# Increasing Redundancy Exponentially Reduces Error Rates During Algorithmic Self-Assembly

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## 1 Controls and Additional Data

### 1.1 Error rates in inner vs. outer ribbon rows

To test whether the unusually high error rate observed for the 1-redundantly encoded row within the the 3-redundant ribbon was caused by a higher error rate in rows adjacent to boundary tile layers, we tabulated the error rate for 1-redundant copying in "inner" rows (those not adjacent to a boundary tile) vs. "outer" rows (those adjacent to a boundary layer.) Our results show no discrepancy between error rates in these rows; in inner rows, the error rate was $0.0097 \pm 0.0017$ per bit and in outer rows, the error rate was $0.0096 \pm 0.0017$ per bit.

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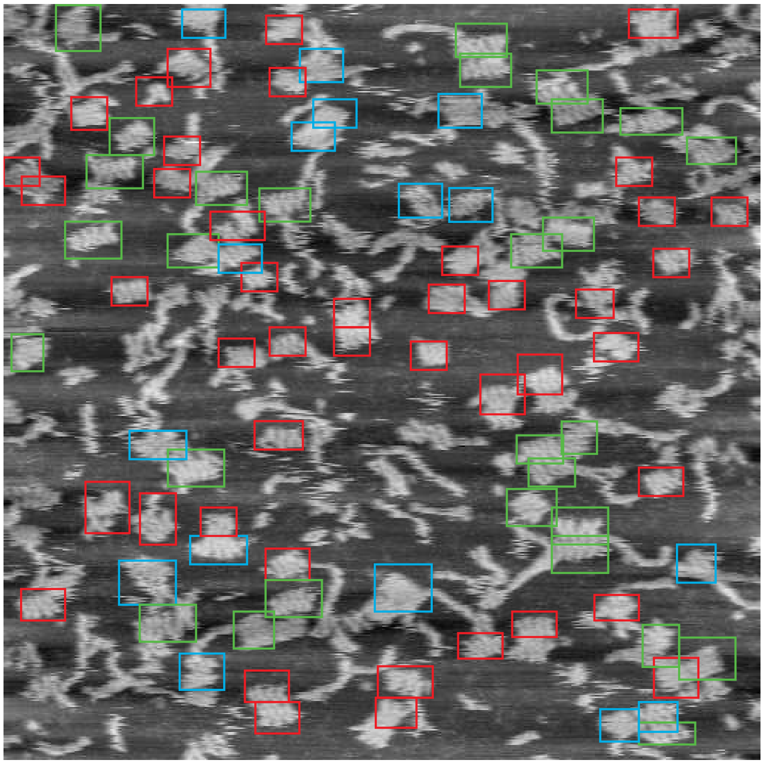
### 1.2 Assembly yield of crystal seeds



Supplemental Figure S1: AFM image (scan size of 500 nm) used to measure the synthesis yield and synthesis quality of crystal seed structures. Structures 5 tiles in height were considered well-formed, structures 3-4 tiles in height were considered malformed, and smaller structures were considered irrelevant for determining the synthesis quality. Green boxes indicate well-formed structures, red boxes indicate malformed structures and blue boxes indicate relevant structures for which the height in tiles could not readily be discerned. To estimate an upper bound for synthesis yield, we counted the number of pixels (i.e. area) of all presumably-DNA structures (i.e. above the mica background) as well as the number of pixels within the green boxes (minus half the overlap with red or blue boxes), and took the ratio; this gave an upper bound of 8%. To estimate the synthesis quality, we counted the number of green-or-red boxes and the number of green boxes, and took the ratio; this estimate ignores structures that could not be classified and came out to be 39%. Assuming all unclassifiable structures (blue boxes) are malformed would imply a synthesis quality of 32% and assuming all unclassifiable structures are well-formed would imply a synthesis quality of 49%. In the main text we report a synthesis quality of approximately 40%.

# 2 Strand design and sequences

## 2.1 Sequence Design

The sequences for the double tiles and the double stranded regions of the "0" tiles were those used in earlier experiments [1]. The sequences for the 8 "1" tiles were newly designed. Design began with the structure of the tiles: the size and placement of the hairpins on the "1" tiles, used for contrast under the atomic force microscope, was identical to those used previously [2].

The design of the sequences themselves proceeded according to the sequence design method described in detail previously [1]. The goal of the design process was to ensure that areas designed to hybridize would do so while minimizing spurious interactions between regions that were designed not to interact [3, 4]. Sticky ends were also designed with the criterion that their binding energies should be similar to one another; binding energies were predicted using the nearest neighbor model of hybridization [5]. The design of all new sequences was done to ensure they would be compatible with existing DNA using these criteria. Additionally, the designed sticky end sequences were arranged on the tiles in such a way that all sticky ends encoding "0" and "1" in the same row have 0 cross-hybridization energy of 0 according to the nearest neighbor model.

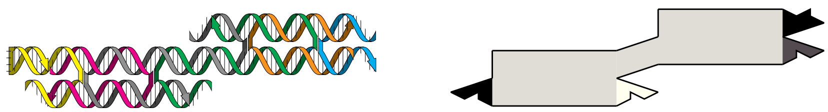
The crystal seeds in the tile rows that nucleated the ribbon used sequences were identical to those used in the "0" tiles in each row of the ribbons. The tail region of the seed consisted of sequences that were used in a previous experiment [6] and were also designed to minimize spurious interactions with the sequences of the ribbon tiles.

## 2.2 Tile sequences

Ribbons were constructed from two types of tiles. Double tiles run along the top and bottom rows and “single” tiles assemble in the middle 4 rows of each ribbon. Each experiment used two types of double tiles, 8 tile types that made up the blocks propagating the “0” bit and 8 tile types that made up the blocks propagating the “1” bit. To create the 1-, 2-, 3- and 4-redundant tile sets, the single-stranded (“sticky”) ends of the tiles were altered, but tile sequences otherwise remained the same in all experiments. Sticky ends that changed between experiments are denoted nnnnn here.

### 2.2.1 Boundary tiles

Z78



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                                                           6  >catac-cttcgtcc tgttcgct/\gagtcaca ggctaacc-tccaa<  4
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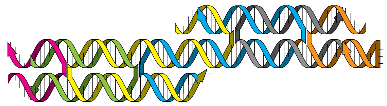
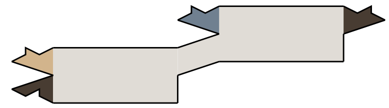
    \tt-cc-agaac----gtaagacc actggtat/\agatagga ggctactg-ctgtc-ggcacggt-ccatcgcc/\atgtgagg-acgaagac<  3
                       | |       Z78      | |
        1  >aggtt-ctaccgca gcctattc\/tgacgtgg tgcctagc-acctt<  5
             2  <gatggcgt-cggataag/\actgcacc-acggatcg>  6
```

Strands:

1 aggttctaccgcaccagaatgcaagaccttttggtcttg
2 cattctggtgaccataagataggaggtgcagtgaataggctgcggtag
3 cagaagcaggagtgtaggcgatggtgttcgctctcagtgtccgattgg
4 aacctccaatcggtgcttctgttcct
5 ttccacgatccgtggctactgctgtcggcacggtccatcgcctacactccacactgagagcgaacaggacgaag
6 catacctt cgtccaccgtgccgacagcagtagcctcctatcttatggtcagcctattcactgcaccacggatcg

Z56





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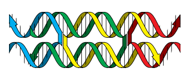
                                            6  >gtgat-cgttcgca ggtgaacc/\cgtcatcc tgcggagc-gcaat<  4
                                                              | |       Z56      | |
      2  >gtttgagg-acgctatg\/ttgtaggt-ccatgagc-acgaa-cgaaagcc tgagctag\/tccagaca ggtcatcg----aaggc-cc-tt\  4
  1  <ctgta-caaactcc tgcgatac/\aacatcca ggtactcg-tgctt-gctttcgg-actcgatc/\aggtctgt-ccagtagc<3 <ttccg-gg-tt/
                   | |       Z56      | |
  1  >cgtta-gctcggca ggtgtctc\/acgaatcc tggttacg-aaggc<  5
      2  <cgagccgt-ccacagag/\tgcttagg-accaatgc-ttccg>  6
```

