Electronic Supplementary Material for

DNA-based Parity Generator/Checker for Error Detection through Data Transmission with Visual Readout and Output-Correction Function

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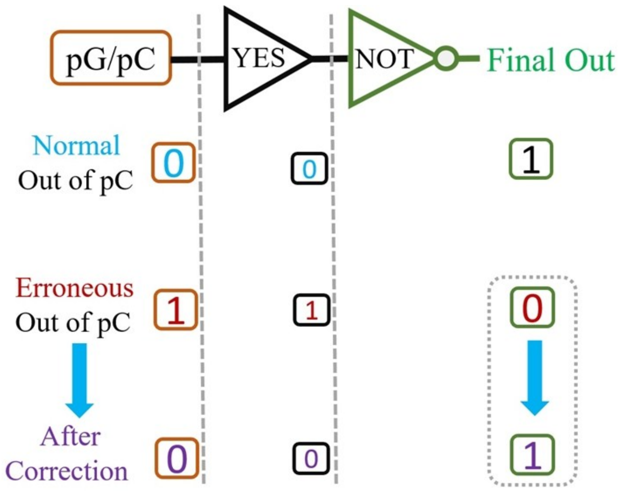
Table S1. Sequences of DNA strands used in this work. Poly-G parts are colored in red, 5T region is colored in grey and 5A region is colored in black.

Strand	Sequence (5' to 3')
TP	ATACAGTAATAG GGGTGGG ATAAGAAAGTACAA
GA	TGGGTGGG CTATTACTGTAT
CA	ATACAGTAATAG CCCA
GB	TTGTACTTTCTTAT GGGTGGGT
CB	ACCC ATAAGAAAGTACAA
GBT	TTTTT TTGTACTTTCTTAT GGGTGGGT
CAA	AAAAA ATACAGTAATAG CCCA

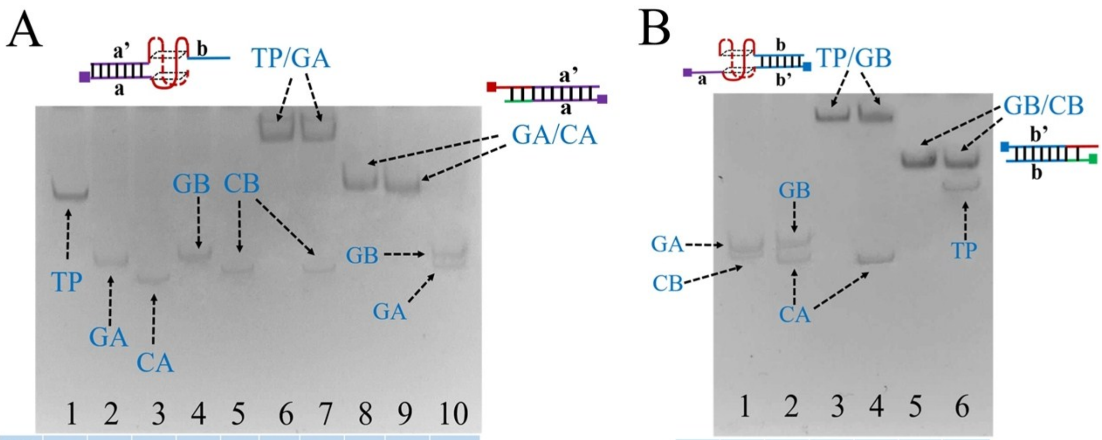


Scheme S1. Illustration for the effect of absence/presence of “Output-Correction” function of pC on the final outputs of concatenated logic circuit.

To demonstrate the effect of absence/presence of “Output-Correction” function of pC on the final outputs of concatenated logic circuit, the simple YES-NOT cascade circuit was taken as example to illustrate its different output states in the absence and presence of “Output-Correction” function of preceding pC.

