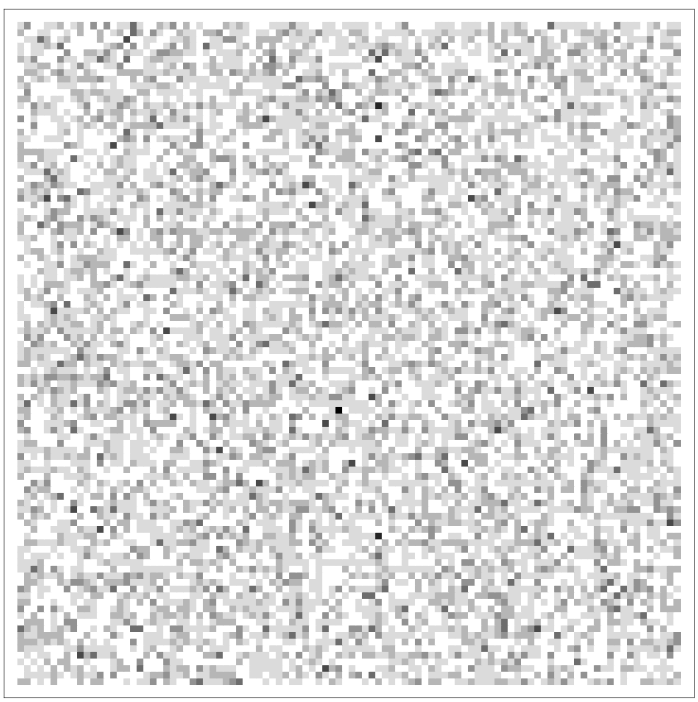
# 360 HW 21

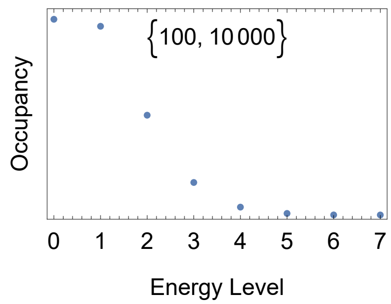
## Problem 1

In[40]:=
```
size = 100;
grid = ConstantArray[1, {size, size}];
gridmove[] := Module[{xA, yA, xB, yB},
   xA = RandomInteger[{1, size}];
   yA = RandomInteger[{1, size}];
   xB = RandomInteger[{1, size}];
   yB = RandomInteger[{1, size}];
   If[grid[[xA, yA]] > 0, grid[[xB, yB]] = grid[[xB, yB]] + 1, grid[[xB, yB]]];
   If[grid[[xA, yA]] > 0, grid[[xA, yA]] = grid[[xA, yA]] - 1 , grid[[xA, yA]]];
  ]
movenum = 10^4;
Do[gridmove[], movenum]
ArrayPlot[grid]
boltzman = Sort[Tally[Flatten[grid]]];
ListPlot[boltzman, PlotRange → All, Frame -> True, PlotStyle → PointSize[0.02],
 BaseStyle → {FontSize → 12}, FrameLabel → {"Energy Level", "Occupancy"},
 ImageSize → 200, FrameTicks → {Automatic, None},
 Epilog -> Inset[{Text[size], Text[movenum]}, Scaled[{0.5, 0.85}]]]
```