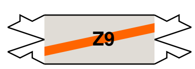
Strands:

1 cgttagctcggcacctcaaacatgtc
2 gtttgaggacgctatgaacatccacctaagcagagacacctgccgagc
3 cgatgacctgtctggagatcgagtggtgaaccgcagtaggacgcctcg
4 taacgcgaggcgtggtcatcgaaggcccttttgggcctt
5 cggaagcattggtggtactcgtgcttgctttcggactcgatctccagacacctactgcggttcacctgcgaacg
6 gtgatcgttcgcaccgaaagcaagcacgagtacctggatgttcatagcgtggtgtctctgcttaggaccaatgcttccg

### 2.2.2 "0" tiles

Z9



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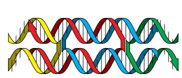
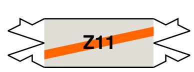
                 | |       Z9       | |
4  >nnnnn-gttcatcc tgcgacgt\/tcaacgca ggctattg-nnnnn<  1
    3  <caagtagg-acgctgca/\agttgcgt-ccgataac>   2
```

Strands:

1 nnnnngttatcggtgctgaccnnnnn
2 ggtcagcaggattcattgatatggtgcgacgtagttgcgtccgataac
3 gagcgagtccatatcaatgaatccacgcaactacgtcgcaggatgaac
4 nnnnngttcatccactcgctcnnnnn

Z11



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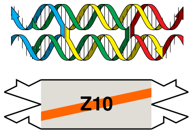
                 | |      Z11       | |
4  <nnnnn-gctgaagg actattgt\/tttgtagt ccctttag-nnnnn>  1
    3  >cgacttcc-tgataaca/\aaacatca-gggaaatc<  2
```

Strands:

1 nnnnnccgaaccaccctttagnnnnn
2 ctaaagggactacaaatgttatcaccgagagtatctagcctggttcgg
3 cgacttcctgataacatttgtagtggctagatactctcggactaagag
4 nnnnnctcttagtggaagtcgnnnnn

Z10

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                 | |       Z10       | |
4  >nnnnn-ctagaaca ggaaacgc\/tagatgcc tgaagacg-nnnnn<  1
        3  <gatcttgt-cctttgcg/\atctacgg-acttctgc>  2
```

Strands:

```
1  nnnnngcagaagtgggtttagnnnnn
2  ctaaaccctgtcgccttactcagtggaaacgcatctacggacttctgc
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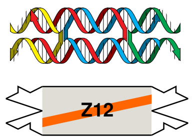
4  nnnnnctagaacacctcattcnnnnn
```

Z12

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4  <nnnnn-gctctaca ggcattag\/gttatgcc tgtatcgc-nnnnn>  1
        3  >cgagatgt-ccgtaatc/\caatacgg-acatagcg<  2
```

Strands:

```
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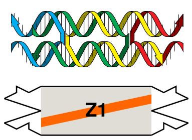
4  nnnnngtttcgccacatctcgnnnnn
```

Z1

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1 <nnnnn-gtctcacc tgctttcg/\tcacggca ggctacag-nnnnn>  4
                | |        Z1        | |
1 >nnnnn-caaacgca ggaacctg\/tatgaacc tgctcaac-nnnnn<  4
       2  <gtttgcgt-ccttggac/\atacttgg-acgagttg>  3
```

Strands:

```
1  nnnnncaaacgcaccactctgnnnnn
2  cagagtggacgaaagctcacggcaccaagtatcaggttcctgcgtttg
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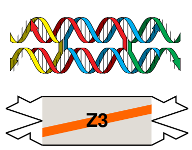
4  nnnnncaactcgtggctacagnnnnn
```

Z3

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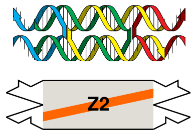
1  >nnnnn-cagccagt ccgagcag/\tgctgtgg actctgcc-nnnnn<  4
                 | |       Z3        | |
1  <nnnnn-gaggatgg acgcttag\/tctgtagt ccgcattg-nnnnn>  4
        2  >ctcctacc-tgcgaatc/\agacatca-ggcgtaac<  3
```

Strands:

```
1  nnnnncagccagtggtaggagnnnnn
2  ctcctacctgcgaatctctgtagtggtgtcgtctgctcggactggctg
3  caatgcggactacagagattcgcaccgagcagacgacacctgagacgg
4  nnnnnccgtctcaccgcattgnnnnn
```

Z2




```
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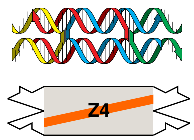
                    | |       Z2       | |
1  >nnnnn-gaacgacc tgattgcg\/taatctca ggcattcg-nnnnn<  4
      2  <cttgctgg-actaacgc/\attagagt-ccgtaagc>  3
```

Strands:

```
1  nnnnngaacgaccacatcatcnnnnn
2  gatgatgtccttgtaaacttcgccactctaatcgcaatcaggtcgttc
3  gagcaacaggcgaagtttacaaggtgattgcgattagagtccgtaagc
4  nnnnngcttacggtgttgctcnnnnn
```

Z4

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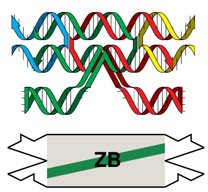
                    | |       Z4       | |
1  <nnnnn-cgccaaca ggttgaat\/ccagatcc tgtagagc-nnnnn>  4
      2  >gcggttgt-ccaactta/\ggtctagg-acatctcg<  3
```

Strands:

```
1  nnnnnggcaatccacaaccgcnnnnn
2  gcggttgtccaacttaccagatccacaagccgacgttacaggattgcc
3  gctctacaggatctggtaagttggtgtaacgtcggcttgtccgttcgc
4  nnnnngcgaacggtgtagagcnnnnn
```

### 2.2.3 “1” tiles

ZB

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1  <nnnnn-ctacgcta ggctggta/\cctagcac tcaaccac-nnnnn>  4
                    | |       ZB       | |
1  >nnnnn-gtgactcc tactctgc\/tccgacga ggcatagg-nnnnn<  4
      2  <cactgagg-atgagacg/\aggctgct-ccgtatcc>  3
                           / || \
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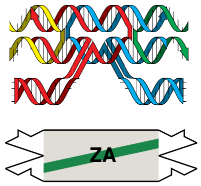
               \tt-gcgaagcc--/    \--gtcgtggc-tt/
```

Strands:

```
1  nnnnngtgactccatcgcatcnnnnn
2  gatgcgatccgaccatcctagcacagcagcctccgaagcgttttcgcttcggttgcagagtaggagtcac
3  gtggttgagtgctaggatggtcggtactctgcgtcgtggcttttgccacgacttaggctgctccgtatcc
4  nnnnnggatacggtcaaccacnnnnn
```

ZA

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                 | |        ZA      | |
1  <nnnnn-gcacgacg agtccgag\/agtaggtt cagcttcg-nnnnn>  4
      2  >cgtgctgc-tcaggctc/\tcatccaa-gtcgaagc<  3
                         / || \
             /tt-cgctctgc  ||  ggcacggc-tt\
             \tt-gcgagacgtt/\ttccgtgccg-tt/
```

Strands:

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2 cgtgctgctcaggctccgtctcgcttttgcgagacgttagtaggttgtccgaatggctggtgaaggtcag
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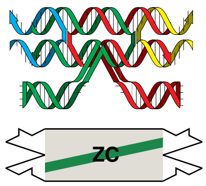
4 nnnnngcctccaacagcttcgnnnnn

ZC

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     2   <gcaaggct-ccaccgac/\aggtgcgg-ataggagc>   3
                         / || \
           /tt-cgcttgcctt  ||  ttggcatcgc-tt\
           \tt-gcgaacgg--/    \--ccgtagcg-tt/
```

Strands:

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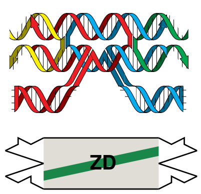
2 gagtgtggaacctgtccaagacgaccgcacctggcaagcgttttcgcttgccttcagccacctcggaacg
3 cagtcgcctcgtcttggacaggttggtggctgccgtagcgttttcgctacggttaggtgcggataggagc
4 nnnnngctcctatggcgactgnnnnn