As shown in **Scheme S1**, the YES-NOT cascade circuit was inserted after the pG/pC. During the normal transmission, the output of pC is “0”, then this output was used as the input of subsequent YES gate, producing the output “0”. After transmitted to the last NOT gate, the final output of the YES-NOT cascade circuit will be normal **“1”**. However, if errors occurred during data transmission, the output of pC will be “1”, after processed by the YES-NOT circuit, the final output will be opposite **“0”**, which is wrong. While, if the erroneous output “1” of the pC was corrected to “0” through “Output-Correction” function of the parity invertor, the final output after processed by the YES-NOT circuit will still be normal **“1”**.

The above YES-NOT device is a simple cascade circuit, if the pG/pC without “Output-Correction” function was cascaded into more sophisticated concatenated circuits, the final outputs of which will be changed greatly, and the regular operation will be largely destroyed. All the above indicated the necessity of the introduction of “Output-Correction” function” to pC.



	1	2	3	4	5	6	7	8	9	10
TP	+					+	+		+	
GA		+				+	+	+	+	+
CA			+					+	+	
GB				+						+
CB					+		+			

	1	2	3	4	5	6
TP			+	+		+
GA	+					
CA		+		+		
GB		+	+	+	+	+
CB	+				+	+

Figure S1. 15% PAGE analysis of the interactions between strand TP, GA, CA, GB and CB. The presence of strand was represented by "+", the formed duplexes were attached with corresponding cartoons. For **(A)**, Lane 1 (TP), Lane 2 (GA), Lane 3 (CA), Lane 4 (GB), Lane 5 (CB), Lane 6 (TP and GA), Lane 7 (TP, GA and CB), Lane 8 (GA and CA), Lane 9 (GA and CA were premixed before the addition of TP), Lane 10 (GA and GB)； For **(B)**, Lane 1 (GA and CB), Lane 2 (GB and CA), Lane 3 (TP and GB), Lane 4 (TP, GB and CA), Lane 5 (GB and CB), Lane 6 (GB and CB were premixed before the addition of TP).

As can be seen in **Figure S1 (A)**, the bands of TP, GA, CA, GB and CB appeared at different positions from Lane 1 to Lane 5, respectively. While, after the mix of TP and GA, a new band appeared in Lane 6, indicating the formation of duplex TP/GA. Besides, in the presence of TP, GA and CB, two separate bands were observed in Lane 7, one band appeared at the same position with that of duplex TP/GA and another band is CB. This phenomenon proved that CB will not influence the G4 formation between TP and GA. Lane 8 showed the formation of duplex GA/CA. While, if GA and CA were premixed before the addition of TP, a band appeared at the same position with that of GA/CA was observed in Lane 9 and TP strand (the tail of band GA/CA in Lane 9) will not influence the formation of the duplex GA/CA. Finally, the two separate bands of GA, GB appeared in Lane 10 indicated that there is no interaction between GA and GB.

Figure S1 (B) presented other interactions of the five strands. For Lane 1, the two separate bands of GA, CB indicated that there is no interaction between GA and CB. Similarly, the bands in Lane 2 proved that GB will not interact with CA, either. For Lane 3, the new band appeared in it indicated the formation of duplex TP/GB. Besides, in the presence of TP, GB and CA, two separate bands were observed in Lane 4, one band appeared at the same position with that of duplex TP/GB and another band is CA. This phenomenon proved that CA will not influence the G4 formation between TP and GB. For Lane 5, the new band appeared in it indicated the formation of duplex GB/CB. While, if GB and CB were premixed before the addition of TP, a band appeared at the same position with that of GB/CB was observed in Lane 6 and another band is strand TP, indicating that TP will not influence the formation of the duplex GB/CB.

