-$\overline{B}$, wherein the second complex comprises a first duplex region ($\overline{A}$::A) formed between the third fragment of the first strand and the first fragment of the second strand, a second duplex region (B::$\overline{B}$) formed between the first fragment of the first strand and the third fragment of the third strand, and a third duplex region (X::$\overline{X}$) formed between the second fragment of the second strand and the second fragment of the third strand,

wherein the first (S) fragment of the first strand of the first complex, the first (A) and second ($\overline{B}$) of the second strand of the first complex, the first fragment (P) of the third strand of the second complex, the third fragment (C) of the second strand of the second complex, and the first fragment ($\overline{D}$) of the third strand of the second complex are single-stranded; and

wherein the first, second and third fragments (A, $\overline{B}$, $\overline{P}$) of the second strand of the first complex have suitable sequence complementarity to the third, second and first fragments ($\overline{A}$, B, P) of the first strand of the second complex to allow binding therebetween, under hybridizing conditions, respectively.

[0006b] In yet another aspect, there is provided a composition comprising a first nucleic acid complex comprising (a) a first, a second, a third and a fourth nucleic acid strands each comprising, sequentially, a first, a second and a third fragments and (b) a first and second RNA strands, wherein the first complex comprises:

(i) a first duplex region formed between the second fragments of the first and second strands;

(ii) a second duplex region formed between the second fragments of the third and fourth strands;

(iii) a third duplex region formed between the third fragment of the first strand and the first fragment of the third strand;

(iv) a fourth duplex region formed between the first fragment of the second strand and the third fragment of the fourth strand;

(v) a fifth duplex region formed between the third fragment of the third strand and the first RNA; and

(vi) a sixth duplex region formed between the first fragment of the fourth strand and the second RNA,

and the first fragment ($\overline{C}$) of the first strand and the third fragment (D) of the second strand are single-stranded.

[0006c] In yet another aspect, there is provided a composition comprising:

(a) a first nucleic acid complex comprising (i) a first nucleic acid strand comprising, sequentially, a first, second and third fragments and defined as B-X-D, (ii) a second nucleic acid strand comprising, sequentially, a first, second and third fragments and defined as $\overline{C}$-$\overline{X}$-$\overline{A}$, (iii) a third strand comprising, sequentially, a first, second and third fragments and defined as $\overline{D}$-$\overline{Y}$-$\overline{E}$, and (iv) a fourth strand comprising, sequentially, a first, second and third fragments and defined as F-Y-C, wherein the first complex comprises a first duplex region (X::$\overline{X}$) formed between the second fragments of the first and second strands, a second duplex region ($\overline{Y}$::Y) formed between the second fragments of the third and fourth strands, a third duplex region

(D:: $\overline{D}$) formed between the third fragment of the first strand and the first fragment of the third strand and a fourth duplex region ($\overline{C}$ ::C) formed between the first fragment of the second strand and the third fragment of the fourth strand; and

(b) a second nucleic acid complex comprising (i) a first nucleic acid strand comprising, sequentially, a first, second and third fragments and defined as $\overline{C}$ - $\overline{Y}$ - $\overline{F}$, (ii) a second nucleic acid strand comprising, sequentially, a first, second and third fragments and defined as E-Y-D, (iii) a third strand comprising, sequentially, a first and second fragments and defined as F-Z , and (iv) a fourth strand comprising, sequentially, a first and second fragment and defined as $\overline{Z}$ - $\overline{E}$, wherein the second complex comprises a first duplex region ($\overline{Y}$ ::Y) formed between the seconds fragments of the first and second strands, a second duplex region (Z:: $\overline{Z}$) formed between the second fragment of the third strand and the first fragment of the fourth strand, a third duplex region ($\overline{F}$ ::F) formed between the third fragment of the first strand and the first fragment of the third strand, and a fourth duplex region (E:: $\overline{E}$) formed between the first fragment of the second strand and the second fragment of the fourth strand,

wherein the first (B) fragment of the first strand, the third fragment ($\overline{A}$) of the second strand, the third fragment ($\overline{E}$) of the third strand, and the first fragment (F) of the fourth strand of the first complex, and the first ($\overline{C}$) fragment of the first strand and the third fragment of the second strand (D) of the second complex are single-stranded;

wherein the first, second and third fragments ($\overline{D}$, $\overline{Y}$, and $\overline{E}$) of the third strand of the first complex have suitable sequence complementarity to the third, second and first fragments (D, Y, and E) of the second strand of the second complex to allow binding therebetween, under hybridizing conditions, respectively; and

wherein the third, second and first fragments (C, Y, and F) of the fourth strand of the first complex have suitable sequence complementarity to the first, second and third

fragments ($\overline{C}$, $\overline{Y}$, and $\overline{F}$) of the first strand of the second complex to allow binding therebetween, under hybridizing conditions, respectively.

