Jeu-de-Joule

A System Dynamics Model of the Earth's Energy Game

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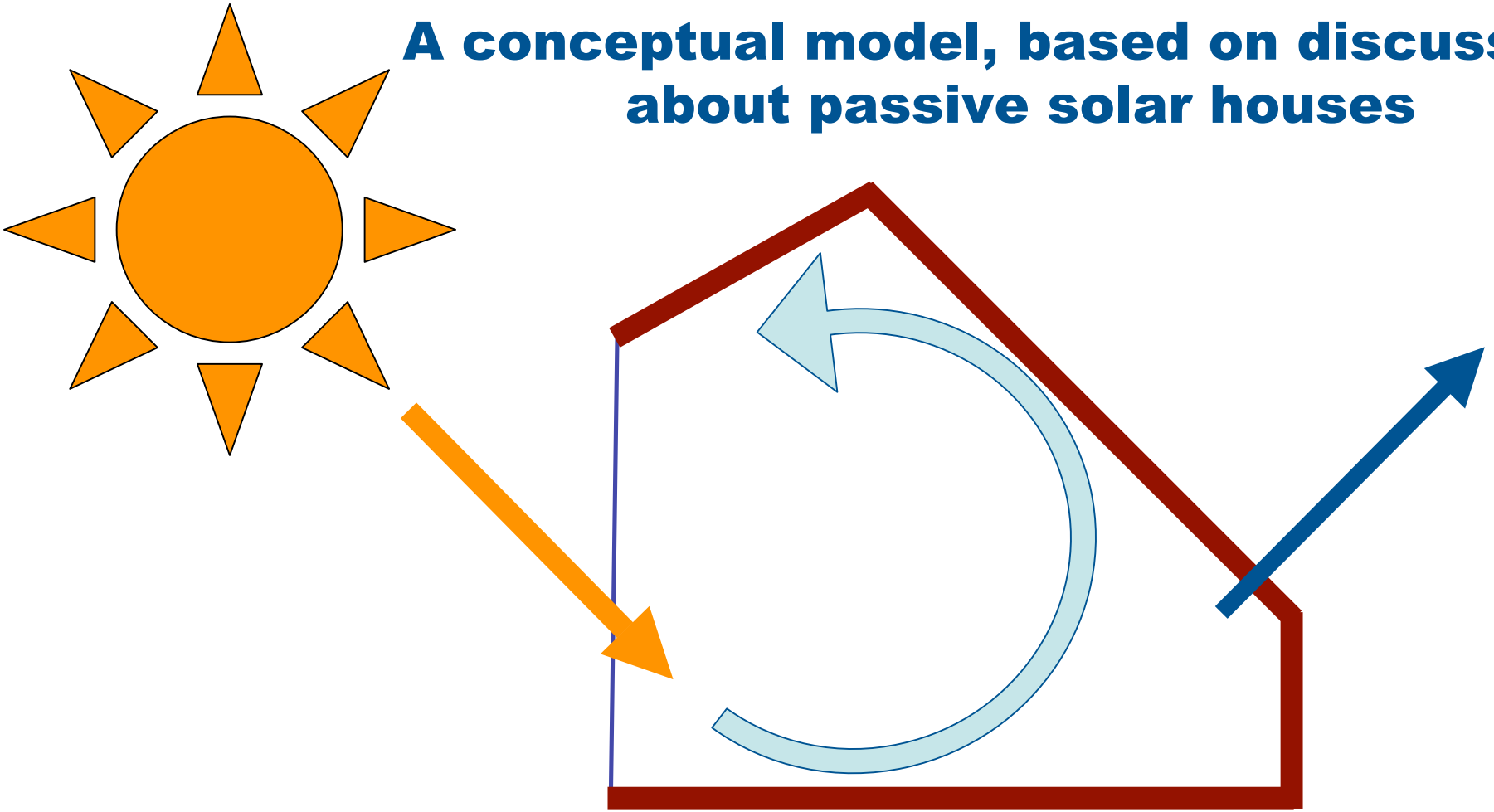
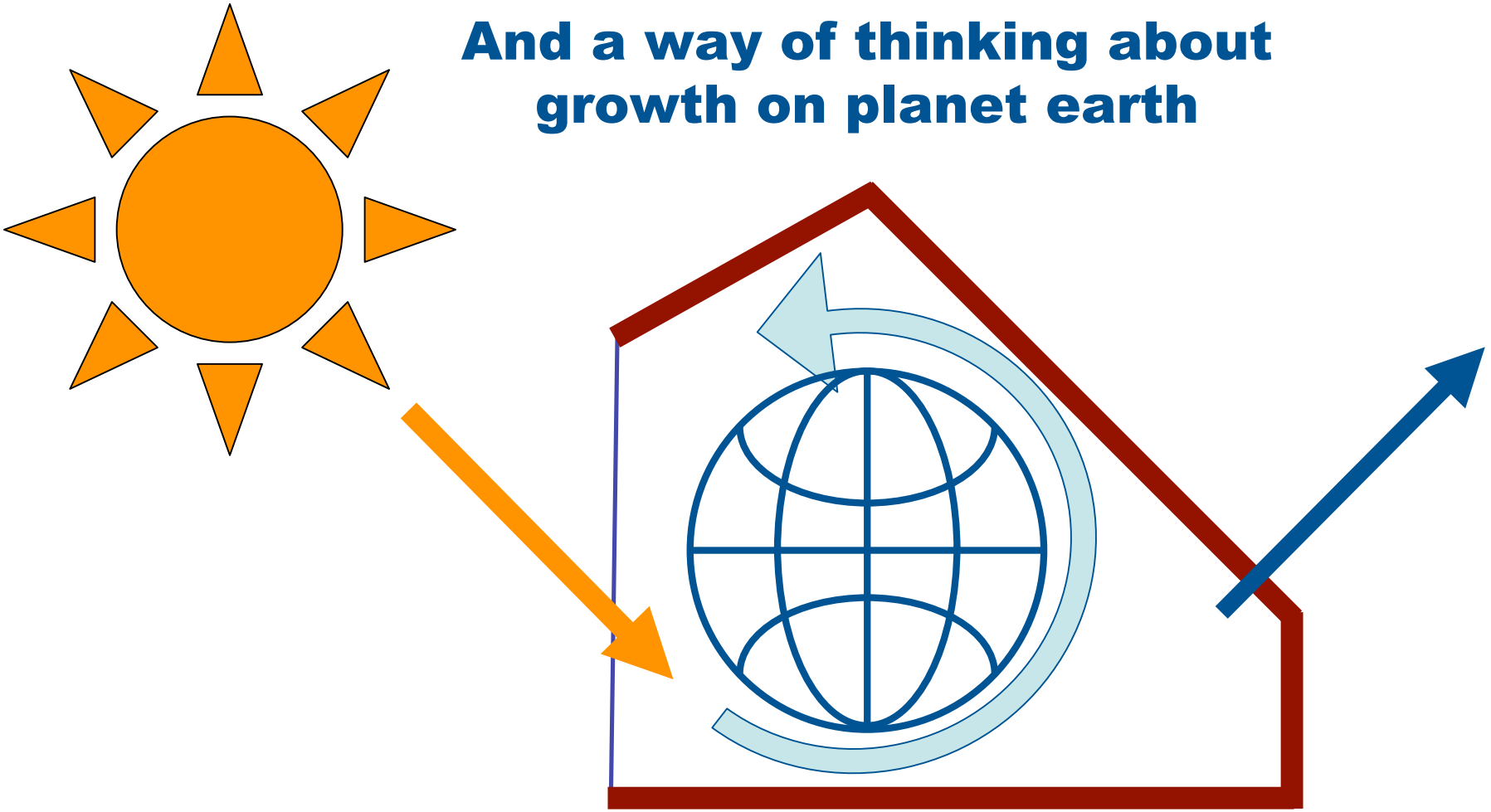
ASPO-5, San Rossoro, 19 July 2006

