# Self-Replication

**Self-replicating artificial systems are technically feasible already today**, and they can and are likely to **become an important functional and aesthetic part of the spaces and environments we live in**, on microscopic / materials scale, everyday objects / human scale, buildings / architectural scale, up to the urban / city scale and even beyond (planetary and interplanetary scale). The increasing use of self-replication in artificial systems **will vastly expand the design space of our living environment** by giving us new impressive possibilities and opportunities.

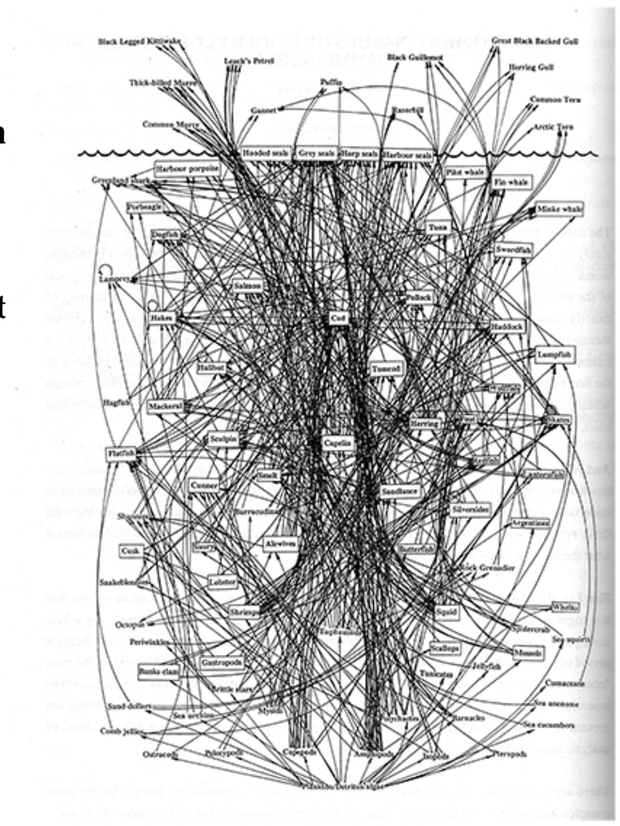
Self-replication is:
1. a process in which something creates a similar copy of itself,
2. or, more broadly, a process in which the existence of something increases the probability that there will be more copies of it in the future.

A typical example is a biological organism that produces offspring (self-replication with heritability and variations is often also called 'self-reproduction'). But, as the broader definition implies, **it is not necessary that the system does all of the constructing by itself — it is sufficient that it just somehow catalyzes the creation of new copies of itself** (while the actual construction process might be executed mostly by the external environment). For example, if some person has a bright idea, then the existence of that idea in the person's head considerably increases the probability that this idea will soon be also present in the heads of many other people, and we could consider this idea to also be self-replicating.

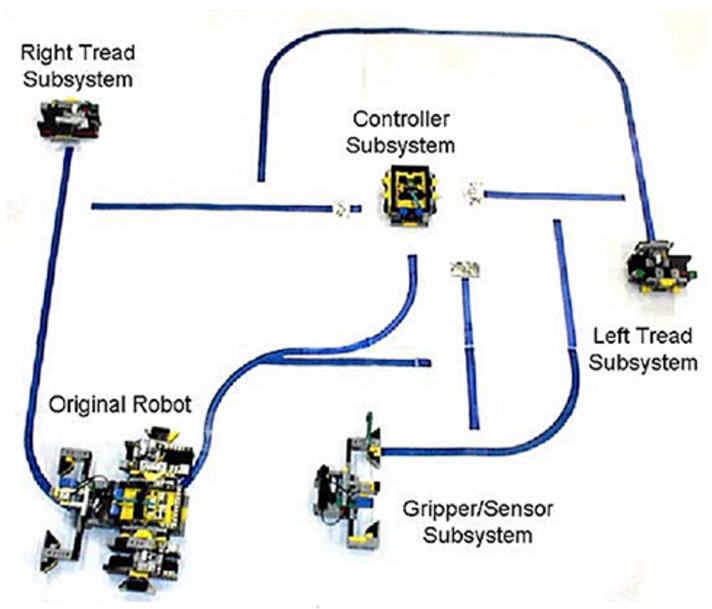
Self-replication does not mean that the system would have to be entirely autonomous and independent. **None of the existing natural self-replicating systems we know are entirely autonomous and independen — they all need external support** in the form of suitable materials / components, energy, various environmental conditions and helpful interactions and influences. If a biological organism is put into an environment that does not provide this necessary support, then that organism will not be able to replicate. For many organisms, the required external support has to be very specific and very complex — being able t replicate only in a particular specialized complex ecosystem.

