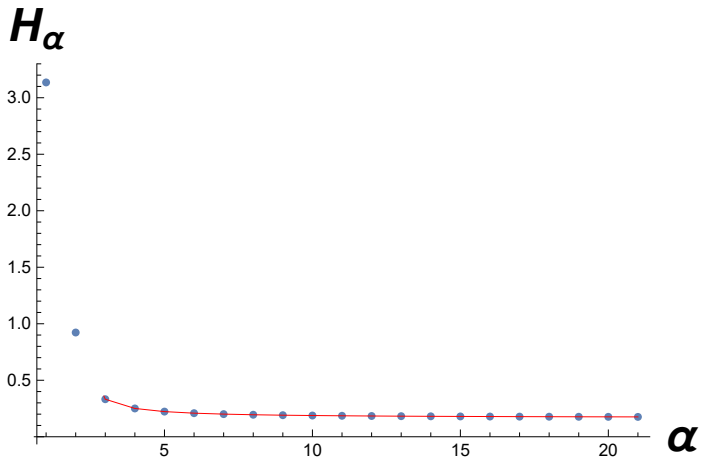
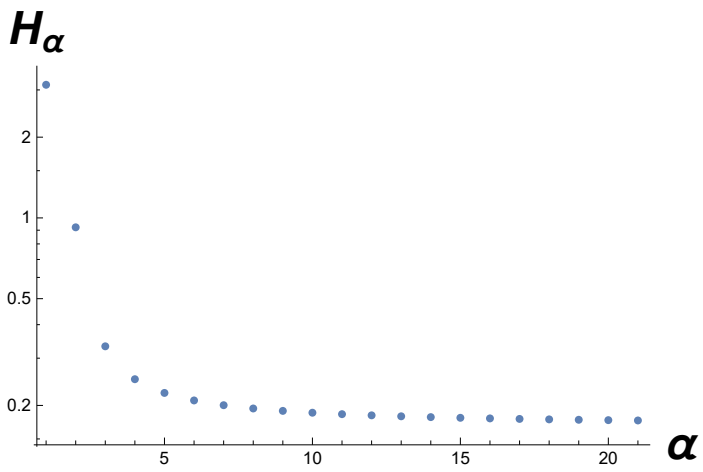
```
For[npow = 1, npow < 1000, npow++, If[Length[M] < (2^(npow)), Break[]];
  FilledSize = 2^(npow + 1)];
Filler[vecvar1_] := Table[4, {i, 1, FilledSize - lengthofgeneitself}]
FilledVec[vecvar2_] := Join[Flatten[vecvar2], Filler[vecvar2]]

Filler[vecvar4_] := Table[4, {i, 1, FilledSize - lengthofgeneitself}]
FilledVec[vecvar5_] := Join[Flatten[vecvar5], Filler[vecvar5]]
For[npow = 1, npow < 1000, npow++, If[lengthofgeneitself ≤ (2^npow), Break[]]];
(* gives npow such that  2^npow > lengthofgeneitself > 2^(npow -1) *)
FilledSize = 2^npow;
FilledM = FilledVec[M];
numrowsW = √Length[FilledM] ;

W = Table[Table[FilledM[[i]],
    {i, (((j - 1) * (numrowsW)) + 1), (j * (numrowsW))}], {j, 1, numrowsW}];

ρ = (W.Transpose[W]); (* ρ as inner product *)
rhoEigens = Sort[DeleteCases[Eigenvalues[ρ] // N, 0.], Greater];
(*DeleteCases Removes 0's from the set of Eigenvalues,
Sort puts the list in order of greatest to least *)
set = rhoEigens / Total[rhoEigens];
(* This is the set of nonzero normalized eigenvalues in order of greatest to least *)
n = Length[set];
H[α_] := 1/(1 - α) Log[2, Sum[(set[[i]])^α, {i, 1, n}]] // N
H0 = Log[n] // N ;(* H₀ = Hartley Entropy*)
H1 = -Sum[((set[[i]])) (Log[2, set[[i]]])), {i, 1, n}] // N; (* H₁ = Shannon Entropy*)
H2onward = Table[H[a], {a, 2, 20}] // N ;(* H₂ onward *)
RenyiEntropyofEigenvalues = Join[{H0}, {H1}, H2onward];

Print[Graphics[Show[
   ListPlot[RenyiEntropyofEigenvalues, PlotRange → All,
    AxesLabel → {Style["α", Large, Bold], Style["Hα", Large, Bold]}],
   ListLinePlot[RenyiEntropyofEigenvalues, PlotStyle → {Red, Thin}]
  ]]]
```