ZD

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1  <nnnnn-gacgaaca ggagcttg\/ggaatgcc tgatggac-nnnnn>  4
      2  >ctgcttgt-cctcgaac/\ccttacgg-actacctg<  3
                         / || \
             /tt-gtcgctgg  ||  gtggagcg-tt\
             \tt-cagcgacctt/\ttcacctcgc-tt/
```

Strands:

1 nnnnngctacgccacaagcagnnnnn
2 ctgcttgtcctcgaacggtcgctgttttcagcgaccttggaatgccaccagacctctgcgaaggcgtagc
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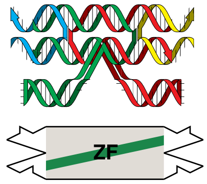
ZF

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               | |       ZF       | |
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    2  <gactgtct-cgatgctc/\aggcgtgg-accatgag>  3
                        / || \
          /tt-cggagacgtt  ||  ttgccttggc-tt\
          \tt-gcctctgc--/    \--cggaaccg-tt/
```

Strands:

1 nnnnnctgacagacggcacagnnnnn
2 ctgtgccgagcatcgccagcactaccacgcctcgtctccgttttcggagacgttctcgtagctctgtcag
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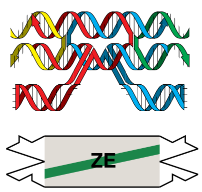
ZE

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1  >nnnnn-ctgcatct cgctggag/\aagcctag accgttgc-nnnnn<  4
               | |       ZE       | |
1  <nnnnn-gactcctg agagctgc\/ggtcaggt ctcacagg-nnnnn>  4
   2   >ctgaggac-tctcgacg/\ccagtcca-gagtgtcc<  3
                        / || \
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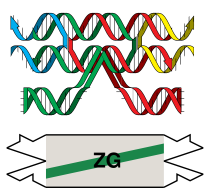
            \tt-cacggagctt/\ttctgtggcg-tt/
```

1 nnnnnctgcatctgtcctcagnnnnn
2 ctgaggactctcgacggctccgtgttttcacggagcttggtcaggtgatccgaactccagcgagatgcag
3 cctgtgagacctgaccgacaccgcttttgcggtgtcttcgtcgagacgctggagttcggatctggcaacg
4 nnnnncgttgccactcacaggnnnnn

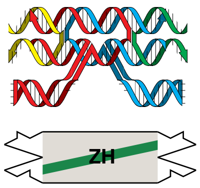
ZG




```
   2   >gaagtcct-cgagactg\/atcgaccg-aaggtccg<  3
1  <nnnnn-cttcagga gctctgac/\tagctggc ttccaggc-nnnnn>  4
               | |       ZG       | |
1  >nnnnn-gccaaggc tgagcacc\/ctgcctaa gctgatcg-nnnnn<  4
   2   <cggttccg-actcgtgg/\gacggatt-cgactagc>  3
                        / || \
          /tt-cggcatcgtt  ||  ttcacaggcg-tt\
          \tt-gccgtagc--/    \--gtgtccgc-tt/
```

1 nnnnngccaaggcaggacttcnnnnn
2 gaagtcctcgagactgtagctggcaatccgtccgatgccgttttcggcatcgttggtgctcagccttggc
3 gcctggaagccagctacagtctcgtgagcaccgtgtccgcttttgcggacacttgacggattcgactagc
4 nnnnngctagtcgttccaggcnnnnn

ZH