A conceptual model, based on discussions about passive solar houses



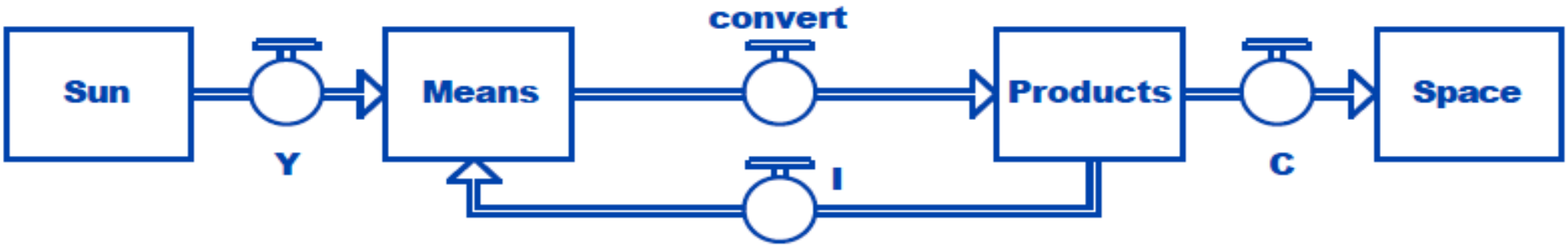
insolation = storage + emittance

And a way of thinking about growth on planet earth



income = investment + consumption (Y=I+C)

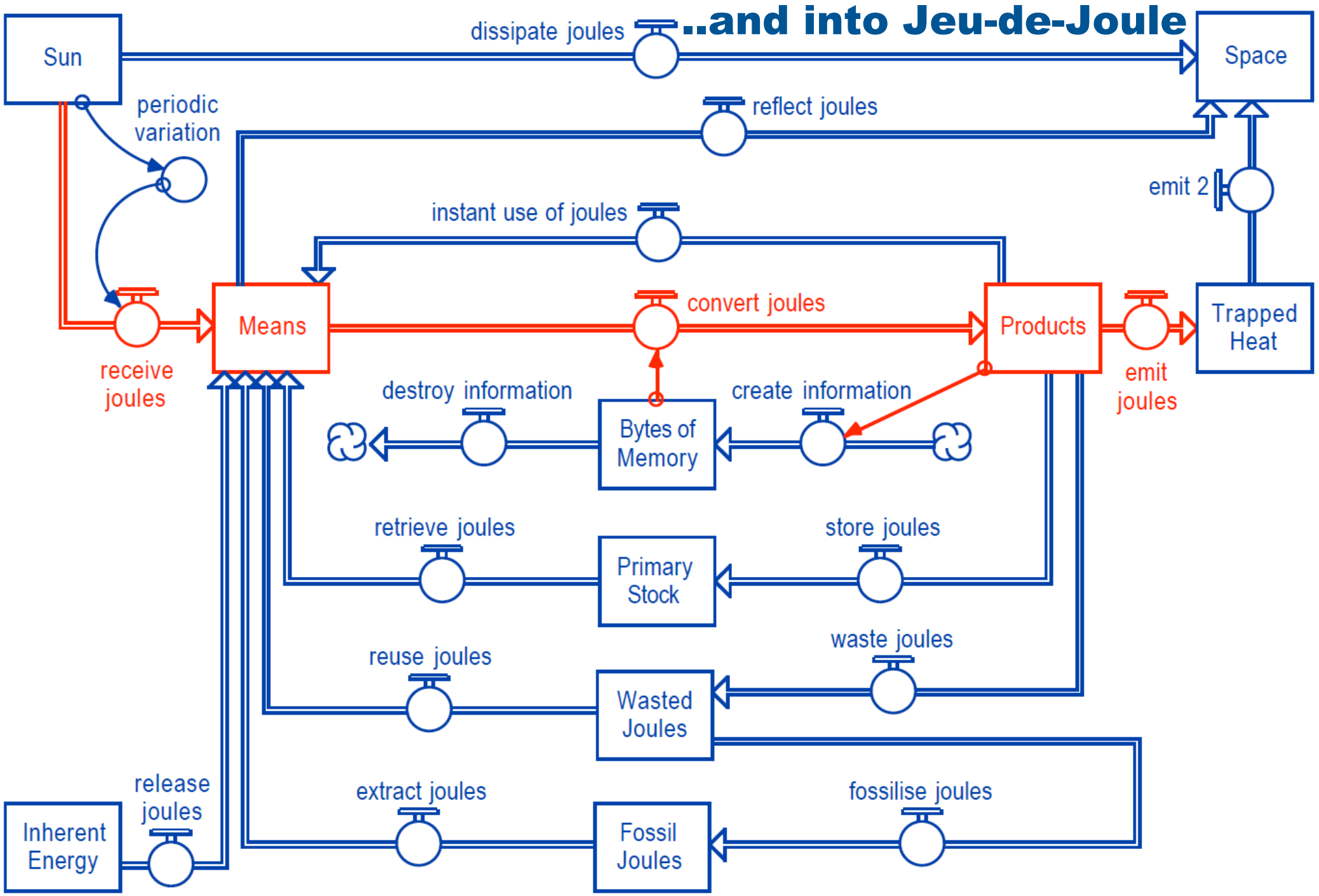
Translated into the “language” of system dynamics