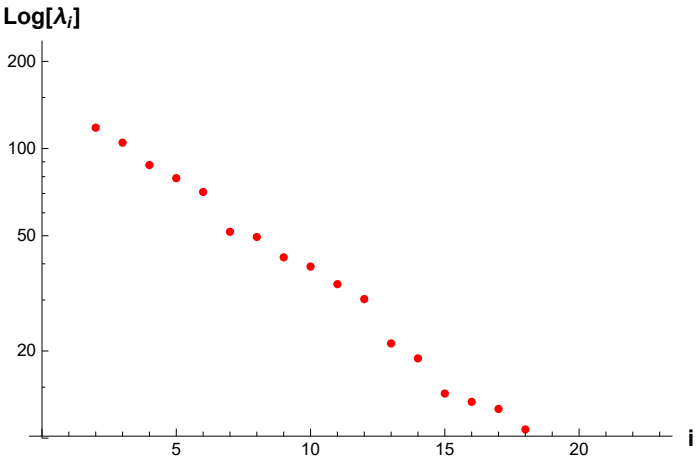


```
Print[Graphics[ListLogPlot[Table[{i, rhoEigens[[i]]}, {i, 2, Length[rhoEigens]}],
   AxesLabel → {Style["i", Medium, Bold], Style["Log[λi]", Medium, Bold]},
   PlotRange → {{10, 2 * rhoEigens[[2]]}}, PlotStyle → Red,
   PlotLabel → Style["Logplot of Eigenvalues, excluding λ1", Red, Bold, 16]] ]]

Print[Graphics[Show[
   ListPlot[RenyiEntropyofEigenvalues, PlotRange → All,
    AxesLabel → {Style["α", Large, Bold], Style["Hα", Large, Bold]}],
   ListLinePlot[RenyiEntropyofEigenvalues, PlotStyle → {Red, Thin}]
  ]]]

ListLogPlot[RenyiEntropyofEigenvalues, PlotRange → All,
 AxesLabel → {Style["α", Large, Bold], Style["Hα", Large, Bold]}]
```

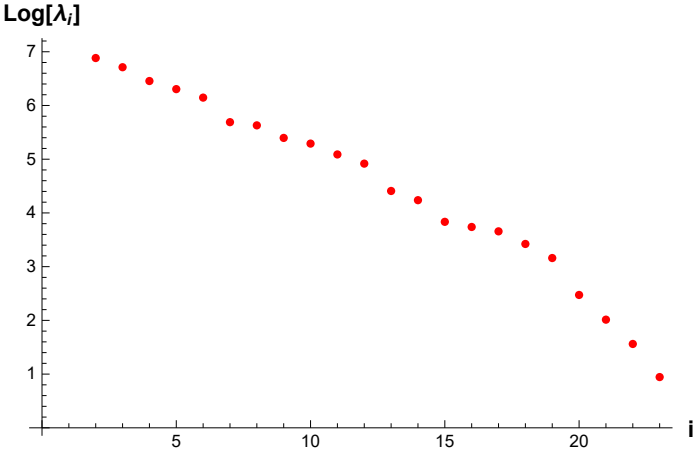



```
Print[Graphics[ListLogPlot[Table[{i, rhoEigens[[i]]}, {i, 2, Length[rhoEigens]}],
   AxesLabel → {Style["i", Medium, Bold], Style["Log[λi]", Medium, Bold]},
   PlotRange → {{10, 2 * rhoEigens[[2]]}}, PlotStyle → Red,
   PlotLabel → Style["Logplot of Eigenvalues, excluding λ1", Red, Bold, 16]] ]]
Print[Graphics[ListPlot[Table[{i, Log[2, rhoEigens[[i]]]}, {i, 2, Length[rhoEigens]}],
   AxesLabel → {Style["i", Medium, Bold], Style["Log[λi]", Medium, Bold]}, PlotStyle → Red,
   PlotLabel → Style["Log2plot of Eigenvalues, excluding λ1", Red, Bold, 16]] ]]
```