[0006d] In yet another aspect, there is provided a nucleic acid complex comprising a first, a second, a third, a fourth, a fifth and a sixth nucleic acid strands, wherein:

the first strand comprises, sequentially, a first, a second, a third and a fourth fragments and is defined as $\overline{Q}$-$\overline{X}$-$\overline{B}$-$\overline{A}$, wherein each letter denotes a fragment and a string of letters connected by "-" denotes a strand;

the second strand comprises, sequentially, a first, a second, a third and a fourth fragments and is defined as $\overline{B}$-$\overline{A}$-$\overline{X}$-P;

the third and fifth strands each comprises, sequentially, a first, a second and a third fragments and is defined as A-Y-C; and

the fourth and sixth strands each comprises, sequentially, a first, a second and a third fragments and is defined as $\overline{D}$-$\overline{Y}$-B;

and wherein the complex comprises:

a first duplex region ($\overline{X}$:X) formed between the second fragment of the first strand and the third strand of the second strand;

a second duplex region ($\overline{A}$::A) formed between the fourth fragment of the first strand and the first strand of the third strand;

a third duplex region ($\overline{B}$::B) formed between the third fragment of the first strand and the third fragment of the fourth strand;

a fourth duplex region ($\overline{A}$::A) formed between the second fragment of the second strand and the first fragment of the fifth strand;

a fifth duplex region ($\overline{B}$::B) formed between the first fragment of the second strand and the third fragment of the sixth strand;

a sixth duplex region (Y:: $\overline{Y}$) formed between the second fragments of the third and fourth strands; and

a seventh duplex region (Y:: $\overline{Y}$) formed between the second fragments of the fifth and sixth strands,

and wherein the first fragment ($\overline{Q}$) of the first strand, the fourth fragment (P) of the second strand, the third fragments (C) of the third and fifth strands and the first fragments ($\overline{D}$) of the fourth and sixth strands are single-stranded.

[0006e] In yet another aspect, there is provided a composition comprising a first, a second and a third nucleic acid complexes, wherein:

the first complex comprises a first, a second, a third and a fourth nucleic acid strands each comprising, sequentially, a first, a second and a third fragments and defined as B-W-D, $\overline{C}$ - $\overline{W}$ - $\overline{A}$, $\overline{D}$ - $\overline{Y}$ -H, and $\overline{G}$ -Y-C, respectively, wherein each letter denotes a fragment and each string of letters connected by "-" denotes a strand, and wherein the first complex comprises a first duplex region (W:: $\overline{W}$) formed between the second fragments of the first and second strands, a second duplex region ($\overline{Y}$ ::Y) formed between the second fragments of the third and fourth strands, a third duplex region (D:: $\overline{D}$) formed between the third fragment of the first strand and the first fragment of the third strand; and a fourth duplex region ($\overline{C}$ ::C) formed between the first fragment of the second strand and the third fragment of the fourth strand;

the second complex comprises a first, a second, a third and a fourth nucleic acid strands each comprising, sequentially, a first, a second and a third fragments and defined as F-X-H, $\overline{G}$ - $\overline{X}$ - $\overline{E}$, $\overline{H}$ - $\overline{Z}$ - $\overline{I}$ and J-Z-G, respectively, wherein the second complex comprises a first duplex region (X:: $\overline{X}$) formed between the second fragments of the first and second strands, a second duplex region ($\overline{Z}$ ::Z) formed between the second fragments of the third and fourth strands, a third duplex region (H:: $\overline{H}$) formed between the third fragment of the first strand and the first fragment of the third

strand; and a fourth duplex region ($\overline{G}$ ::G) formed between the first fragment of the second strand and the third fragment of the fourth strand;