```
       2  <ctgtgagg-atgctccg\/agatcggt-caaggacc>  3
1  >nnnnn-gacactcc tacgaggc/\tctagcca gttcctgg-nnnnn<  4
                 | |       ZH       | |
1  <nnnnn-caactcca ggtcaacc\/cacagtcc tgtctcac-nnnnn>  4
       2  >gttgaggt-ccagttgg/\gtgtcagg-acagagtg<  3
                          / || \
                /tt-gcctcagc  ||  gcgagccg-tt\
                \tt-cggagtcgtt/\ttcgctcggc-tt/
```

1 nnnnngacactccacctcaacnnnnn
2 gttgaggtccagttggcgactccgttttcggagtcgttcacagtccaccgatctgcctcgtaggagtgtc
3 gtgagacaggactgtggcgagccgttttcggctcgcttccaactggtacgaggcagatcggtcaaggacc
4 nnnnnggtccttgtgtctcacnnnnn

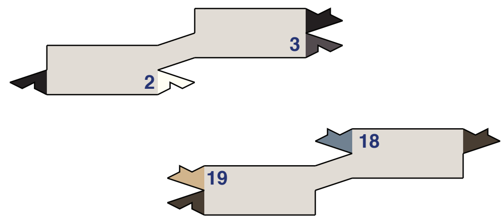
## 2.3 Tile schematics

This section shows how the sticky ends were programmed to produce the four levels of redundancy. To accomplish this, the same tile cores were used and the row in which each tile could assemble remained the same, but the sticky ends of some tiles changed. The following schematics show which sticky ends were used in which experiment and the function of each of the sticky ends.

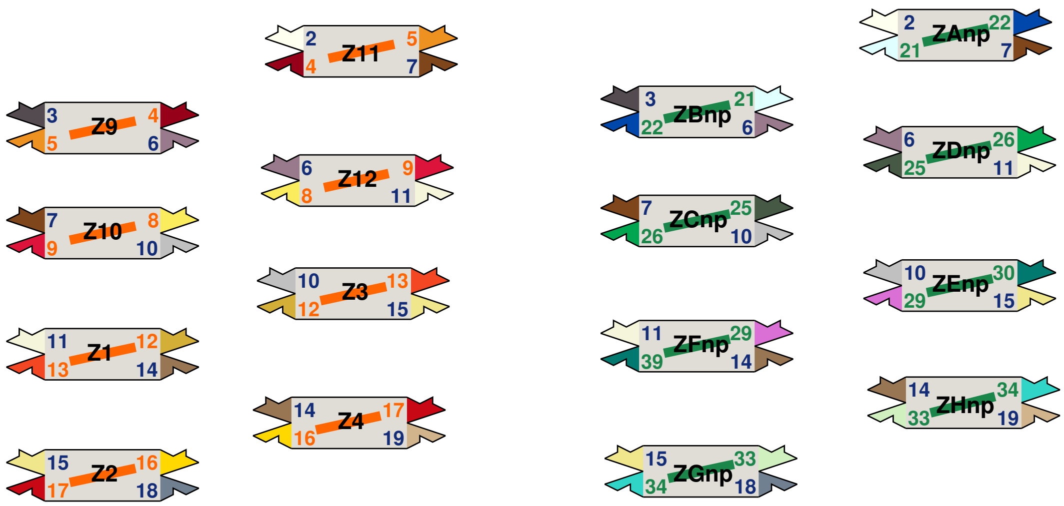
Numbers next to each claw denote which sticky end was used (these are also indicated by the color of the claws, but the numbers can be more easily matched to the sticky end sequences given below than can subtle color changes). The colors of the numbers indicate whether the sticky end type is used only in 0 tiles (orange), only in 1 tiles (green) or in tiles encoding both bits (blue). While the sticky ends for the 0 tiles were the same in all experiments, the colors of some of the 0 tile sticky ends change in the schematics below dependening on whether they are shared by the 1 tiles or not.

While each sticky end in a matching pair have the same number label, the two sticky ends have complementary (as opposed to identical) sequences.

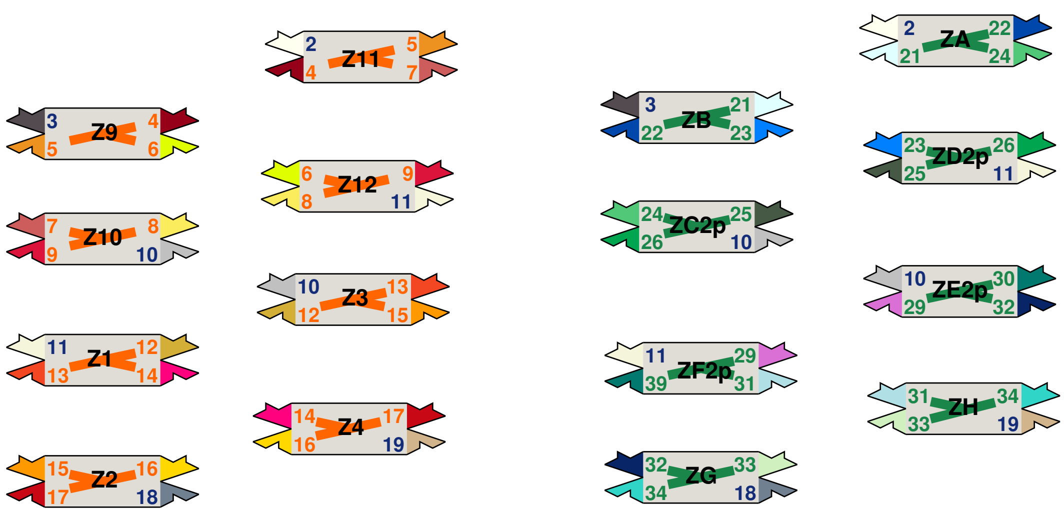
**Schematic arrangement of and sticky ends for the boundary tiles, which are included the 1-redudant, 2-redudant, 3-redundant and 4-redundant tile sets:**



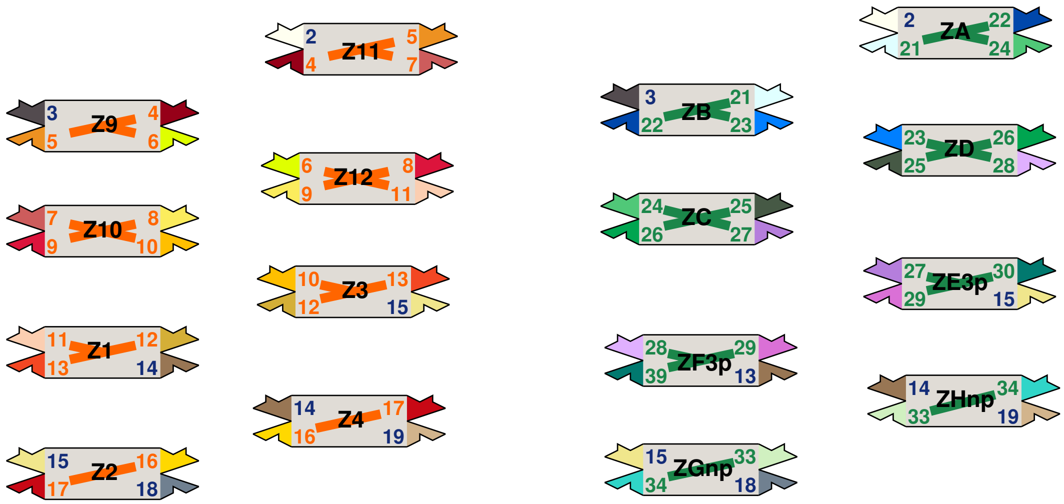

**Schematic arrangement of and sticky ends for the 1-redundant proofreading tile set:**



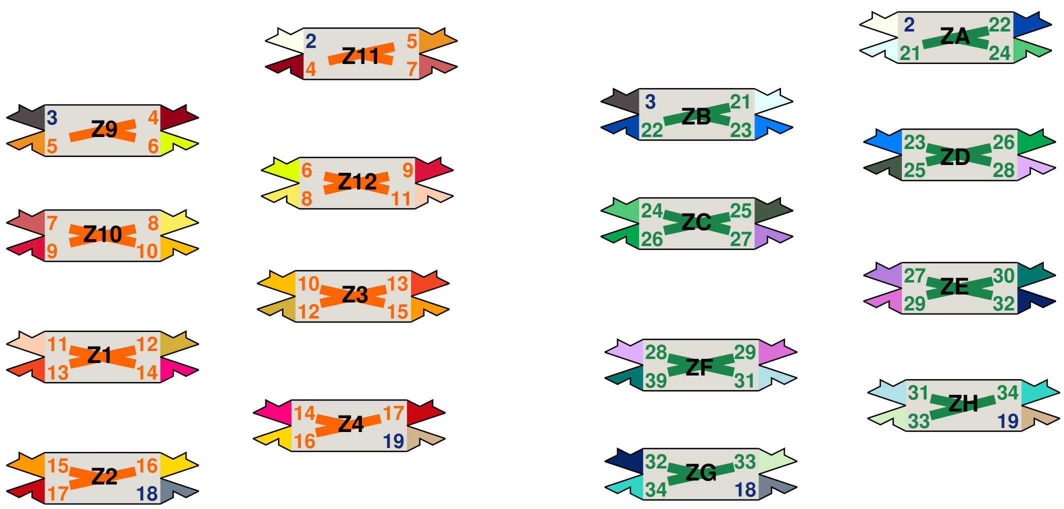

**Schematic arrangement of and sticky ends for the 2-redundant proofreading tile set:**



**Schematic arrangement of and sticky ends for the 3-redundant proofreading tile set:**




**Schematic arrangement of and sticky ends for the 4-redundant proofreading tile set:**



## 2.4 Tile sticky end sequences

1-redundant "0" tile sticky end sequences

| | | |
|---|---|---|
| Z1-1 | 13—11 | cttgt—caaacgcaccactctg—ttggt |
| Z1-4 | 14—12 | atgct—caactcgtggctacag—aagag |
| Z2-1 | 17—15 | aagtc—gaacgaccacatcatc—cgatt |
| Z2-4 | 18—16 | atcac—gcttacggtgttgctc—gctaa |
| Z3-1 | 10—12 | accaa—cagccagtggtaggag—ctctt |
| Z3-4 | 13—15 | acaag—ccgtctcaccgcattg—aatcg |
| Z4-1 | 14—16 | agcat—ggcaatccacaaccgc—ttagc |
| Z4-4 | 17—19 | gactt—gcgaacggtgtagagc—gacat |
| Z9-1 | 6—4 | ggtaa—gttatcggtgctgacc—agaac |
| Z9-4 | 5—3 | tgagt—gttcatccactcgctc—aggaa |
| Z10-1 | 10—8 | ttggt—gcagaagtgggtttag—tgagt |
| Z10-4 | 9—7 | aatgg—ctagaacacctcattc—ggtta |
| Z11-1 | 5—7 | actca—ccgaaccaccctttag—taacc |
| Z11-4 | 2—4 | tggaa—ctcttagtggaagtcg—gttct |
| Z12-1 | 9—11 | ccatt—gtctaaggtgtatcgc—accaa |
| Z12-4 | 6—8 | ttacc—gtttcgccacatctcg—actca |

1-redundant "1" tile sticky end sequences:

| | | |
|---|---|---|
| ZA-1 | 2—21 | tggaa—ctgaccttgcagcacg—atgac |
| ZA_np-4 | 22—7 | gagat—gcctccaacagcttcg—taacc |
| ZB-1 | 22—3 | atctc—gtgactccatcgcatc—aggaa |
| ZB_np-4 | 6—21 | ggtaa—ggatacggtcaaccac—gtcat |
| ZC_np-1 | 26—7 | tcaga—cgttccgaccacactc—ggtta |
| ZC_np-4 | 10—25 | ttggt—gctcctatggcgactg—acaca |
| ZD_np-1 | 6—25 | ttacc—gctacgccacaagcag—tgtgt |
| ZD_np-4 | 26—11 | tctga—cgcaacggtgatggac—accaa |
| ZE_np-1 | 10—29 | accaa—ctgcatctgtcctcag—tacga |
| ZE_np-4 | 30—15 | tcctt—cgttgccactcacagg—aatcg |
| ZF_np-1 | 39—11 | aagga—ctgacagacggcacag—ttggt |
| ZF_np-4 | 14—29 | atgct—ctcatggtgagccttg—tcgta |
| ZG_np-1 | 34—15 | gctta—gccaaggcaggacttc—cgatt |
| ZG-4 | 18—33 | atcac—gctagtcgttccaggc—atgac |
| ZH_np-1 | 14—33 | agcat—gacactccacctcaac—gtcat |
| ZH-4 | 34—19 | taagc—ggtccttgtgtctcac—gacat |

2-redundant “0” tile sticky end sequences

| | | |
|---|---|---|
| Z1-1 | 13—11 | cttgt—caaacgcaccactctg—ttggt |
| Z1-4 | 14—12 | atgct—caactcgtggctacag—aagag |
| Z2-1 | 17—15 | aagtc—gaacgaccacatcatc—cgatt |
| Z2-4 | 18—16 | atcac—gcttacggtgttgctc—gctaa |
| Z3-1 | 10—12 | accaa—cagccagtggtaggag—ctctt |
| Z3-4 | 13—15 | acaag—ccgtctcaccgcattg—aatcg |
| Z4-1 | 14—16 | agcat—ggcaatccacaaccgc—ttagc |
| Z4-4 | 17—19 | gactt—gcgaacggtgtagagc—gacat |
| Z9-1 | 6—4 | ggtaa—gttatcggtgctgacc—agaac |
| Z9-4 | 5—3 | tgagt—gttcatccactcgctc—aggaa |