**Similarly, an artificial system cannot be expected to be able to replicate in an environment that does not give it the support that this artificial system needs**, and, because the artificial system may be considerably different from natural biological systems, this required support is also likely to be considerably different.

**It is entirely feasible and, in some cases, almost trivial, to build artificial systems already today that are able to create copies or variations of itself** if given sufficiently well-prepared components. Self-evident and quite "trivial" in practice are bacterial and other cells created in the framework of the synthetic biology approach that has been developing very fast since the beginning of this century. Also quite obvious examples are various virtual self-replicating systems such as computer viruses and various experimental software models of self-replication.



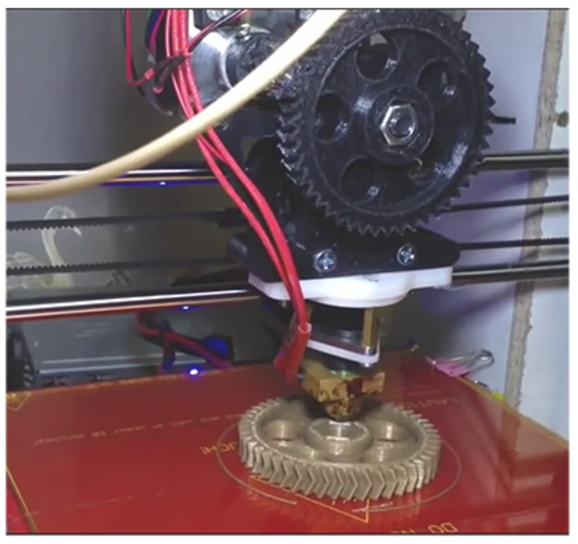
A very small part (only the food web) of the interactions in a relatively simple ecosystem (North Atlantic). Image: David Lavigne.



An autonomous Lego robot (lower left) ready to start assembling a copy of itself from smaller components. [J. Suthakorn et al. (2003) "An Autonomous Self-Replicating Robotic System"]

In case of non-biological non-virtual systems, the quite trivial examples include, for example, robots that can assemble copies of themselves if given the required physical and electronic components. Such robots have been built, for demonstration purposes, even from Lego toy robotics kits (by the research group of Gregory Chirikjian).

If the assembler robots would be combined with, for example, 3D-printers, then the resulting system would already be able to also create most of the mechanical parts by itself, requiring only the supply of electronic components and the raw material for printing.


A 3D-printer printing a part of itself.
[https://www.youtube.com/watch?v=AomaNIpup30]

We would surely be more impressed if such systems would be able to create all their required components from simple raw materials instead of needing the supply of some complex components, and even this is in principle technically almost feasible already today, and quite certainly very feasible in practice in the near future. But **in many practical cases we actually would even specifically want to keep the system partially dependent on some nontrivial components that only we can provide, so as to have control on the artificial system's replication**.
This is one of the most straightforward ways to ensure the safety of using self-replicating artificial systems.

The use of self-replication does not necessarily imply self-similarity on those scales that we are interested in. Just like the simple classical clay bricks can be used for building a huge variety of brick houses, the **self-replication can be used on the level of components** ("bricks", but with an immensely larger set of potential forms and functions compared to the classical clay bricks), **and those components in turn can together form an endless variety of both static and dynamic structures.**