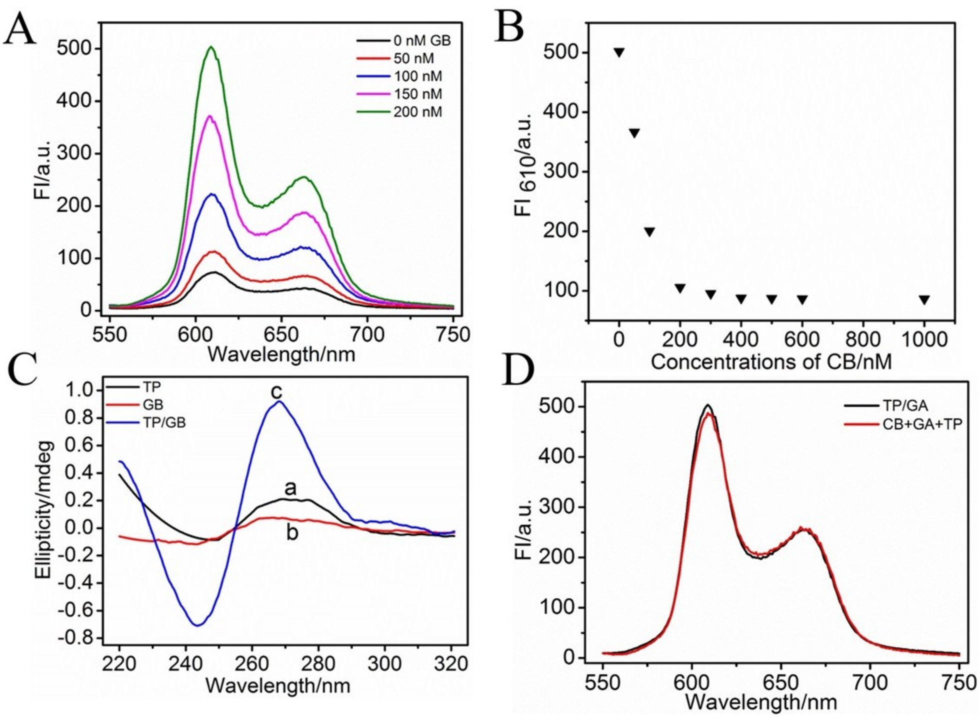


Figure S2. (A) Fluorescent spectra of NMM in the presence of 200 nM TP and different concentrations of GB (from 0 nM to 200 nM); **(B)** FI_{610} of NMM (200 nM GB was premixed with increasing concentrations of CB before the addition of 200 nM TP); **(C)** Circular dichroism spectra of TP **(a)**, GB **(b)**, TP and GB **(c)**. **(D)** Fluorescent spectra of NMM in the presence of 200 nM TP and 200 nM GA (black line), 200 nM TP, 200 nM GA and 400 nM CB (red line).

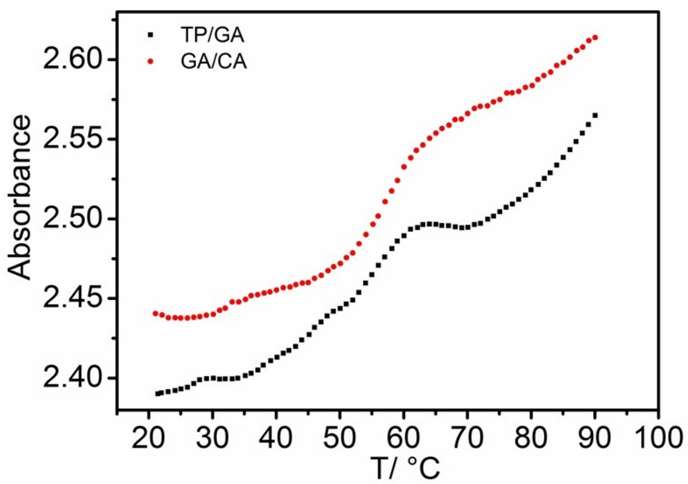


Figure S3. Thermal denaturation curves of duplex TP/GA (black line) and GA/CA (red line).