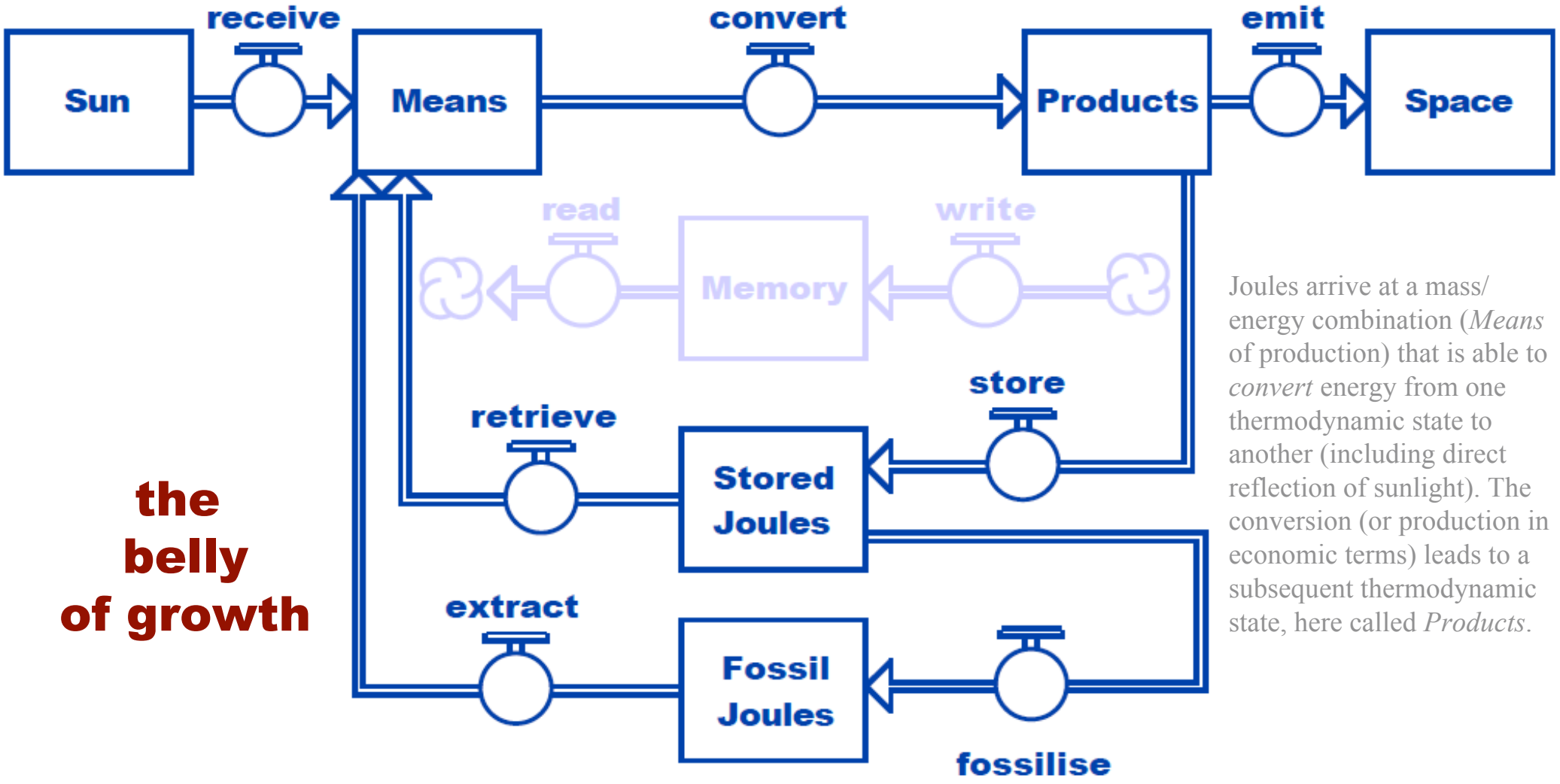
Income fixed, yet extremely large

Y=I+C

Consumption includes all joules leaving earth


..and into Jeu-de-Joule
Sun
dissipate joules
Space
periodic variation
reflect joules
emit 2
instant use of joules
Means
convert joules
Products
Trapped Heat
receive joules
emit joules