Out[45]=



Out[47]=

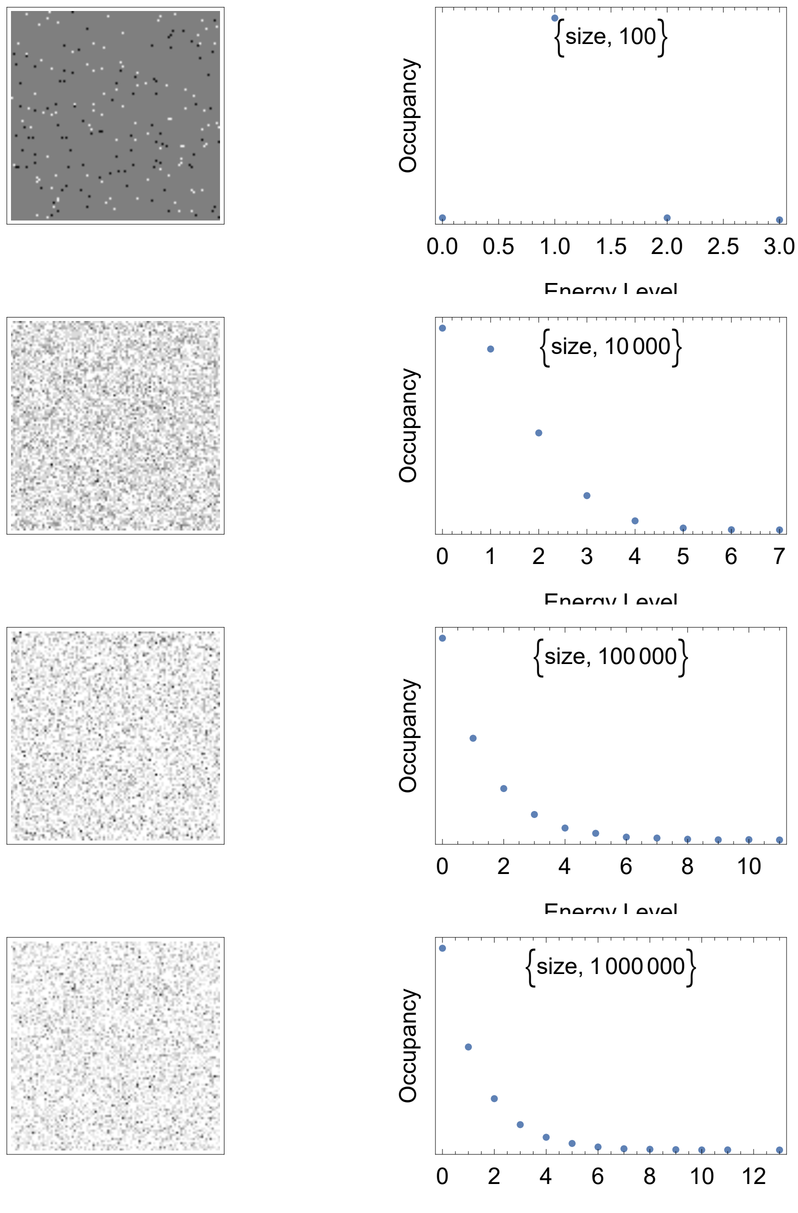


# Problem 2

## Part A

In[5]:=
```
sizearray = 100;
gridarray = ConstantArray[1, {sizearray, sizearray}];
gridmovearrayplot[] := Module[{xA, yA, xB, yB},
  xA = RandomInteger[{1, sizearray}];
  yA = RandomInteger[{1, sizearray}];
  xB = RandomInteger[{1, sizearray}];
  yB = RandomInteger[{1, sizearray}];
  If[gridarray[[xA, yA]] > 0,
   gridarray[[xB, yB]] = gridarray[[xB, yB]] + 1, gridarray[[xB, yB]]];
  If[gridarray[[xA, yA]] > 0, gridarray[[xA, yA]] = gridarray[[xA, yA]] - 1 ,
   gridarray[[xA, yA]]];
 ]
dogridmovearrayplot[g_] := Module[{movenumarray},
  movenumarray = 10^g;
  Do[gridmovearrayplot[], movenumarray];
  boltzman = Sort[Tally[Flatten[gridarray]]];
  ArrayPlot[gridarray]
 ]
sizelist = 100;
gridlist = ConstantArray[1, {sizelist, sizelist}];
gridmovelistplot[] := Module[{xA, yA, xB, yB},
  xA = RandomInteger[{1, sizelist}];
  yA = RandomInteger[{1, sizelist}];
  xB = RandomInteger[{1, sizelist}];
  yB = RandomInteger[{1, sizelist}];
  If[gridlist[[xA, yA]] > 0,
   gridlist[[xB, yB]] = gridlist[[xB, yB]] + 1, gridlist[[xB, yB]]];
  If[gridlist[[xA, yA]] > 0, gridlist[[xA, yA]] = gridlist[[xA, yA]] - 1 ,
   gridlist[[xA, yA]]];
 ]
dogridmovelistplot[g_] := Module[{movenum},
  movenum = 10^g;
  Do[gridmovelistplot[], movenum];
  boltzman = Sort[Tally[Flatten[gridlist]]];
  ListPlot[boltzman, PlotRange → All, Frame -> True, PlotStyle → PointSize[0.02],
   BaseStyle → {FontSize → 12}, FrameLabel → {"Energy Level", "Occupancy"},
   ImageSize → 200, FrameTicks → {Automatic, None},
   Epilog -> Inset[{Text[size], Text[movenum]}, Scaled[{0.5, 0.85}]]]
 ]
g = {0, 0, 0, 0, 0, 0};
e = {0, 0, 0, 0, 0, 0};
i = 2; While[i < 7, g[[i]] = dogridmovearrayplot[i]; i++]
i = 2; While[i < 7, e[[i]] = dogridmovelistplot[i]; i++]
GraphicsGrid[{{g[[2]], e[[2]]}, {g[[4]], e[[4]]},
  {g[[5]], e[[5]]}, {g[[6]], e[[6]]}}, ImageSize → 500]
```