Logplot of Eigenvalues, excluding λ_1



Log_2plot of Eigenvalues, excluding λ_1




```
Log[2, 1024]
```

```
10
```

```
For[npow = 1, npow < 1000, npow++, If[Length[M] < (2^(npow)), Break[]];
  FilledSize = 2^(npow + 1)];
Filler[vecvar1_] := Table[4, {i, 1, FilledSize - lengthofgeneitself}]
FilledVec[vecvar2_] := Join[Flatten[vecvar2], Filler[vecvar2]]

Filler[vecvar4_] := Table[4, {i, 1, FilledSize - lengthofgeneitself}]
FilledVec[vecvar5_] := Join[Flatten[vecvar5], Filler[vecvar5]]
For[npow = 1, npow < 1000, npow++, If[lengthofgeneitself ≤ (2^npow), Break[]]];
(* gives npow such that  2^npow > lengthofgeneitself > 2^(npow -1) *)
FilledSize = 2^npow;
FilledM = FilledVec[M];
numrowsW = √Length[FilledM] ;

W = Table[Table[FilledM[[i]],
    {i, (((j - 1) * (numrowsW)) + 1), (j * (numrowsW))}], {j, 1, numrowsW}];

ρ = (W.Transpose[W]); (* ρ as inner product *)
rhoEigens = Sort[DeleteCases[Eigenvalues[ρ] // N, 0.], Greater];
(*DeleteCases Removes 0's from the set of Eigenvalues,
Sort puts the list in order of greatest to least *)
set = rhoEigens / Total[rhoEigens];
(* This is the set of nonzero normalized eigenvalues in order of greatest to least *)
n = Length[set];
H[α_] := 1/(1 - α) Log[2, Sum[(set[[i]])^α, {i, 1, n}]] // N
H0 = Log[n] // N ;(* H₀ = Hartley Entropy*)
H1 = -Sum[((set[[i]])) (Log[2, set[[i]]])), {i, 1, n}] // N; (* H₁ = Shannon Entropy*)
H2onward = Table[H[a], {a, 2, 20}] // N ;(* H₂ onward *)
RenyiEntropyofEigenvalues = Join[{H0}, {H1}, H2onward];

RenyiEntropyofEigenvalues
```

```
{4.81218, 3.02888, 1.19163, 0.898593, 0.798784, 0.74886, 0.718906,
 0.698936, 0.684672, 0.673974, 0.665653, 0.658997, 0.653551, 0.649012,
 0.645172, 0.64188, 0.639027, 0.636531, 0.634329, 0.632371, 0.630619}
```