Table S2. The corresponding *Tm* values of different duplexes formed in this work.

Duplex	Tm Value(℃)	Duplex	Tm Value(℃)
TP/GA	46	GA/CA	61.7
		GA/CAA	63.3
TP/GB	54.4	GB/CB	66
TP/GBT	54.7	GBT/CB	66.2

As shown in **Table S2**, the duplexes GA/CA, GA/CAA possessed higher Tm values than TP/GA, which indicated the more stable structure of them. Analogously, GB/CB and GBT/CB are more stable than TP/GB, TP/GBT, respectively.

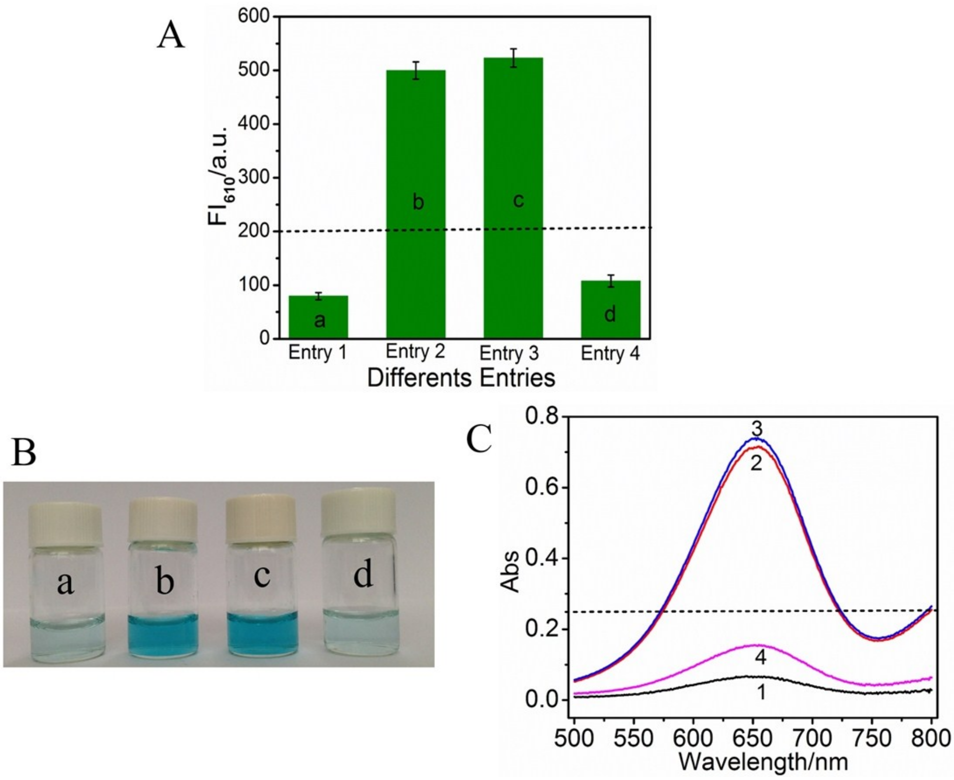
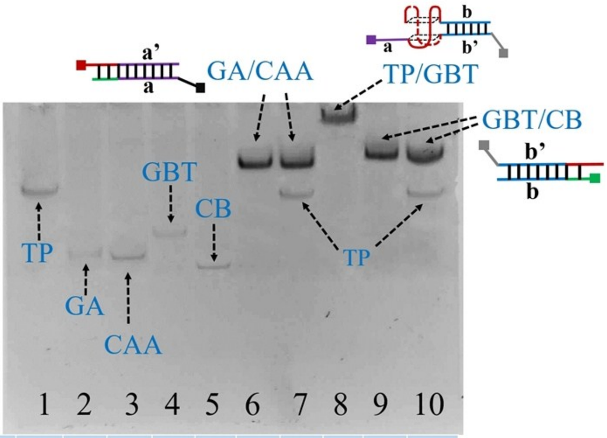


Figure S4. (A) Column bars of FI_{610} of different entries of the 2-Bit even pG (Entry 1 to Entry 4); **(B)** Photographs of all four entries of the 2-Bit even pG, Entry 1 **(a),** Entry 2 **(b),** Entry 3 **(c),** Entry 4 **(d); (C)** Corresponding absorbance spectra of all four entries in **Figure S4 (B)**.