destroy information
create information
Bytes of Memory
retrieve joules
store joules
Primary Stock
reuse joules
waste joules
Wasted Joules
release joules
extract joules
fossilise joules
Inherent Energy
Fossil Joules

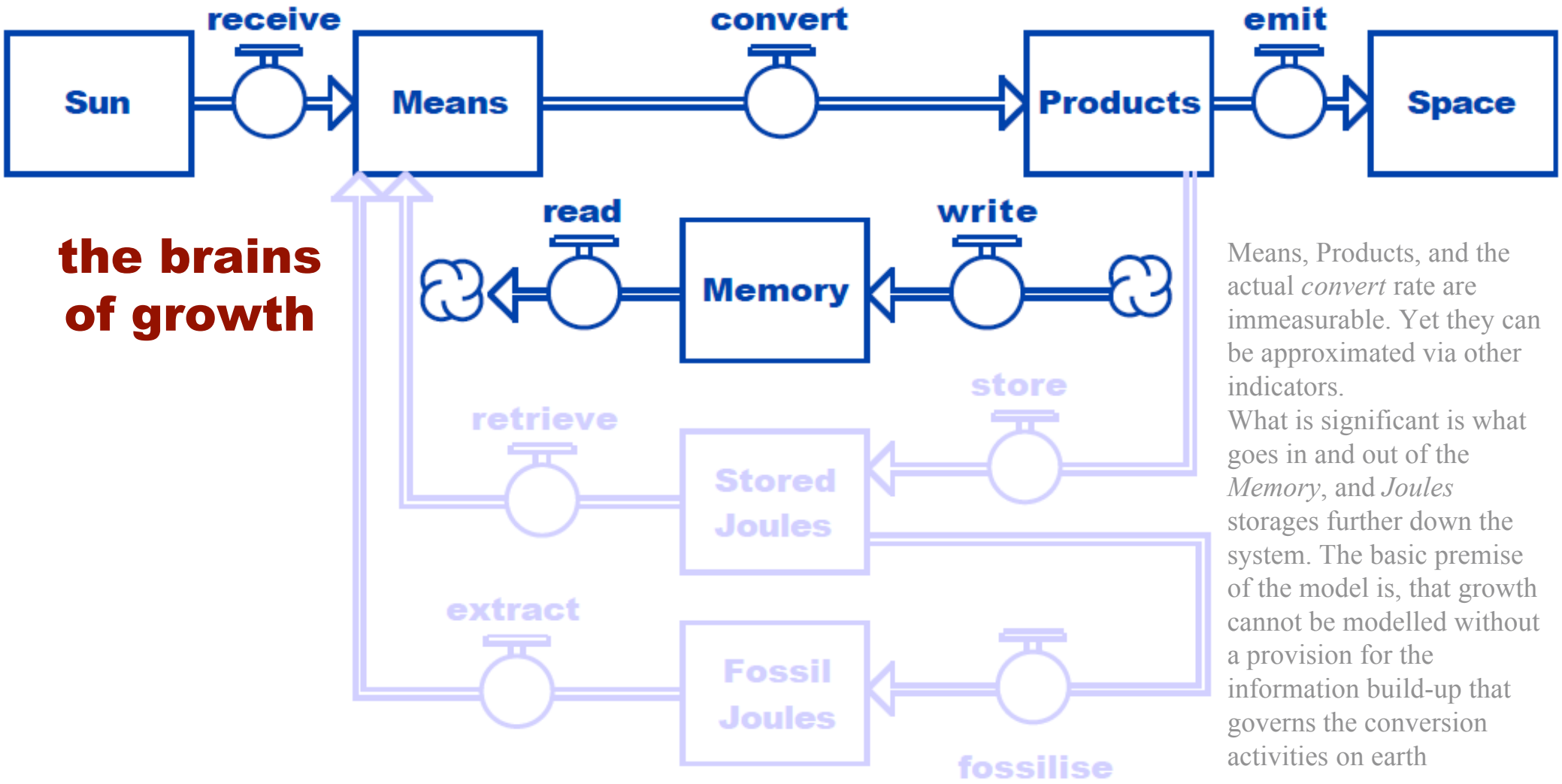
The model is about the self-organising growth of conversion activities