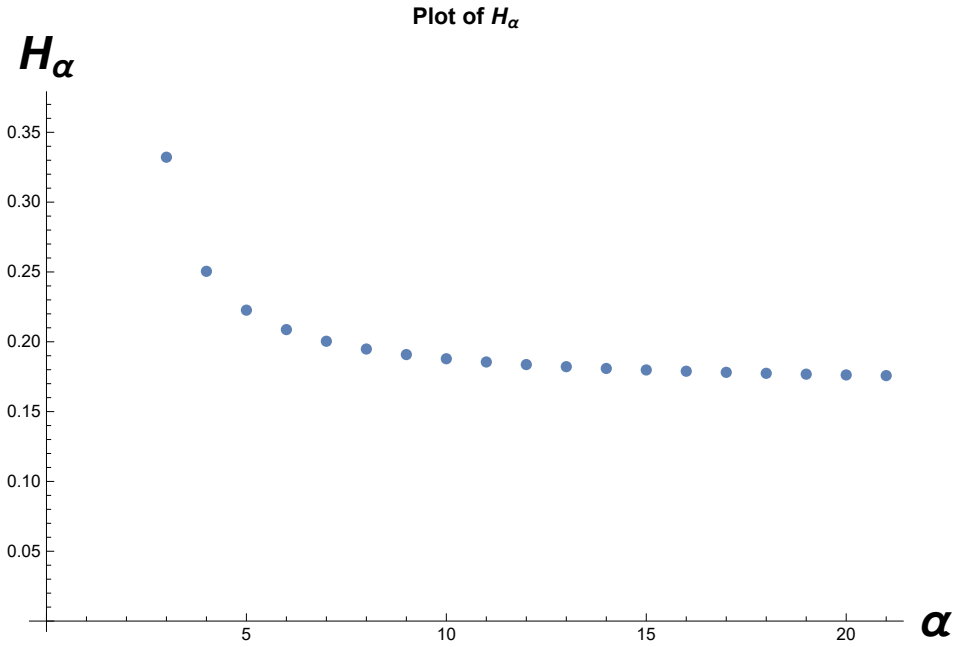
Data

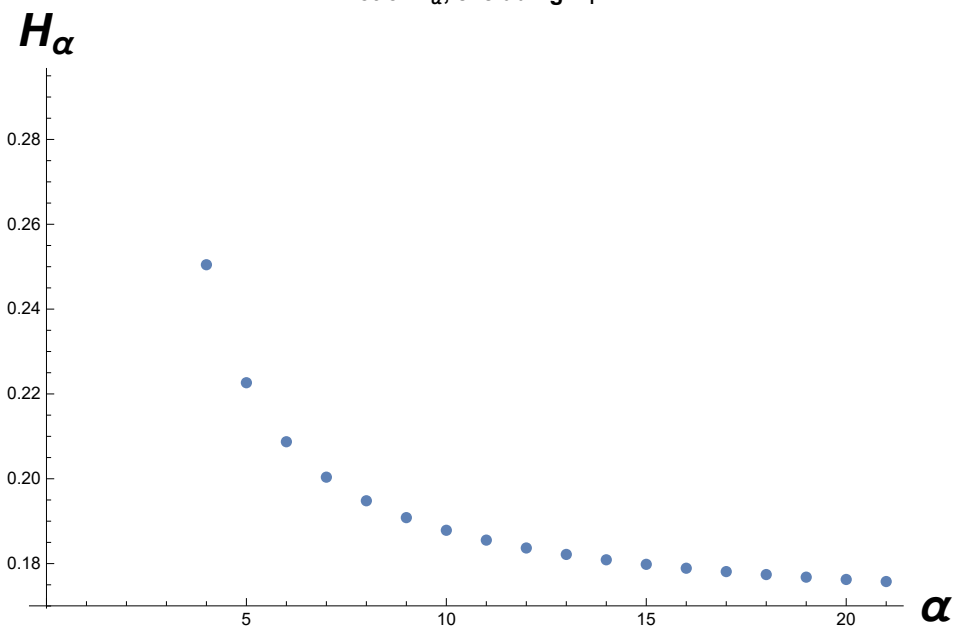
```
PCV1KP3373491RenyiEntropyofEigenvalues =
  {3.1354942159291497`, 0.9224876815068266`, 0.3321644424748865`, 0.2504622262433977`,
   0.2226432523739165`, 0.2087281509895171`, 0.20037902613420414`, 0.19481294208998814`,
   0.1908371677618248`, 0.18785533701554916`, 0.18553613532399918`, 0.18368077397075921`,
   0.18216275104538102`, 0.1808977319408992`, 0.17982733116018382`,
   0.17890984477671348`, 0.17811468991103924`, 0.17741892940357426`,
   0.17680502307345808`, 0.17625932855779922`, 0.1757710755701045`};
Print["For ", "PCV1 Genbank:KP337349.1"]

Table[{i, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]},
  {i, 2, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}];
```

```
Table[{i, Log[PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 2, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}];
Table[{Log[i], Log[PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 2, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}];

Print["Values of Hα   ", PCV1KP3373491RenyiEntropyofEigenvalues]
ListPlot[Table[{i, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]},
  {i, 1, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Hα", Large, Bold]},
 PlotLabel → Style["Plot of Hα", Black, Bold, 12]]
ListPlot[Table[{i, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]},
  {i, 2, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Hα", Large, Bold]},
 PlotLabel → Style["Plot of Hα, excluding H1", Black, Bold, 12]]

Print["Values of Log2[Hα]   ", Log[PCV1KP3373491RenyiEntropyofEigenvalues]]
ListPlot[Table[{i, Log[2, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 1, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log2[Hα]", Large, Bold]},
 PlotLabel → Style["Plot of Log2[Hα]", Black, Bold, 12]]
ListPlot[Table[{i, Log[2, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 1, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log2[Hα]", Large, Bold]},
 PlotLabel → Style["Plot of Log2[Hα]", Black, Bold, 12]]

ListPlot[Table[{i, Log[2, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 2, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log2[Hα]", Large, Bold]},
 PlotLabel → Style["Logplot of Hα, excluding H1", Black, Bold, 12]]
ListPlot[Table[{i, Log[2, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 3, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log2[Hα]", Large, Bold]},
 PlotLabel → Style["Logplot of Hα, excluding H1,H2", Black, Bold, 12]]
ListPlot[Table[{i, Log[2, PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i, 4, Length[PCV1KP3373491RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log2[Hα]", Large, Bold]},
 PlotLabel → Style["Logplot of Hα, excluding H1,H2,H3", Black, Bold, 12]]


(*ListPlot[Table[{Log[2,i],Log[2,PCV1KP3373491RenyiEntropyofEigenvalues[[i]]]},
  {i,1,Length[PCV1KP3373491RenyiEntropyofEigenvalues]}]]*)
```