Out[17]=




## Part B

The probability distribution gets closer and closer to looking like an exponential graph as movenum increases. I find it interesting that there is such a great number of values of 1. The appearance of the plots stop changing at about 10^5 movenum.

## Part C

This occurs because the microstates of the same Boltzman macrostates have the same internal energy. This is what it means to be in contact with a thermal reservoir in statistical mechanics. However, the microstates are not all equally probable, but they are referred to as a canonical ensemble.

# Problem 3

## Part A

In[18]:=
```
dogridmovelist[g_] := Module[{movenum},
  movenum = 10^g;
  Do[gridmovelistplot[], movenum];
  boltzman = Sort[Tally[Flatten[gridlist]]]
 ]
```

In[19]:=
```
fit = NonlinearModelFit[dogridmovelist[5], a * Exp[-b * x], {a, b}, x]
```

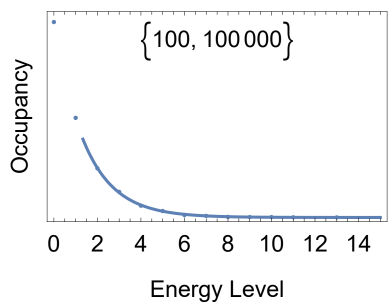
Out[19]= FittedModel[ $4992.08\, e^{-0.69004\, x}$ ]

In[20]:=
```
A = 4992.08;
B = -0.69004;
```

## Part B

In[25]:=
```
Show[ListPlot[dogridmovelist[5]], Plot[4992.08 * Exp[-0.69004 * x], {x, 0, 15}],
 PlotRange → All, Frame -> True, PlotStyle → PointSize[0.02],
 BaseStyle → {FontSize → 12}, FrameLabel → {"Energy Level", "Occupancy"},
 ImageSize → 200, FrameTicks → {Automatic, None},
 Epilog -> Inset[{Text[sizelist], Text[100000]}, Scaled[{0.5, 0.85}]]]
```

Out[25]=




## Part C

In[34]:=
```
lambda = 0.69004;
epsilon = 20 * 10^-3 * 1.602 * 10^-19;
k = 1.38 * 10^-23;
T = ((lambda * k) / epsilon)^-1
```

$$T = \left(\frac{\text{lambda} * k}{\text{epsilon}}\right)^{-1}$$

Out[37]= 336.464

## Part D

$$\text{lambda} = \frac{\text{epsilon}}{k * T};$$

When Q = N, $\frac{\text{epsilon}}{k * T} = \ln\left(\frac{2\,u + \text{epsilon}}{2\,u - \text{epsilon}}\right) = \ln\left(\frac{2\,u / \text{epsilon} + 1}{2\,u / \text{epsilon} - 1}\right) = \ln(2)$

In[39]:=
```
N[Log[2]]
```

Out[39]=
```
0.693147
```

Therefore, ln(2) is approximately equal to the value I got for lambda : 0.69004