| Z10-1 | 10—8 | ttggt—gcagaagtgggtttag—tgagt |
| Z10-4 | 9—7 | aatgg—ctagaacacctcattc—ggtta |
| Z11-1 | 5—7 | actca—ccgaaccaccctttag—taacc |
| Z11-4 | 2—4 | tggaa—ctcttagtggaagtcg—gttct |
| Z12-1 | 9—11 | ccatt—gtctaaggtgtatcgc—accaa |
| Z12-4 | 6—8 | ttacc—gtttcgccacatctcg—actca |

2-redundant “1” tile sticky end sequences

| | | |
|---|---|---|
| ZA-1 | 2—21 | tggaa—ctgaccttgcagcacg—atgac |
| ZA-4 | 22—24 | gagat—gcctccaacagcttcg—agcat |
| ZB-1 | 22—3 | atctc—gtgactccatcgcatc—aggaa |
| ZB-4 | 23—21 | atgac—ggatacggtcaaccac—gtcat |
| ZC-1 | 26—24 | tcaga—cgttccgaccacactc—atgct |
| ZC_np-4 | 10—25 | ttggt—gctcctatggcgactg—acaca |
| ZD-1 | 23—25 | gtcat—gctacgccacaagcag—tgtgt |
| ZD_np-4 | 26—11 | tctga—cgcaacggtgatggac—accaa |
| ZE_np-1 | 10—29 | accaa—ctgcatctgtcctcag—tacga |
| ZE-4 | 30—32 | tcctt—cgttgccactcacagg—cttac |
| ZF_np-1 | 39—11 | aagga—ctgacagacggcacag—ttggt |
| ZF-4 | 31—29 | caaac—ctcatggtgagccttg—tcgta |
| ZG-1 | 34—32 | gctta—gccaaggcaggacttc—gtaag |
| ZG-4 | 18—33 | atcac—gctagtcgttccaggc—atgac |
| ZH-1 | 31—33 | gtttg—gacactccacctcaac—gtcat |
| ZH-4 | 34—19 | taagc—ggtccttgtgtctcac—gacat |

3-redundant "0" tile sticky end sequences

| | | |
|---|---|---|
| Z1-1 | 13—11 | cttgt—caaacgcaccactctg—ttggt |
| Z1-4 | 14—12 | atgct—caactcgtggctacag—aagag |
| Z2-1 | 17—15 | aagtc—gaacgaccacatcatc—cgatt |
| Z2-4 | 18—16 | atcac—gcttacggtgttgctc—gctaa |
| Z3-1 | 10—12 | accaa—cagccagtggtaggag—ctctt |
| Z3-4 | 13—15 | acaag—ccgtctcaccgcattg—aatcg |
| Z4-1 | 14—16 | agcat—ggcaatccacaaccgc—ttagc |
| Z4-4 | 17—19 | gactt—gcgaacggtgtagagc—gacat |
| Z9-1 | 6—4 | ggtaa—gttatcggtgctgacc—agaac |
| Z9-4 | 5—3 | tgagt—gttcatccactcgctc—aggaa |
| Z10-1 | 10—8 | ttggt—gcagaagtgggtttag—tgagt |
| Z10-4 | 9—7 | aatgg—ctagaacacctcattc—ggtta |
| Z11-1 | 5—7 | actca—ccgaaccaccctttag—taacc |
| Z11-4 | 2—4 | tggaa—ctcttagtggaagtcg—gttct |
| Z12-1 | 9—11 | ccatt—gtctaaggtgtatcgc—accaa |
| Z12-4 | 6—8 | ttacc—gtttcgccacatctcg—actca |

3-redundant "1" tile sticky end sequences

| | | |
|---|---|---|
| ZA-1 | 2—21 | tggaa—ctgaccttgcagcacg—atgac |
| ZA-4 | 22—24 | gagat—gcctccaacagcttcg—agcat |
| ZB-1 | 22—3 | atctc—gtgactccatcgcatc—aggaa |
| ZB-4 | 23—21 | atgac—ggatacggtcaaccac—gtcat |
| ZC-1 | 26—24 | tcaga—cgttccgaccacactc—atgct |
| ZC-4 | 27—25 | ctatc—gctcctatggcgactg—acaca |
| ZD-1 | 23—25 | gtcat—gctacgccacaagcag—tgtgt |
| ZD-4 | 26—28 | tctga—cgcaacggtgatggac—gatag |
| ZE-1 | 27—29 | gatag—ctgcatctgtcctcag—tacga |
| ZE_np-4 | 30—15 | tcctt—cgttgccactcacagg—aatcg |
| ZF-1 | 39—28 | aagga—ctgacagacggcacag—ctatc |
| ZF_np-4 | 13—29 | atgct—ctcatggtgagccttg—tcgta |
| ZG_np-1 | 34—15 | gctta—gccaaggcaggacttc—cgatt |
| ZG-4 | 18—33 | atcac—gctagtcgttccaggc—atgac |
| ZH_np-1 | 14—33 | agcat—gacactccacctcaac—gtcat |
| ZH-4 | 34—19 | taagc—ggtccttgtgtctcac—gacat |

4-redundant "0" tile sticky end sequences

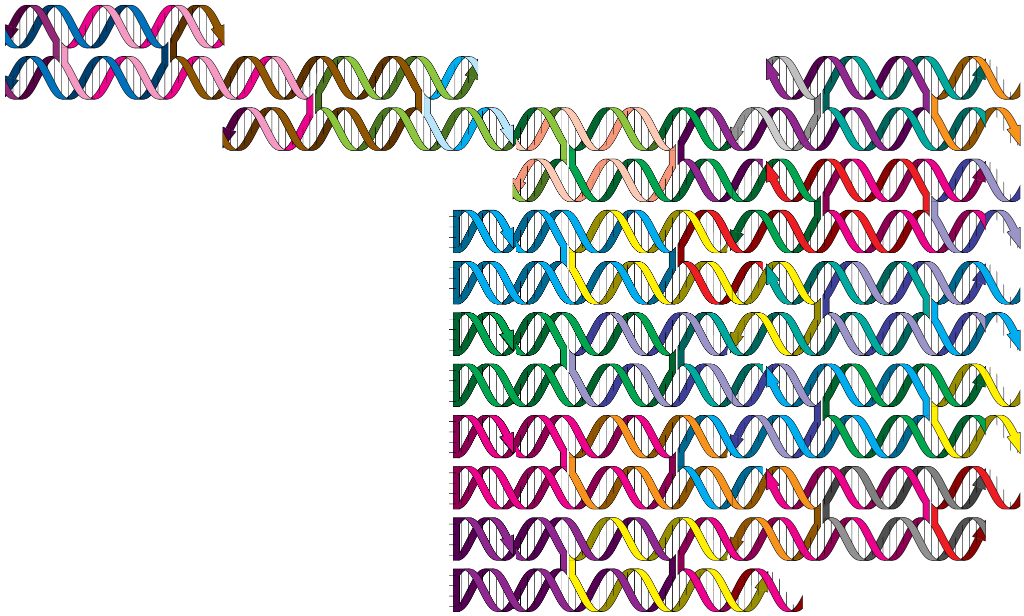
| | | |
|---|---|---|
| Z1-1 | 13—11 | cttgt—caaacgcaccactctg—ttggt |
| Z1-4 | 14—12 | atgct—caactcgtggctacag—aagag |
| Z2-1 | 17—15 | aagtc—gaacgaccacatcatc—cgatt |
| Z2-4 | 18—16 | atcac—gcttacggtgttgctc—gctaa |
| Z3-1 | 10—12 | accaa—cagccagtggtaggag—ctctt |
| Z3-4 | 13—15 | acaag—ccgtctcaccgcattg—aatcg |
| Z4-1 | 14—16 | agcat—ggcaatccacaaccgc—ttagc |
| Z4-4 | 17—19 | gactt—gcgaacggtgtagagc—gacat |
| Z9-1 | 6—4 | ggtaa—gttatcggtgctgacc—agaac |
| Z9-4 | 5—3 | tgagt—gttcatccactcgctc—aggaa |
| Z10-1 | 10—8 | ttggt—gcagaagtgggtttag—tgagt |
| Z10-4 | 9—7 | aatgg—ctagaacacctcattc—ggtta |
| Z11-1 | 5—7 | actca—ccgaaccaccctttag—taacc |
| Z11-4 | 2—4 | tggaa—ctcttagtggaagtcg—gttct |
| Z12-1 | 9—11 | ccatt—gtctaaggtgtatcgc—accaa |
| Z12-4 | 6—8 | ttacc—gtttcgccacatctcg—actca |

4-redundant “1” tile sticky end sequences

| | | |
|---|---|---|
| ZA-1 | **2——21** | tggaa—ctgaccttgcagcacg—atgac |
| ZA-4 | **22——24** | gagat—gcctccaacagcttcg—agcat |
| ZB-1 | **22——3** | atctc—gtgactccatcgcatc—aggaa |
| ZB-4 | **23——21** | atgac—ggatacggtcaaccac—gtcat |
| ZC-1 | **26——24** | tcaga—cgttccgaccacactc—atgct |
| ZC-4 | **27——25** | ctatc—gctcctatggcgactg—acaca |
| ZD-1 | **23——25** | gtcat—gctacgccacaagcag—tgtgt |
| ZD-4 | **26——28** | tctga—cgcaacggtgatggac—gatag |
| ZE-1 | **27——29** | gatag—ctgcatctgtcctcag—tacga |
| ZE-4 | **30——32** | tcctt—cgttgccactcacagg—cttac |
| ZF-1 | **39——28** | aagga—ctgacagacggcacag—ctatc |
| ZF-4 | **31——29** | caaac—ctcatggtgagccttg—tcgta |
| ZG-1 | **34——32** | gctta—gccaaggcaggacttc—gtaag |
| ZG-4 | **18——33** | atcac—gctagtcgttccaggc—atgac |
| ZH-1 | **31——33** | gtttg—gacactccacctcaac—gtcat |
| ZH-4 | **34——19** | taagc—ggtccttgtgtctcac—gacat |

## 2.5 Crystal seed schematics

**Schematic diagram of the crystal seed structure.**



**Arrangement of sequences within the crystal seed structure.**