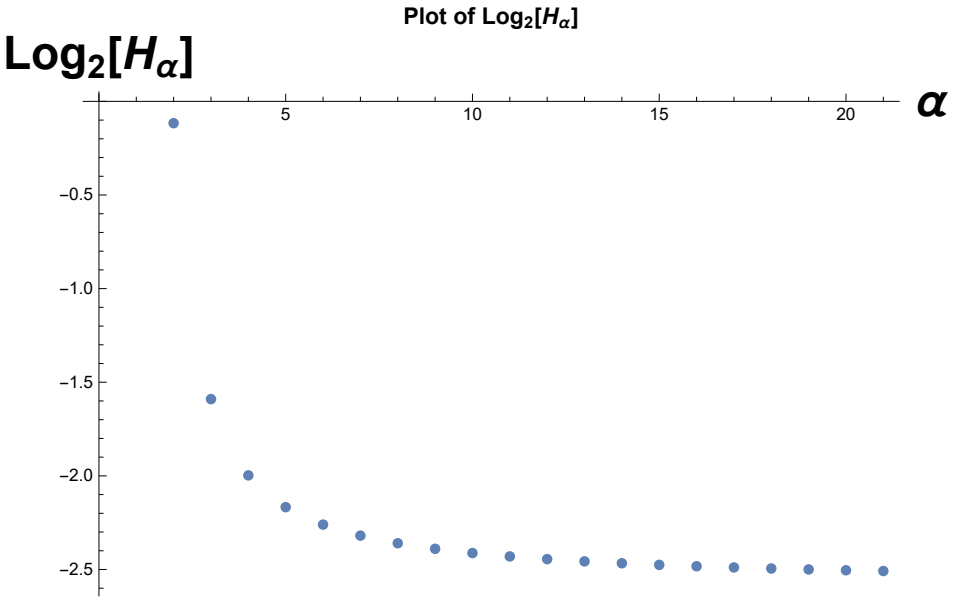
For PCV1 Genbank:KP337349.1

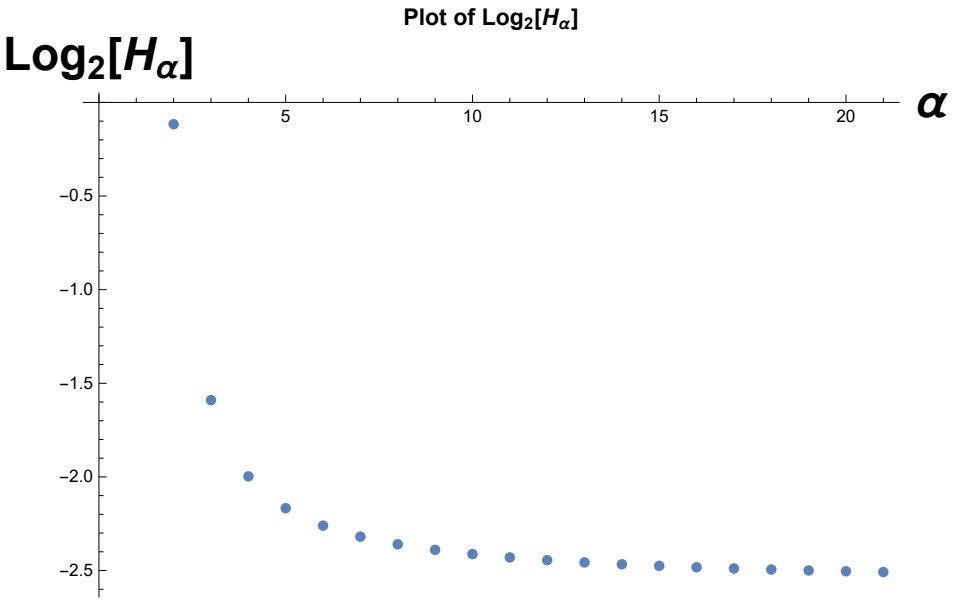
```
Values of Hα   {3.13549, 0.922488, 0.332164, 0.250462, 0.222643,
  0.208728, 0.200379, 0.194813, 0.190837, 0.187855, 0.185536, 0.183681, 0.182163,
  0.180898, 0.179827, 0.17891, 0.178115, 0.177419, 0.176805, 0.176259, 0.175771}
```