the belly of growth

Joules arrive at a mass/ energy combination (*Means* of production) that is able to *convert* energy from one thermodynamic state to another (including direct reflection of sunlight). The conversion (or production in economic terms) leads to a subsequent thermodynamic state, here called *Products*.

And about what is organising the self-organisation



the brains of growth

Means, Products, and the actual *convert* rate are immeasurable. Yet they can be approximated via other indicators.
What is significant is what goes in and out of the *Memory*, and *Joules* storages further down the system. The basic premise of the model is, that growth cannot be modelled without a provision for the information build-up that governs the conversion activities on earth

(Bytes of) Memory available in DNA & human information

Joules & Bytes

- The flow of solar income is not in itself sufficient to explain the growth of energy conversion activities during the existence of earth.
- It is the ability to store and retrieve solar energy for various periods of time, that make-up the uniqueness of planet earth.
- The main physical enabler for the storage of *Joules* is the earth's mass, and especially its mass of water.
- In the model, mass as such is not discussed, since energy conversions do not change the amount of mass on earth in a significant way.
- The amount of *Bytes of Memory* does change significantly over time.
- The two sources for the memory build-up on earth are the genetic information in living organisms (DNA) and the replicable information produced by humans. The model enables to map the parallel development of Bytes of information and joules of energy.
- The assumption is that the memory build-up will proof to be the simplest possible indicator of the organisation of the self-organisation of energy conversion processes on earth.

Memory growth

The basic premise of the model is, that growth cannot be modelled without a provision for the information build-up that governs the energy conversion activities on earth.

Before human civilisation, the memory stock of planet earth mainly consisted of DNA in living organisms, plus whatever memory there was in the living brains of those organisms. The knowledge about DNA surfaced only recently. With that knowledge, the stock of DNA information now becomes part of the common memory of information created by humans.

The growth of this information build-up went initially more or less hand in hand with the rate of use of the *Fossil Joules*. At present, the memory growth is far greater.

Because/despite of the memory growth, the carrier capacity crisis due to fossil fuel use, now becomes apparent in climate change and peak oil.

The Oxygen Catastrophe

Some 2.5 billion years ago, the earth's plant kingdom came against their limits to growth as a consequence of their waste product: oxygen. The result was the Oxygen Catastrophe, which is an example where the growing stock of memory, encapsulated in DNA, increased the probability of a carrying capacity crisis.
Yet at the same time the sheer volume of the memory stock raised the probability of a DNA pool that –eventually– could overcome the crisis.

In this case, that memory pool enabled the creation of species that use oxygen (and hydrocarbons), and produce carbon dioxide as a waste product that can again be used by plants.

So it seems that more memory means a greater probability of both a carrying capacity crisis *and* a solution of that crisis.

Bridging the two is of course the difficult part.

Trapped Heat

- After the oxygen crisis, the new synthesis of plants and animals triggered a renewed growth in the stocks of (DNA) memory on earth. It also led to ever increasing stocks of joules, including the stock of fossilised joules.
- Such fossilised joules could not be reused by the then living organisms. They were in fact lost as a means of production in the conversion cycles, and became unused investment (dead capital).
- Such savings decrease CO_2 levels in the atmosphere, followed by a decrease in the total amount of *Trapped Heat*.
- In the model, the *periodic variation* of the earth's solar income is included because of the time it should be able to cover, and the eras of glaciations that have occurred during that time. These variations are of particular interest since the intriguing observations about the human influences that may or may not have countered the effects of the present variation cycle. (Ruddiman WF. 2005. *Plows, Plagues, and Petroleum: How Humans Took Control over Climate.* Princeton University Press.)