the third complex comprises a first, a second, a third, a fourth, a fifth and a sixth nucleic acid strands each comprising, sequentially, a first, a second and a third fragments and defined as $\overline{C}$ -$\overline{Y}$ -G, $\overline{H}$ -Y-D, $\overline{G}$ -$\overline{Z}$ -$\overline{J}$, I-Z-H, J-Q-M and $\overline{N}$ -$\overline{Q}$ -$\overline{I}$, respectively, wherein the third complex comprises a first duplex region ($\overline{Y}$ ::Y) formed between the second fragments of the first and second strands, a second duplex region ($\overline{Z}$ ::Z) formed between the second fragments of the third and fourth strands, a third duplex region (Q:: $\overline{Q}$) formed between the second fragments of the fifth and sixth strands, a fourth duplex region (G:: $\overline{G}$) formed between the third fragment of the first strand and the first fragment of the third strand; a fifth duplex region ($\overline{H}$ ::H) formed between the first fragment of the second strand and the third fragment of the fourth strand, a sixth duplex region ($\overline{J}$ ::J) formed between the third fragment of the third strand and the first fragment of the fifth strand, and a seventh duplex region (I:: $\overline{I}$) formed between the first fragment of the fourth strand and the third fragment of the sixth strand;

wherein, in the first complex, the first fragment (B) of the first strand, the third fragment ($\overline{A}$) of the second fragment, the third fragment (H) of the third strand, and the first fragment ($\overline{G}$) of the fourth strand are single-stranded; in the second complex, the first fragment (F) of the first strand, the third fragment ($\overline{E}$) of the second fragment, the third fragment ($\overline{I}$) of the third strand, and the first fragment (J) of the fourth strand are single-stranded; and in the third complex, the first fragment ($\overline{C}$) of the first strand, the third (D) fragment of the second strand, the third fragment (M) of the fifth fragment, and the first fragment ($\overline{N}$) of the sixth strand are single-stranded,

and wherein:

the third strand ($\overline{D}$ - $\overline{Y}$ -H) of the first complex and the second strand ($\overline{H}$ -Y-D) of the third complex have suitable sequence complementarity to allow binding therebetween under hybridizing conditions;

the fourth strand ($\overline{G}$ -Y-C) of the first complex and the first strand ($\overline{C}$ - $\overline{Y}$ -G) of the third complex have suitable sequence complementarity to allow binding therebetween under hybridizing conditions;

the third strand ($\overline{H}$ - $\overline{Z}$ - $\overline{I}$) of the second complex and the fourth strand (I-Z-H) of the third complex have suitable sequence complementarity to allow binding therebetween under hybridizing conditions; and

the fourth strand (J-Z-G) of the second complex and the third strand ($\overline{G}$ - $\overline{Z}$ - $\overline{J}$) of the third complex have suitable sequence complementarity to allow binding therebetween under hybridizing conditions.

[0006f] In yet another aspect, there is provided a composition comprising a first and a second nucleic complexes, wherein:

the first complex comprises a first, a second, a third and a fourth nucleic acid strands each comprising, sequentially, a first, a second and a third fragments and defined as B-X-D, $\overline{C}$ - $\overline{X}$ - $\overline{A}$, $\overline{D}$ - $\overline{Z}$ - $\overline{I}$ and J-Z-C, respectively, wherein each letter denotes a fragment and each string of letters connected by "-" denotes a strand, and wherein the first complex comprises a first duplex region (X:: $\overline{X}$) formed between the second fragments of the first and second strands, a second duplex region ($\overline{Z}$ ::Z) formed between the second fragments of the third and fourth strands, a third duplex region (D:: $\overline{D}$) formed between the third fragment of the first strand and the first fragment of the third strand, and fourth duplex region ($\overline{C}$ ::C) formed between the first fragment of the second strand and the third fragment of the fourth strand; and

the second complex comprises a first and second nucleic acid strands each comprising, sequentially, a first, a second and a third fragment and defined as F-Y-D and $\overline{C}$ - $\overline{Y}$ -

$\overline{E}$, respectively, and a third nucleic acid comprising, sequentially, a first and a second fragment and defined as $\overline{D}$-C, wherein the second complex comprises a first duplex region (Y::$\overline{Y}$) formed between the second fragments of the first and second strand, a second duplex region (D::$\overline{D}$) formed between the third fragment of the first strand and the first fragment of the third strand, and a third duplex region ($\overline{C}$::C) formed between the first fragment of the second strand and the second fragment of the third strand;

wherein the first fragment (B) of the first strand of the first complex, the third fragment ($\overline{A}$) of the second strand of the first complex, the third fragment ($\overline{I}$) of the third strand of the first complex, the first fragment (J) of the fourth strand of the first complex, the first fragment (F) of the first strand of the second complex, and the third fragment ($\overline{E}$) of the second strand of the second complex are single-stranded;

and wherein:

the third strand ($\overline{D}$-C) of the second complex and the combination of the first fragment ($\overline{D}$) of the third strand of the first complex and the third fragment (C) of the fourth strand of the first complex, sequentially, have suitable sequence identity to allow their binding to a same target nucleic acid sequence.