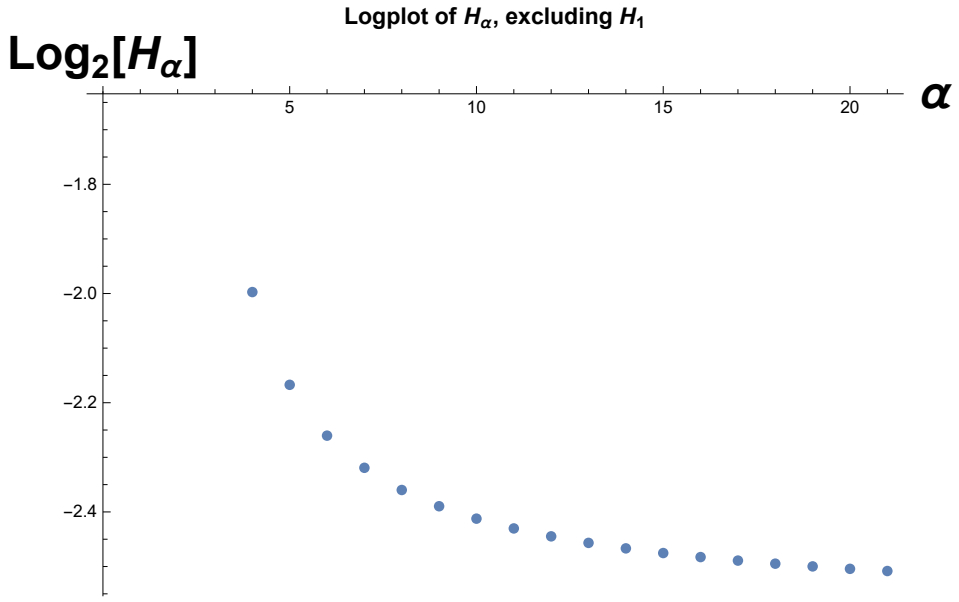


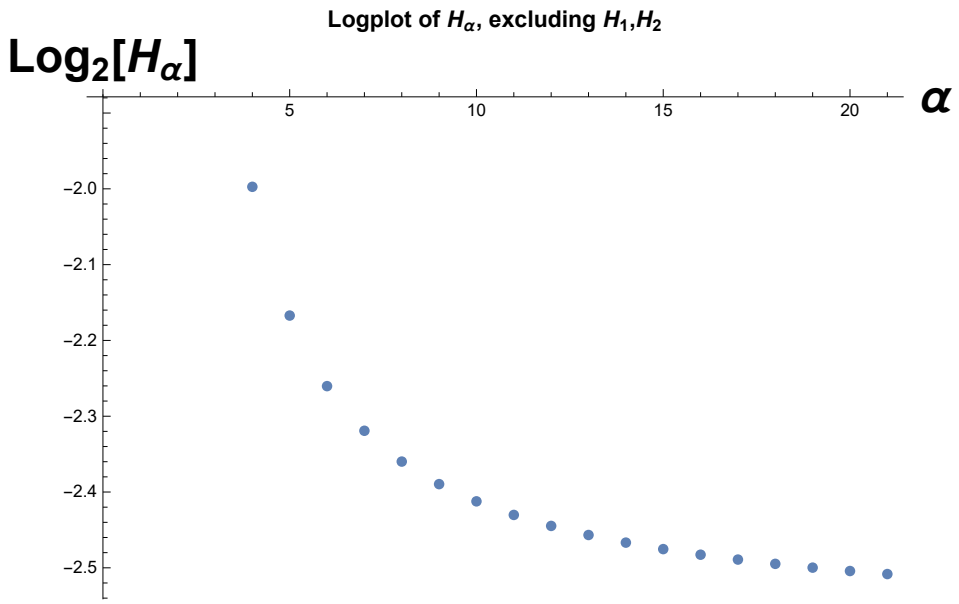


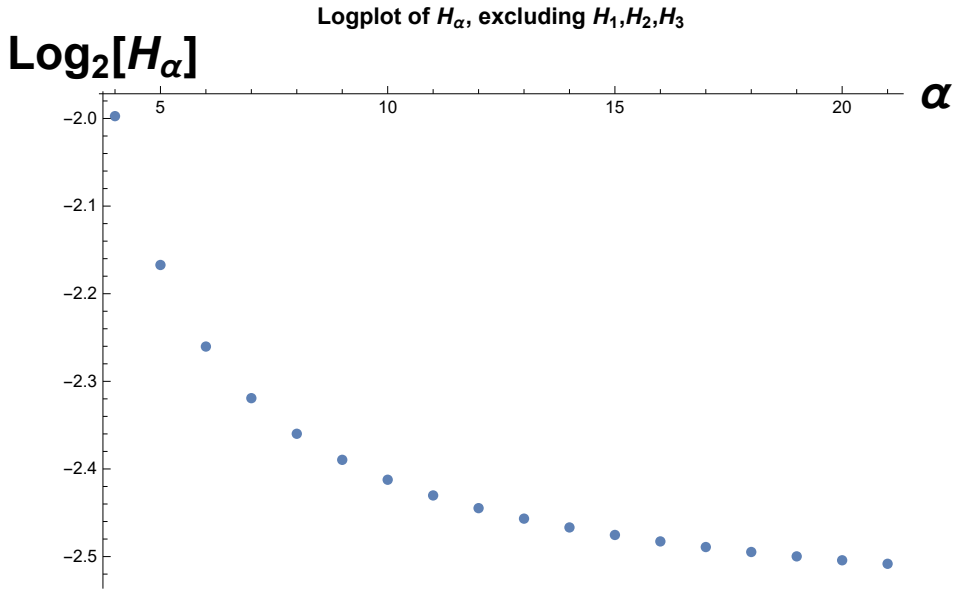
Values of $\text{Log}_2[H_\alpha]$ {1.14279, -0.0806813, -1.10213, -1.38445, -1.50218, -1.56672, -1.60754, -1.63572, -1.65633, -1.67208, -1.68451, -1.69456, -1.70285, -1.70982, -1.71576, -1.72087, -1.72533, -1.72924, -1.73271, -1.7358, -1.73857}