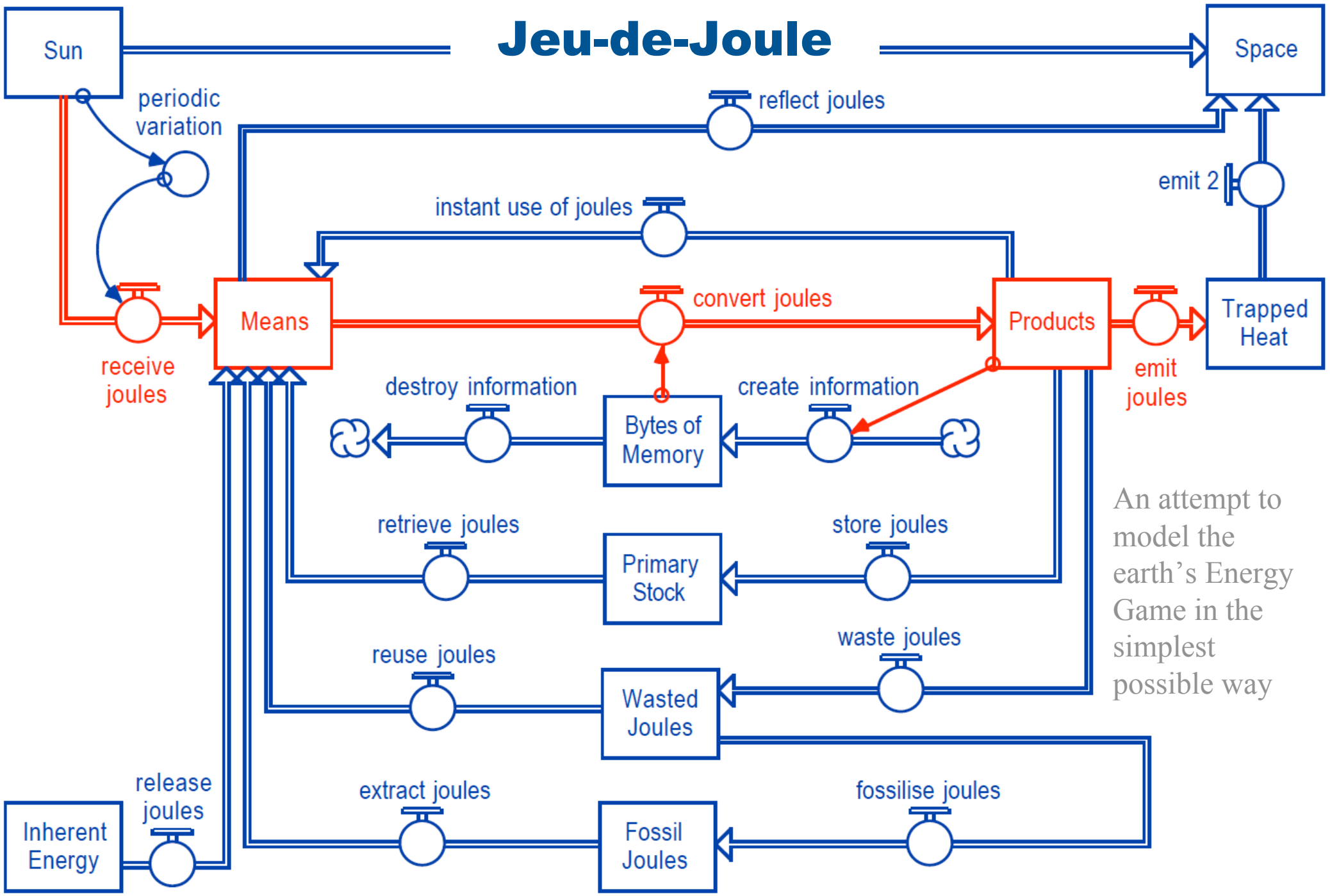
Use of the model

In a federation of energy models, Jeu-de-Joule would rank as both galactic, and minimalistic. It is an all-encompassing model, yet without the structure or data to simulate the past or the future.
But even in its present form, it already helps to provide a simple structure to tell the *story* about the parallel development of joules and memory during the earth's past.

The model can help to think-through the parallel development of (1) the main energy stocks and flows of successive ecological and socio-economic periods in the earth's history, and (2) the growth of the amounts of Bytes of memory, both in the form of DNA and in the form of human information. The parallel tracks can then be used to distinguish a recurring relationship between the growth of memory and the crisis and subsequent solutions in the energy stocks and flows of the past.