[0006g] In yet another aspect, there is provided a cell comprising the composition as describe herein.

[0006h] In yet another aspect, there is provided a non-transitory computer-readable medium comprising program code for representing or displaying composition as describe herein.

[0007] In one ~~aspect~~example, the composition further comprises a third nucleic acid complex comprising a first and a second nucleic acid strands, each of the strands comprising, sequentially, a first, a second

and a third fragments, wherein the first and second strands are defined as E-Z-H and $\overline{G}$ - $\overline{Z}$ - $\overline{F}$ respectively, wherein the third nucleic acid complex comprises a duplex region formed between the second fragments of the first and second strands (Z:: $\overline{Z}$) and the first fragment (E) of the first strand and the third fragment of the second strand ($\overline{F}$) are singled-stranded, and wherein:

the third strand of the second complex (F-Z-G) has suitable sequence complementarity to the second strand of the third complex ($\overline{G}$ - $\overline{Z}$ - $\overline{F}$) to allow binding therebetween under hybridizing conditions; and the fourth strand of the second complex ($\overline{H}$ - $\overline{Z}$ - $\overline{E}$) has suitable sequence complementarity to the first strand of the third complex (E-Z-H) to allow binding therebetween under hybridizing conditions.

[0008] In some ~~aspects~~examples, the third fragment ($\overline{E}$) of the third strand of the first complex *and the first fragment (E) of the first strand of the third complex have sequence complementarity but* do not stably bind to each other under normal hybridizing conditions due to chemical modification to either or both of the fragments; and the first fragment (F) of the fourth strand of the first complex and the third fragment ($\overline{F}$) the first strand of the third complex have sequence complementarity but do not stably bind to each other under normal hybridizing conditions due to chemical modification to either or both of the fragments.

[0009] Chemical modifications suitable for practicing the present technology include, without limitation, replacing sugar-phosphodiester backbone of a nucleic acid fragment with a mini-PEG-conjugated, serine-derived gamma-PNA. In some aspects, the chemical modification comprises substituting a tricyclic cytosine analogue for the nitrogenous base of at least one nucleoside in a nucleic acid fragment. In one aspect, the chemical modification comprises introducing a heteroatom at the 2'-position of a sugar moiety in a nucleotide.

[0010] Illustrations of the complexes and their relationships can be found in **FIG. 6A**, where translator **102** corresponds to the first complex, translator **103** corresponds to the second complex, and translator **104** corresponds to the third complex. Likewise, **FIG. 10-13, 14A-D, and 15-16**, also

illustrate translators (nucleic acid complexes) within the scope of the present disclosure, including each individual translator and their combinations as translator sets (or in the form of a composition).

[0011] In one ~~aspect~~example, each fragment is from about 5 bases to about 50 bases long. In another ~~aspect~~example, each each fragment that is single-stranded is from about 5 bases to about 30 bases long.

[0012] It also is within the scope of the disclosure that each composition can further optionally comprise a pharmaceutically acceptable carrier. Some embodiments of the present disclosure, further, provide a cell comprising the composition or complex of the present disclosure.

[0013] Computer-implemented methods and non-transitory computer-readable media suitable for simulating, designing, recording, reporting, or analyzing certain aspects of the disclosed technology are also provided here.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Provided as embodiments of this disclosure are drawings which illustrate by exemplification only, and not limitation, wherein:

[0015] **FIG. 1A** illustrates a solid-phase sequestering implementation of a nucleic acid translator, where individual sections (A, B, etc) represent stretches of oligonucleotides of arbitrary length and sequence;

[0016] **FIG. 1B** illustrates how a solid-phase sequestering implementation of a nucleic acid translator sequesters stretches of oligonucleotides;

[0017] **FIG. 2A** illustrates a "toe-hold" sequestering implementation of a nucleic acid translator. Again, individual sections represent stretches of oligonucleotides of arbitrary length and sequence;

[0018] **FIG. 2B** illustrates how the toe-hold-sequestered implementation shown in **FIG. 2A** sequesters stretches of oligonucleotides;