# GRAPHICAL EVOLUTION

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The mathematical theory of random graphs concerns the changes in the characteristics of a graph with a given number of nodes (also called vertices). A stochastic process is randomly adding branches (also called edges) to the graph. The process starts with the first branch between two randomly chosen nodes, and it stops when there
is a branch between all pairs of nodes in the graph.

## A supplementary procedure

To study random graphs, you need to load Maple's networks package. Press <enter> to load Maple code:

```
> with(networks):
```

Maple's procedures do not follow the sequential approach to random graphs. Therefore, a modified procedure has been used. Press <enter>

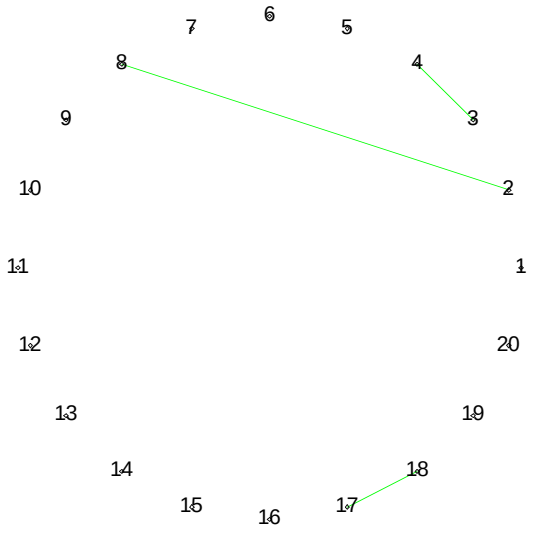
```
> Random := proc(N,K,seed)
> global _seed;
> local die, edge, G, i, q, success;
>   if K/N > 2 then
>      ERROR(`this procedure is unfit for high K/N ratios`);
>   fi;
>   _seed := seed;
>   G := new();
>   addvertex({seq(i,i=1..N)},G);
>   die := rand(1..N);
>   for i from 1 to K do success := false;
>      while success <> true do
>         edge := convert([die(),die()],set);
>         if not member(edge, ends(G)) then
>            if nops(edge) = 2 then
>               addedge(edge,G);
>               success := true;
>            fi;
>         fi;
>      od;
>   od;
>   RETURN(G);
> end:
```

# An unfolding graph

Here we try to hand simulate a process of graphical evolution. To get the same sequence of edges each time, we define the seed value of the random generator (to 5).

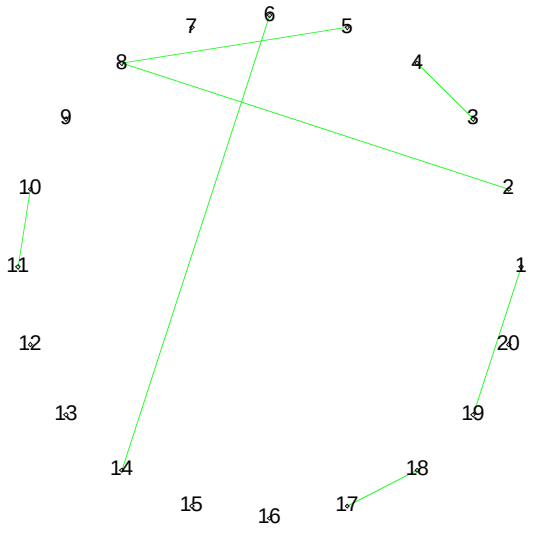
```
> Gr1 := Random(20, 3, 5):  components(Gr1); draw(Gr1); # K/N =
  0.15
```

```
{{1}, {5}, {2, 8}, {20}, {13}, {16}, {6}, {7}, {9}, {10}, {11}, {12}, {14}, {15},
    {17, 18}, {3, 4}}
```