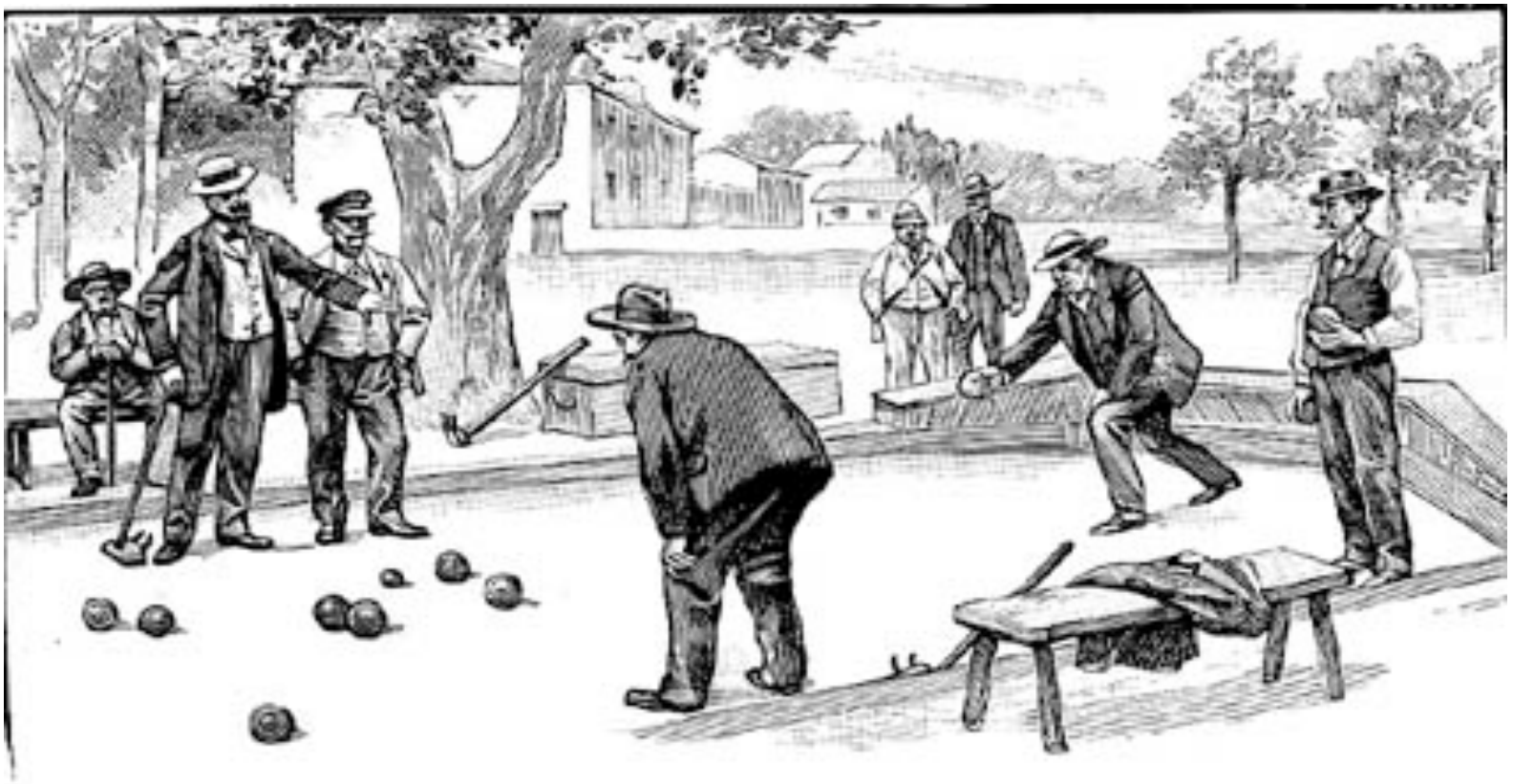
And the model could help to narrow the search field for emerging options.

Jeu-de-Joule



An attempt to model the earth's Energy Game in the simplest possible way

with a wink to ‘jeu de boule’



The Jeu-de-Joule paper can be found in the proceedings of the 24th International Conference of the System Dynamics Society (www.systemdynamics.org)