TP	+						+	+		+
GA		+				+	+			
CAA			+			+	+			
GBT				+				+	+	+
CB					+				+	+

Figure S5. 15% PAGE analysis of the interactions of strand TP, GA, CAA, GBT, CB. The presence of strand was represented by "+", the formed duplexes were attached with corresponding cartoons. Lane 1 (TP), Lane 2 (GA), Lane 3 (CAA), Lane 4 (GBT), Lane 5 (CB), Lane 6 (GA and CAA), Lane 7 (GA and CAA were premixed before the addition of TP), Lane 8 (TP and GBT), Lane 9 (GBT and CB), Lane 10 (GBT and CB were premixed before the addition of TP).

As illustrated in **Figure S5,** CAA has similar property to that of CA, and GBT has identical property to that of GB.

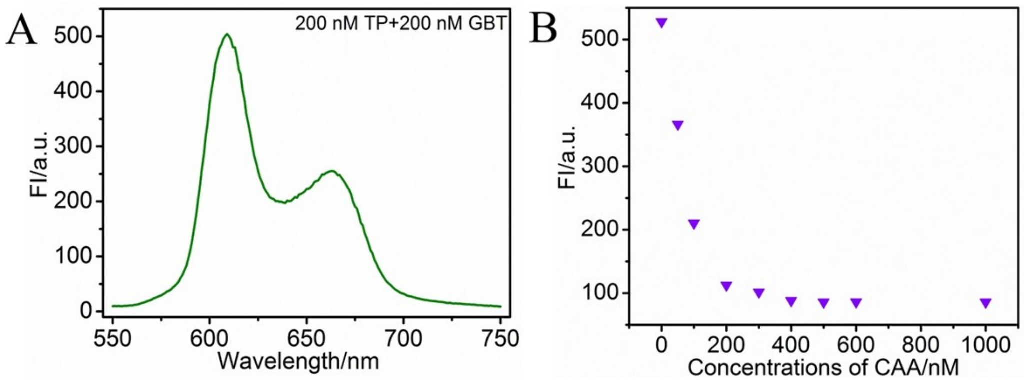


Figure S6. (A) Fluorescent spectra of NMM in the presence of 200 nM TP and 200 nM GBT; **(B)** FI_{610} of NMM (200 nM GA was premixed with increasing concentrations of CAA before the addition of 200 nM TP).