```
3 >cggagcac-tctgtacc\/agactgct-cttgcacc<  1
2 <gcctcgtg agacatgg/\tctgacga gaacgtgg>
           | |    Weave-12    | |
2 >ggctaact ccattgtg\/ttcatacc ttatgacc-gagaa-cgtatcag-aaatcctt\/tcaacctt-gctcttgt> 2                                                       1<gaagcagg-acaagcga\/ctcagtgt-ccgattgg>  3
3 <ccgattga-ggtaacac/\aagtatgg-aatactgg-ctctt-gcatagtc tttaggaa/\agttggaa cgagaaca< 1                                               2  >catac-cttcgtcc tgttcgct/\gagtcaca ggctaacc-tccaa<  4
                                                     | |    Weave-11    | |                                                                                                  | |    Weave-10    | |
                                       <aacgt-gcaactca gcattgtg\/ggaagatg tggcagac-----ttggt>1 1>cattctgg-tgaccata\/tctatcct-ccgatgac<2 2<gacag-----ccgtgcca ggtagcgg\/tacactcc tgcttctg-ttcct>  4
                                   3   >ttgca-cgttgagt-cgtaacac/\ccttctac-accgtctg-----aacca-----gtaagacc actggtat/\agatagga ggctactg-----ctgtc-----ggcacggt-ccatcgcc/\atgtgagg-acgaagac<  3
                                                                                                         | |    Weave-9     | |
                                                                                                 <ctaccgca gcctattc\/tgacgtgg tgcctagc-----acctt<1 1<gagaatca-ggctctca\/atctagcc-nnnnnnnn>  2
                                                                                               1 >gatggcgt-cggataag/\actgcacc-acggatcg-----tggaa-----ctcttagt ccgagagt/\tagatcgg nnnnnnnn-nnnnn<  3
                                                                                                                                                            | |    Weave-8     | |
                                                                                  /tt-gg-ttcct> 1 >gagcgagt-ccatatca\/tacttagg-acgactgg<2 2<tcttg-----gctgaagg actattgt\/tttgtagt nnnnnnnn-nnnnn>  3
                                                                                  \tt-cc-aggaa-----ctcgctca ggtatagt/\atgaatcc tgctgacc-----agaac-----cgacttcc-tgataaca/\aaacatca-nnnnnnnn<  2
                                                                                                         | |    Weave-7     | |
                                                                                              /tt-gttcatcc tgcgacgt\/tcaacgca ggctattg-----aatgg<1 1<caaagcgg-acaacgta\/ttccatgt-nnnnnnnn>  2
                                                                                              \tt-caagtagg-acgctgca/\agttgcgt-ccgataac-----ttacc-----gtttcgcc tgttgcat/\aaggtaca nnnnnnnn-nnnnn<  3
                                                                                                                                                            | |    Weave-6     | |
                                                                                  /tt-gg-taacc> 1 >gaatgagg-actgagta\/tccgctgt-cccaaatc<2 2<actca-----gctctaca ggcattag\/gttatgcc nnnnnnnn-nnnnn>  3
                                                                                  \tt-cc-attgg-----cttactcc tgactcat/\aggcgaca gggtttag-----tgagt-----cgagatgt-ccgtaatc/\caatacgg-nnnnnnnn<  2
                                                                                                         | |    Weave-5     | |
                                                                                              /tt-ctagaaca ggaaacgc\/tagatgcc tgaagacg-----tggtt<1 1<gtcggtca-ggctcgtc\/acgacacc-nnnnnnnn>  2
                                                                                              \tt-gatcttgt-cctttgcg/\atctacgg-acttctgc-----accaa-----cagccagt ccgagcag/\tgctgtgg nnnnnnnn-nnnnn<  3
                                                                                                                                                            | |    Weave-4     | |
                                                                                  /tt-gg-ttcct> 1 >cagagtgg-acgaaagc\/agtgccgt-ccgatgtc<2 2<ttctc-----gaggatgg acgcttag\/tctgtagt nnnnnnnn-nnnnn>  3
                                                                                  \tt-cc-aagga-----gtctcacc tgctttcg/\tcacggca ggctacag-----aagag-----ctcctacc-tgcgaatc/\agacatca-nnnnnnnn<  2
                                                                                                         | |    Weave-3     | |
                                                                                              /tt-caaacgca ggaacctg\/tatgaacc tgctcacc-----tcgta<1 1<ccgttagg-acattgca\/cggcttgt-nnnnnnn>  2
                                                                                              \tt-gtttgcgt-ccttggac/\atacttgg-acgagttg-----agcat-----ggcaatcc tgtaacgt/\gccgaaca nnnnnnn-nnnnn<  3
                                                                                                                                                            | |    Weave-2     | |
                                                                                  /tt-gg-aatcg> 1 >gatgatgt-ccttgtaa\/tgaagcgg-acaacgag<2 2<cgatt-----cgccaaca ggttgaat\/ccagatcc nnnnnnnn>  3
                                                                                  \tt-cc-ttagc-----ctactaca ggaacatt/\acttcgcc tgttgctc-----gctaa-----gcggttgt-ccaactta/\ggtctagg-nnnnnnnn<  2
                                                                                                         | |    Weave-1     | |
                                                                                              /tt-gaacgacc tgattgcg\/taatctca ggcattcg-----cacta<
                                                                                              \tt-cttgctgg-actaacgc/\attagagt-ccgtaagc>
```

## 2.6 Crystal seed sequences

Weave-1

1 gatgatgtccttgtaaacttcgccactctaatcgcaatcaggtcgttcttttgaacgaccacatcatccgattccttttggaatcg
2 gagcaacaggcgaagtttacaaggtgattgcgattagagtccgtaagc

Weave-2

1 atcacgcttacggtgttgctcgctaagcggttgtccaacttaccagatccacaagccgacgttacaggattgcc
2 nnnnnnnnaggatctggtaagttggtgtaacgtcggcttgtnnnnnnnn
3 nnnnnnnnnnnnnnnnnnnnnnnnnn

Weave-3

1 cagagtggacgaaagctcacggcaccaagtatcaggttcctgcgtttgttttcaaacgcaccactctgaggaaccttttggttcct
2 ctgtagcctgccgtgagctttcgtggaacctgatacttggacgagttg

Weave-4

1 atgctcaactcgtggctacagaagagctcctacctgcgaatctctgtagtggtgtcgtctgctcggactggctg
2 nnnnnnnnactacagagattcgcaccgagcagacgacaccnnnnnnnn
3 nnnnnnnnnnnnnnnnnnnnnnnnnn

Weave-5

1 gaatgaggactgagtaaggcgacaccgtagatgcgtttcctgttctagttttctagaacacctcattcggttaccttttggtaacc
2 ctaaaccctgtcgccttactcagtggaaacgcatctacggacttctgcaccaacagccagtggtaggagctctt

Weave-6

1 ttggtgcagaagtgggtttagtgagtcgagatgtccgtaatcgttatgccacatggaaatgcaacaggcgaaac
2 nnnnnnnnggcataacgattacggtgttgcatttccatgtnnnnnnnn
3 nnnnnnnnnnnnnnnnnnnnnnnnnn

Weave-7

1 gagcgagtccatatcaatgaatccacgcaactacgtcgcaggatgaacttttgttcatccactcgctcaggaaccttttggttcct
2 ggtcagcaggattcattgatatggtgcgacgtagttgcgtccgataacttaccgtttcgccacatctcgactca

Weave-8

1 ggtaagttatcggtgctgaccagaaccgacttcctgataacatttgtagtggctagatactctcggactaagag
2 nnnnnnnnactacaaatgttatcaccgagagtatctagccnnnnnnnn
3 nnnnnnnnnnnnnnnnnnnnnnnnnn

Weave-9

1 cattctggtgaccataagataggaggtgcagtgaataggctgcggtag
2 cagtagcctcctatcttatggtcagcctattcactgcaccacggatcgtggaactcttagtggaagtcggttct

Weave-10