Plot of Log2[Hα]
Log2[Hα]
α
5
10
15
20
−0.5
−1.0
−1.5
−2.0
−2.5


Plot of Log2[Hα]
Log2[Hα]
α
5
10
15
20
−0.5
−1.0
−1.5
−2.0
−2.5


Logplot of H_α, excluding H_1
$\mathrm{Log}_2[H_\alpha]$
α
5
10
15
20
−1.8
−2.0
−2.2
−2.4

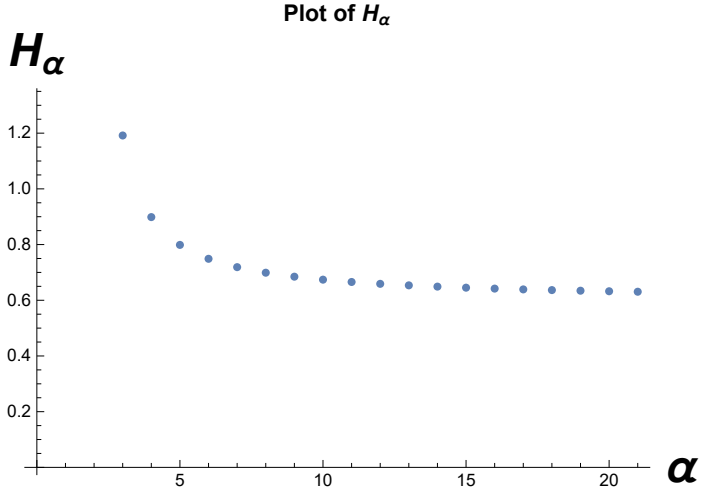

Logplot of H_α, excluding H_1,H_2
$\mathrm{Log}_2[H_\alpha]$
α
5
10
15
20
−2.0
−2.1
−2.2
−2.3
−2.4
−2.5


Logplot of H_α, excluding H_1,H_2,H_3
$\mathrm{Log}_2[H_\alpha]$
α
5
10
15
20
−2.0
−2.1
−2.2
−2.3
−2.4
−2.5

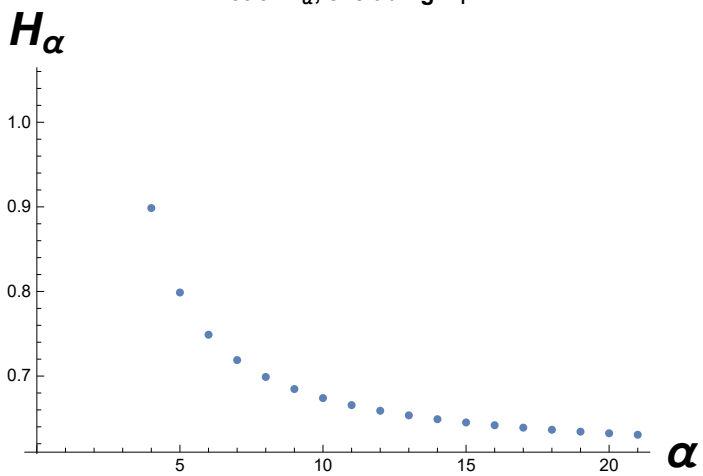
```
HumanMitoChonDQ1129612RenyiEntropyofEigenvalues =
  {4.812184355372417`, 3.028884662199708`, 1.1916259910182405`, 0.8985929912796556`,
   0.7987837436451032`, 0.7488601080689298`, 0.7189057081568627`,
   0.6989361052172268`, 0.6846721030709843`, 0.6739741014605183`,
   0.6656534335412528`, 0.6589968992058404`, 0.6535506438405028`, 0.6490120977027216`,
   0.6451717894322913`, 0.6418800966290653`, 0.6390272961996027`, 0.6365310958238231`,
   0.634328566080488`, 0.6323707618641902`, 0.6306190423022395`};
Print["For ", "HumanMitoChondrial Genbank:DQ112961.2"]

Table[{i, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]},
  {i, 2, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}];
Table[{i, Log[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]]},
  {i, 2, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}];
Table[{Log[i], Log[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]]},
  {i, 2, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}];

Print["Values of H_α   ", HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]
ListPlot[Table[{i, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]},
  {i, 1, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["H_α", Large, Bold]},
 PlotLabel → Style["Plot of H_α", Black, Bold, 12]]
ListPlot[Table[{i, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]},
  {i, 2, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["H_α", Large, Bold]},
 PlotLabel → Style["Plot of H_α, excluding H_1", Black, Bold, 12]]

Print["Values of Log_2[H_α]   ", Log[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]]
ListPlot[Table[{i, Log[2, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]]},
  {i, 1, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log_2[H_α]", Large, Bold]},
 PlotLabel → Style["Plot of Log_2[H_α]", Black, Bold, 12]]

ListPlot[Table[{i, Log[2, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]]},
  {i, 2, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log_2[H_α]", Large, Bold]},
 PlotLabel → Style["Logplot of H_α, excluding H_1", Black, Bold, 12]]
ListPlot[Table[{i, Log[2, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]]},
  {i, 3, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log_2[H_α]", Large, Bold]},
 PlotLabel → Style["Logplot of H_α, excluding H_1,H_2", Black, Bold, 12]]
ListPlot[Table[{i, Log[2, HumanMitoChonDQ1129612RenyiEntropyofEigenvalues[[i]]]},
  {i, 4, Length[HumanMitoChonDQ1129612RenyiEntropyofEigenvalues]}],
 AxesLabel → {Style["α", Large, Bold], Style["Log_2[H_α]", Large, Bold]},
 PlotLabel → Style["Logplot of H_α, excluding H_1,H_2,H_3", Black, Bold, 12]]
```

```
For HumanMitoChondrial Genbank:DQ112961.2

Values of H_α   {4.81218, 3.02888, 1.19163, 0.898593, 0.798784,
  0.74886, 0.718906, 0.698936, 0.684672, 0.673974, 0.665653, 0.658997, 0.653551,
  0.649012, 0.645172, 0.64188, 0.639027, 0.636531, 0.634329, 0.632371, 0.630619}
```