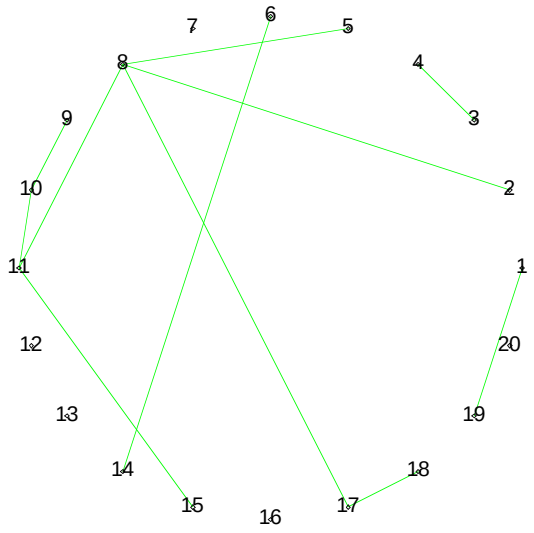

```
> Gr2 := Random(20, 7, 5):  components(Gr2); draw(Gr2); # K/N =
  0.35
```

```
{{20}, {13}, {2, 5, 8}, {6, 14}, {16}, {7}, {9}, {12}, {15}, {17, 18}, {1, 19}, {
    {10, 11}}
```



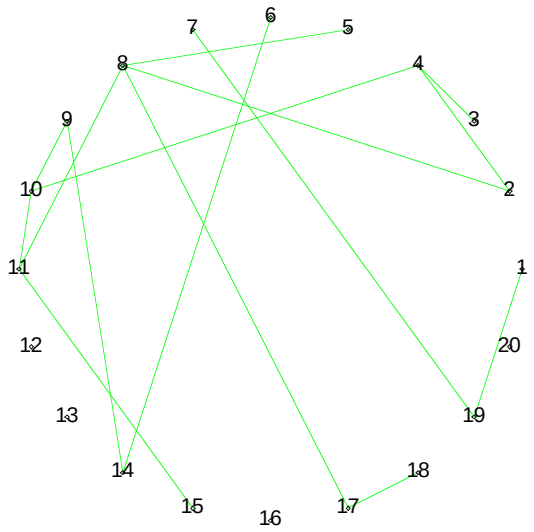
```
> Gr3 := Random(20, 11, 5): components(Gr3); draw(Gr3); # K/N =
  0.55
```

```
{{20}, {13}, {6, 14}, {16}, {7}, {12}, {1, 19}, {3, 4}, {17, 2, 5, 8, 9, 10, 11,
```



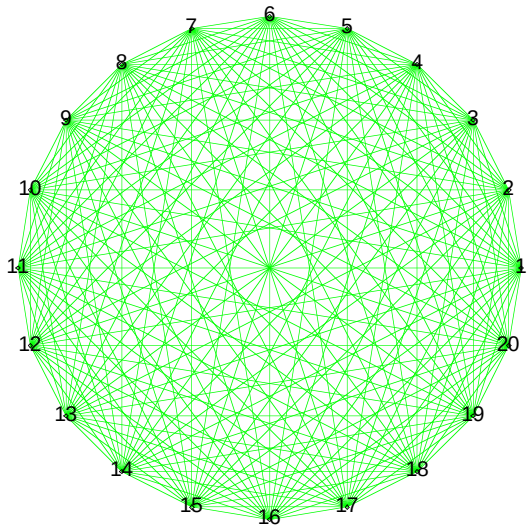

```
> Gr4 := Random(20, 15, 5): components(Gr4); draw(Gr4); # K/N =
  0.65
```

```
 {{20}, {13}, {16}, {12}, {1, 7, 19}, {17, 2, 3, 4, 5, 6, 8, 9, 10, 11, 14, 15,
```



```
> Gr5 := random(20, prob=1):components(Gr5); draw(Gr5); # K/N =
  9.5
```

```
{{20, 16, 17, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19}}
```




# References

Further reading:
Edgar M. Palmer (1985), "Graphical Evolution", Wiley & Sons, New York.
Stuart A. Kauffman (1993), "The Origins of Order: Self-Organization and Selection in Evolution", New York and Oxford, Oxford University Press, pp. 307 ff.