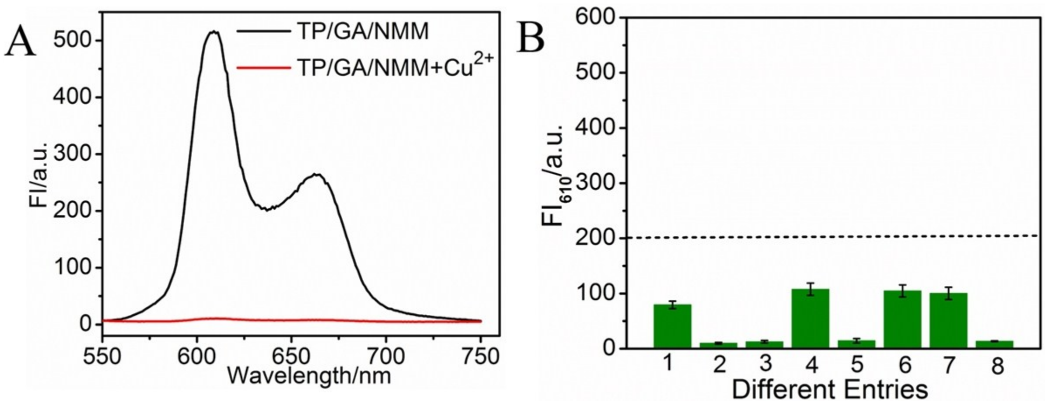


Figure S7. (A) Fluorescent spectra of NMM in the presence of 200 nM TP and 200 nM GA before (black line) and after the addition of 10 mM Cu^{2+} (red line); **(B)** Column bars of FI_{610} of all eight entries in the 3-Bit pC after corrected the erroneous entries (Entry 2, 3, 5, 8) by 10 mM Cu^{2+} .

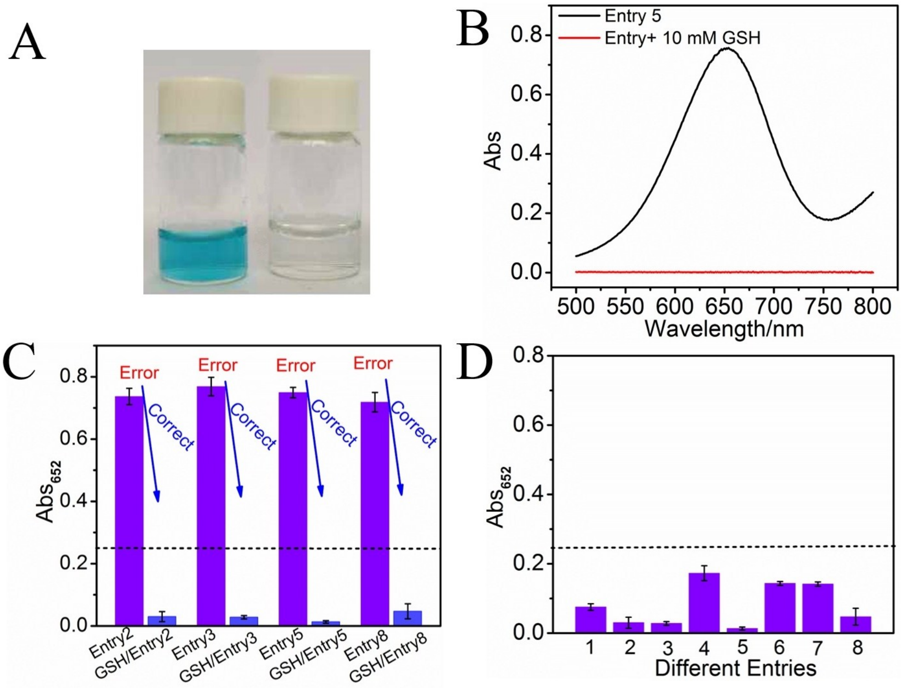
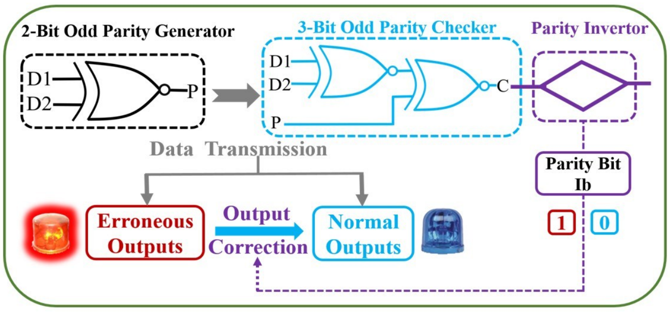


Figure S8. (A) Photographs of Entry 5 in the 3-Bit even pC before **(a)** and after **(b)** the addition of 10 mM GSH; **(B)** Corresponding absorbance spectra of **Figure S8 (A)**; **(C)** Column bars of absorbance at 652 nm of erroneous entries (Entry 2, 3, 5, 8) in the 3-Bit even pC before and after the addition of 10 mM GSH; **(D)** Column bars of absorbance at 652 nm of all eight entries in the 3-Bit even pC after corrected the erroneous entries (Entry 2, 3, 5, 8).