Plot of H_α

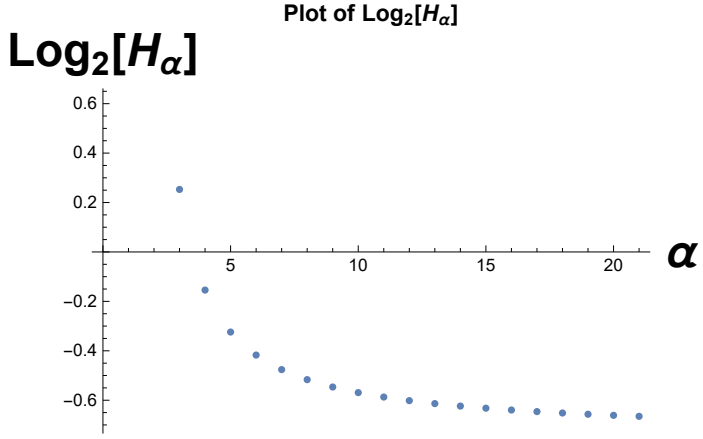


Plot of H_α, excluding H_1

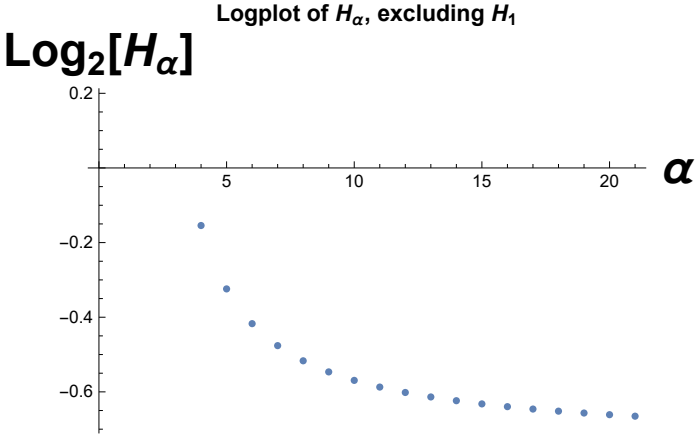



```
Values of Log2[Hα]   {1.57115, 1.10819, 0.175319, -0.106925, -0.224665, -0.289203,
  -0.330025, -0.358196, -0.378815, -0.394564, -0.406986, -0.417036, -0.425335, -0.432304,
  -0.438239, -0.443354, -0.447808, -0.451722, -0.455188, -0.458279, -0.461053}
```

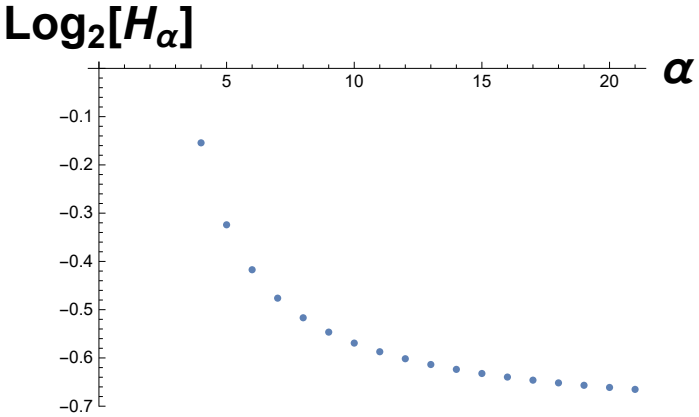
Plot of $\mathrm{Log}_2[H_\alpha]$



Logplot of H_α, excluding H_1



Logplot of H_α, excluding H_1,H_2



Logplot of H_α, excluding H_1,H_2,H_3