```
1  ttccacgatccgtggctactgctgtcggcacggtccatcgcctacactccacactgagagcgaacaggacgaag
2  cttcgtccaccgtgccgacag
3  cagaagcaggagtgtaggcgatggtgttcgctctcagtgtccgattgg
4  aacctccaatcggtgcttctgttcct
```

Weave-11

```
1  acaagagctggcagacttggt
2  ctaccgcaccagaatgaccaagtctgccacatcttccgtgttacgtttaggaatcaaccttgctcttgt
3  ttgcacgttgagtcgtaacacggaagatgaaggttgattcctaaagactatgcaagagccagtattgaacgtgg
```

Weave-12

```
1  ccacgttctcgtcagaggtacagaccattgtgaagtatggaatactggctcttgcatagtcactcaacgtgcaa
2  ggctaactgtgctccg
3  cggagcactctgtaccagcagtctccatacttcacaatggagttagcc
```

### 2.6.1 Crystal seed sticky end sequences

A particular sequence is nucleated from the seed by controlling the sticky ends presented by the structure: for each vertical position on the seed, the sticky ends presented match the sticky ends of the tiles that propagate the desired bit. This presentation requires both a long strand (#2) that binds to the "scaffold" of the seed that does not change with sequence and a shorter strand (#3) that binds specifically to the long strand and has the presented sticky ends. An example arrangement for the 0101 sequence is shown following the sequences.

**1-redundant sequences for 0101 seed**

```
Weave8-2  ctaaagggactacaaatgttatcaccgagagtatctagcctggttcgg
Weave8-3  actcaccgaaccaccctttagtaacc
Weave6-2  gtccatcaggcataacgattacggtgttgcatttccatgtccgttgcg
Weave6-3  tctgacgcaacggtgatggacaccaa
Weave4-2  caatgcggactacagagattcgcaccgagcagacgacacctgagacgg
Weave4-3  acaagccgtctcaccgcattgaatcg
Weave2-2  gtgagacaggatctggtaagttggtgtaacgtcggcttgt caaggacc
Weave2-3  taagcggtccttg tgtctcac
```

**1-redundant sequences for 1010 seed**

```
Weave8-2  cgaagctgactacaaatgttatcaccgagagtatctagccttggaggc
Weave8-3  gagatgcctccaacagcttcgtaacc
Weave6-2  gcgatacaggcataacgattacggtgttgcatttccatgtccttagac
Weave6-3  ccattgtctaaggtgtatcgcaccaa
Weave4-2  cctgtgagactacagagattcgcaccgagcagacgacacctggcaacg
Weave4-3  tccttcgttgccactcacaggaatcg
Weave2-2  gctctacaggatctggtaagttggtgtaacgtcggcttgtccgttcgc
Weave2-3  gacttgcgaacggtgtagagc
```

**2-redundant sequences for 0011 seed**

```
Weave8-2  ctaaagggactacaaatgttatcaccgagagtatctagcctggttcgg
Weave8-3  actcaccgaaccaccctttagtaacc
Weave6-2  gcgatacaggcataacgattacggtgttgcatttccatgtccttagac
Weave6-3  ccattgtctaaggtgtatcgcaccaa
Weave4-2  cctgtgagactacagagattcgcaccgagcagacgacacctggcaacg
Weave4-3  tccttcgttgccactcacaggcttac
Weave2-2  gtgagacaggatctggtaagttggtgtaacgtcggcttgtcaaggacc
Weave2-3  taagcggtccttgtgtctcac
```

**2-redundant sequences for 1100 seed**

```
Weave8-2  cgaagctgactacaaatgttatcaccgagagtatctagccttggaggc
Weave8-3  gagatgcctccaacagcttcgagcat
Weave6-2  gtccatcaggcataacgattacggtgttgcatttccatgtccgttgcg
Weave6-3  tctgacgcaacggtgatggacaccaa
Weave4-2  caatgcggactacagagattcgcaccgagcagacgacacctgagacgg
Weave4-3  acaagccgtctcaccgcattgaatcg
Weave2-2  gctctacaggatctggtaagttggtgtaacgtcggcttgtccgttcgc
Weave2-3  gacttgcgaacggtgtagagc
```

**3-redundant sequences for 0001 seed**

```
Weave8-2  ctaaagggactacaaatgttatcaccgagagtatctagcctggttcgg
Weave8-3  actcaccgaaccaccctttagtaacc
Weave6-2  gcgatacaggcataacgattacggtgttgcatttccatgtccttagac
Weave6-3  ccattgtctaaggtgtatcgcaccaa
Weave4-2  caatgcggactacagagattcgcaccgagcagacgacacctgagacgg
Weave4-3  acaagccgtctcaccgcattgaatcg
Weave2-2  gtgagacaggatctggtaagttggtgtaacgtcggcttgtcaaggacc
Weave2-3  taagcggtccttgtgtctcac
```

**3-redundant sequences for 1110 seed**

```
Weave8-2  cgaagctgactacaaatgttatcaccgagagtatctagccttggaggc
Weave8-3  gagatgcctccaacagcttcgagcat
Weave6-2  gtccatcaggcataacgattacggtgttgcatttccatgtccgttgcg
Weave6-3  tctgacgcaacggtgatggacgatag
Weave4-2  cctgtgagactacagagattcgcaccgagcagacgacacctggcaacg
Weave4-3  tccttcgttgccactcacaggaatcg
Weave2-2  gctctacaggatctggtaagttggtgtaacgtcggcttgtccgttcgc
Weave2-3  gacttgcgaacggtgtagagc
```

**4-redundant sequences for 0000 seed**