Equation S1: oxTMB+2GSH=TMB+GSSG+2H^+

(GSH= glutathione; GSSH= glutathione disulfide)

A



B

Entry	Inputs		Output Before Negative conversion	Output	∑[a]
	D1[b]	D2[c]		P[d]	
1	0	0	0	1	1, odd
2	0	1	1	0	1, odd
3	1	0	1	0	1, odd
4	1	1	0	1	3, odd

C

Entry	Inputs			Output Before Negative conversion	Output	∑[a]	States	Added Bit	∑[f]	Output after Correction
	D1[b]	D2[c]	P[d]		C[e]			Ib		
1	0	0	0	0	1	0, even	Error	1	1, odd	0
2	0	1	0	1	0	1, odd	Ok	0	1, odd	
3	1	0	0	1	0	1, odd	Ok	0	1, odd	
4	1	1	0	0	1	2, even	Error	1	3, odd	
5	0	0	1	1	0	1, odd	Ok	0	1, odd	
6	0	1	1	0	1	2, even	Error	1	3, odd	
7	1	0	1	0	1	2, even		1	3, odd	
8	1	1	1	1	0	3, odd	Ok	0	3, odd	

Figure S9. (A) Illustration of the 2-Bit odd pG and 3-Bit odd pC for error detection through data transmission with "Output-Correction" function (Red light represents the erroneous outputs and blue light indicates the normal outputs); **(B)** Truth table of the 2-Bit odd pG through negative logic conversion; **(C)** Truth table of the 3-Bit odd pC through negative logic conversion. ([a] Number of 1's in the D1D2P string, [b] The mixture of strand GBT and CAA, [c] The mixture of strand GB and CA, [d] The mixture of strand GA and CB, [e] FI_{610} of NMM or the color changes of TMB, [f] Number of 1's in the D1D2PIb string).

The two-input XNOR logic gate properly meets the requirements of 2-Bit odd pG. Through negative logic conversion towards the outputs of 2-Bit even pG, the 2-Bit odd pG was obtained. Analogously, the 3-Bit odd pC could also be operated.