```
Weave8-2  ctaaagggactacaaatgttatcaccgagagtatctagcctggttcgg
Weave8-3  actcaccgaaccaccctttagtaacc
Weave6-2  gcgatacaggcataacgattacggtgttgcatttccatgtccttagac
Weave6-3  ccattgtctaaggtgtatcgcaccaa
Weave4-2  caatgcggactacagagattcgcaccgagcagacgacacctgagacgg
Weave4-3  acaagccgtctcaccgcattgaatcg
Weave2-2  gctctacaggatctggtaagttggtgtaacgtcggcttgtccgttcgc
Weave2-3  gacttgcgaacggtgtagagc
```

**4-redundant sequences for 1111 seed**

```
Weave8-2  cgaagctgactacaaatgttatcaccgagagtatctagccttggaggc
Weave8-3  gagatgcctccaacagcttcgagcat
Weave6-2  gtccatcaggcataacgattacggtgttgcatttccatgtccgttgcg
Weave6-3  tctgacgcaacggtgatggacgatag
Weave4-2  cctgtgagactacagagattcgcaccgagcagacgacacctggcaacg
Weave4-3  tccttcgttgccactcacaggcttac
Weave2-2  gtgagacaggatctggtaagttggtgtaacgtcggcttgtcaaggacc
Weave2-3  taagc ggtccttg tgtctcac
```

Sequences for programming a particular sequence can in principle be mixed and matched to nucleate any desired sequence.

**Arrangement of sequences within the crystal seed structure for sequence 0101**

```
3 >cggagcac-tctgtacc\/agactgct-cttgcacc<  1
2 <gcctcgtg agacatgg/\tctgacga gaacgtgg>
          | |    Weave-12    | |
2 >ggctaact ccattgtg\/ttcatacc ttatgacc-gagaa-cgtatcag-aaatcctt\/tcaacctt-gctcttgt> 2                                                             1<gaagcagg-acaagcga\/ctcagtgt-ccgattgg>  3
3 <ccgattga-ggtaacac/\aagtatgg-aatactgg-ctctt-gcatagtc tttaggaa/\agttggaa cgagaaca< 1                                                     2  >catac-cttcgtcc tgttcgct/\gagtcaca ggctaacc-tccaa<  4
                                                     | |    Weave-11    | |                                                                                | |    Weave-10    | |
                                       <aacgt-gcaactca gcattgtg\/ggaagatg tggcagac-----ttggt>1 1>cattctgg-tgaccata\/tctatcct-ccgatgac<2 2<gacag-----ccgtgcca ggtagcgg\/tacactcc tgcttctg-ttcct>  4
                                   3   >ttgca-cgttgagt-cgtaacac/\ccttctac-accgtctg-----aacca-----gtaagacc actggtat/\agatagga ggctactg-----ctgtc-----ggcacggt-ccatcgcc/\atgtgagg-acgaagac<  3
                                                                                                        | |    Weave-9     | |
                                                                                                <ctaccgca gcctattc\/tgacgtgg tgcctagc-----acctt<1 1<gagaatca-ggctctca\/atctagcc-nnnnnnnn>  2
                                                                                              1 >gatggcgt-cggataag/\actgcacc-acggatcg-----tggaa-----ctcttagt ccgagagt/\tagatcgg nnnnnnnn-nnnnn<  3
                                                                                                                                                           | |    Weave-8     | |
                                                                                /tt-gg-ttcct> 1 >gagcgagt-ccatatca\/tacttagg-acgactgg<2 2<tcttg-----gctgaagg actattgt\/tttgtagt nnnnnnnn-nnnnn>  3
                                                                                \tt-cc-aggaa-----ctcgctca ggtatagt/\atgaatcc tgctgacc-----agaac-----cgacttcc-tgataaca/\aaacatca-nnnnnnnn<  2
                                                                                                        | |    Weave-7     | |
                                                                                             /tt-gttcatcc tgcgacgt\/tcaacgca ggctattg-----aatgg<1 1<caaagcgg-acaacgta\/ttccatgt-nnnnnnnn>  2
                                                                                             \tt-caagtagg-acgctgca/\agttgcgt-ccgataac-----ttacc-----gtttcgcc tgttgcat/\aaggtaca nnnnnnnn-nnnnn<  3
                                                                                                                                                           | |    Weave-6     | |
                                                                                /tt-gg-taacc> 1 >gaatgagg-actgagta\/tccgctgt-cccaaatc<2 2<actca-----gctctaca ggcattag\/gttatgcc nnnnnnnn-nnnnn>  3
                                                                                \tt-cc-attgg-----cttactcc tgactcat/\aggcgaca gggtttag-----tgagt-----cgagatgt-ccgtaatc/\caatacgg-nnnnnnnn<  2
                                                                                                        | |    Weave-5     | |
                                                                                             /tt-ctagaaca ggaaacgc\/tagatgcc tgaagacg-----tggtt<1 1<gtcggtca-ggctcgtc\/acgacacc-nnnnnnnn>  2
                                                                                             \tt-gatcttgt-cctttgcg/\atctacgg-acttctgc-----accaa-----cagccagt ccgagcag/\tgctgtgg nnnnnnnn-nnnnn<  3
                                                                                                                                                           | |    Weave-4     | |
                                                                                /tt-gg-ttcct> 1 >cagagtgg-acgaaagc\/agtgccgt-ccgatgtc<2 2<ttctc-----gaggatgg acgcttag\/tctgtagt nnnnnnnn-nnnnn>  3
                                                                                \tt-cc-aagga-----gtctcacc tgctttcg/\tcacggca ggctacag-----aagag-----ctcctacc-tgcgaatc/\agacatca-nnnnnnnn<  2
                                                                                                        | |    Weave-3     | |
                                                                                             /tt-caaacgca ggaacctg\/tatgaacc tgctcacc-----tcgta<1 1<ccgttagg-acattgca\/cggcttgt-nnnnnnn>  2
                                                                                             \tt-gtttgcgt-ccttggac/\atacttgg-acgagttg-----agcat-----ggcaatcc tgtaacgt/\gccgaaca nnnnnnn-nnnnn<  3
                                                                                                                                                           | |    Weave-2     | |
                                                                                /tt-gg-aatcg> 1 >gatgatgt-ccttgtaa\/tgaagcgg-acaacgag<2 2<cgatt-----cgccaaca ggttgaat\/ccagatcc nnnnnnnn>  3
                                                                                \tt-cc-ttagc-----ctactaca ggaacatt/\acttcgcc tgttgctc-----gctaa-----gcggttgt-ccaactta/\ggtctagg-nnnnnnnn<  2
                                                                                                        | |    Weave-1     | |
                                                                                             /tt-gaacgacc tgattgcg\/taatctca ggcattcg-----cacta<
                                                                                             \tt-cttgctgg-actaacgc/\attagagt-ccgtaagc>
```

# References

[1] Rebecca Schulman and Erik Winfree. Synthesis of Crystals with a Programmable Kinetic Barrier to Nucleation. *P. Natl. Acad. Sci.*, 104(39):15236–15241, 2007.

[2] Paul W. K. Rothemund, Nick Papadakis, and Erik Winfree. Algorithmic Self-Assembly of DNA Sierpinski Triangles. *PLOS Biology*, 2:424–436, 2004.

[3] Nadrian C. Seeman. *De Novo* Design of Sequences for Nucleic Acid Structural Engineering. *J. Biomol. Struct. Dyn.*, 8(3):573–581, 1990.

[4] Robert M. Dirks, Milo Lin, Erik Winfree, and Niles A. Pierce. Paradigms for Computational Nucleic Acid Design. *Nucleic Acids Res.*, 32:1392, 2004.

[5] John SantaLucia, Jr., Hatim T. Allawi, and P. Ananda Seneviratne. Improved Nearest-Neighbor Parameters for Predicting DNA Duplex Stability . *Biochemistry*, 35(11):3555–3562, 1996.

[6] Ho-Lin Chen, Rebecca Schulman, Ashish Goel, and Erik Winfree. Reducing Facet Nucleation During Algorithmic Self-Assembly. *Nano Lett.*, 7(9):2912–2919, 2007.