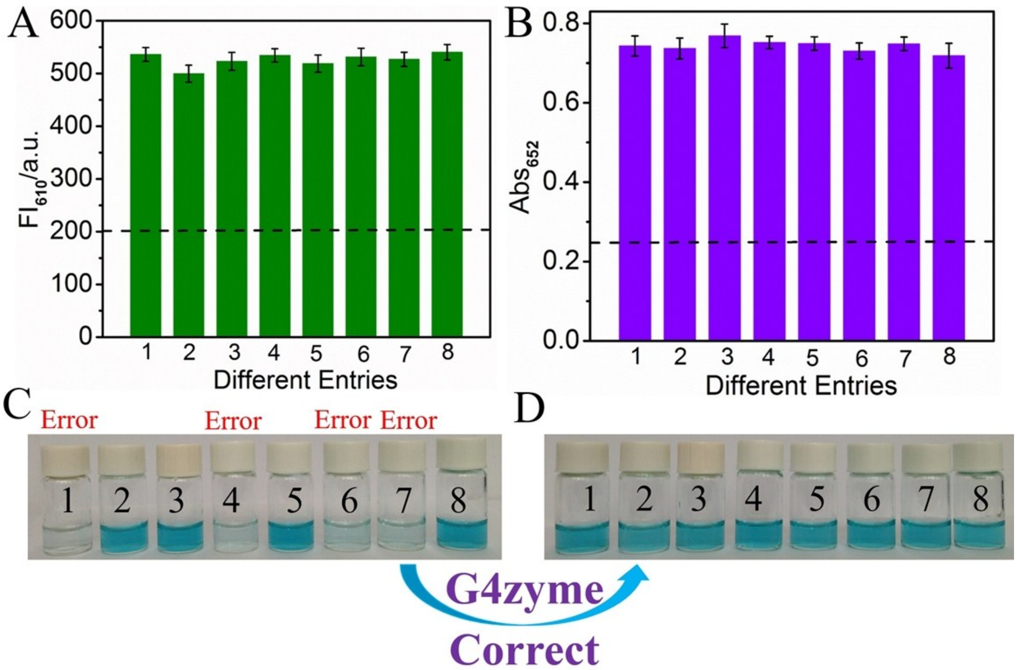


Figure S10. (A) Column bars of FI_{610} of all eight entries in the 3-Bit odd pC after corrected the erroneous entries (Entry 1, 4, 6, 7) by 200 nM T30695 strand; **(B)** Column bars of absorbance at 652 nm of all eight entries in the 3-Bit odd pC after corrected the erroneous entries (Entry 1, 4, 6, 7) by 200 nM T30695 G4zyme.

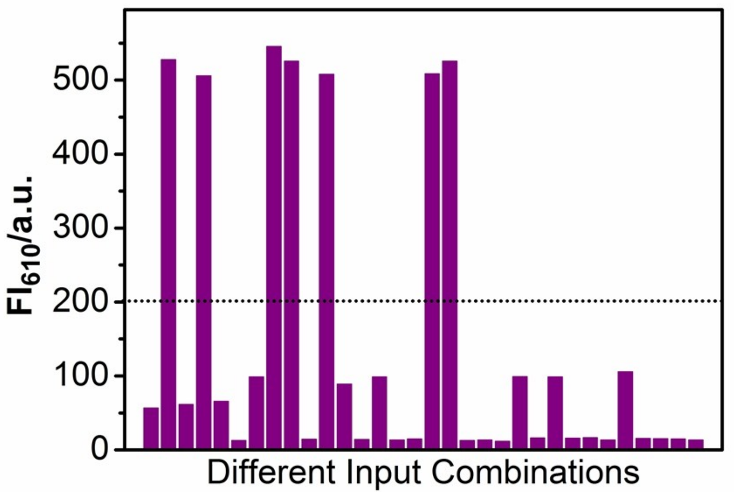


Figure S11. Column values at FI_{610} of all 32 variations of the five-input concatenated logic circuit.

Table S3. Corresponding truthtable of the five-input concatenated logic circuit with 32 input variations. (The output "1" have been colored in red)

Entry	Inputs					Output (Fluorescent/ visual)	Entry	Inputs					Output (Fluorescent/ visual)
	GA	CA	GB	CB	Cu/GSH			GA	CA	GB	CB	Cu/GSH	
1	0	0	0	0	0	0	17	1	1	1	0	0	1
2	1	0	0	0	0	1	18	1	0	1	1	0	1
3	0	1	0	0	0	0	19	1	0	1	0	1	0
4	0	0	1	0	0	1	20	1	0	0	1	1	0
5	0	0	0	1	0	0	21	1	0	1	0	1	0
6	0	0	0	0	1	0	22	1	1	0	1	0	0
7	1	1	0	0	0	0	23	1	1	0	0	1	0
8	1	0	1	0	0	1	24	0	1	1	1	0	0
9	1	0	0	1	0	1	25	0	1	0	1	1	0
10	1	0	0	0	1	0	26	0	1	1	0	1	0
11	0	1	1	0	0	1	27	0	0	1	1	1	0
12	0	1	0	1	0	0	28	1	1	1	1	0	0
13	0	1	0	0	1	0	29	1	0	1	1	1	0
14	0	0	1	1	0	0	30	1	1	0	1	1	0
15	0	0	1	0	1	0	31	1	1	1	0	1	0
16	0	0	0	1	1	0	32	1	1	1	1	1	0