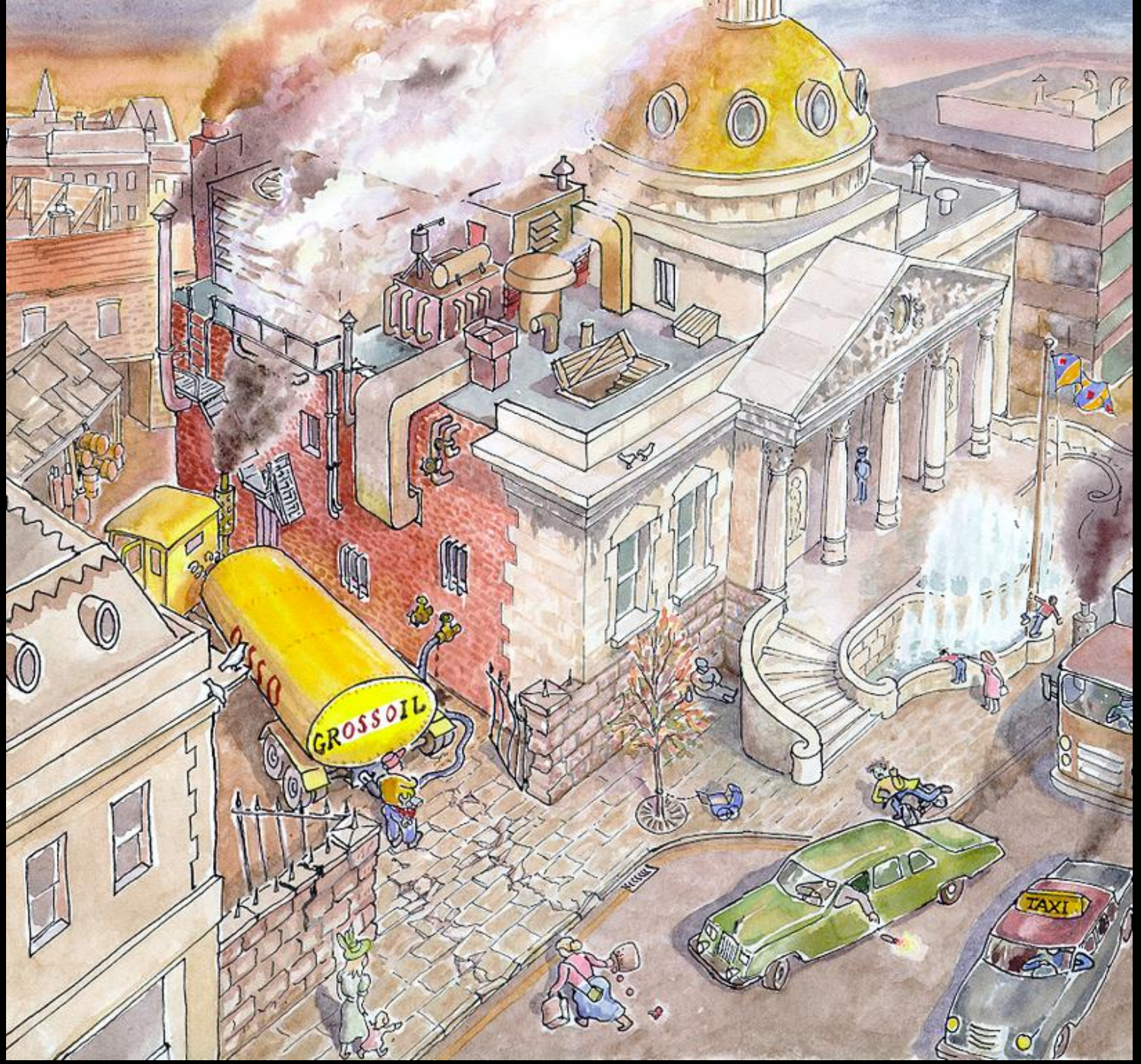
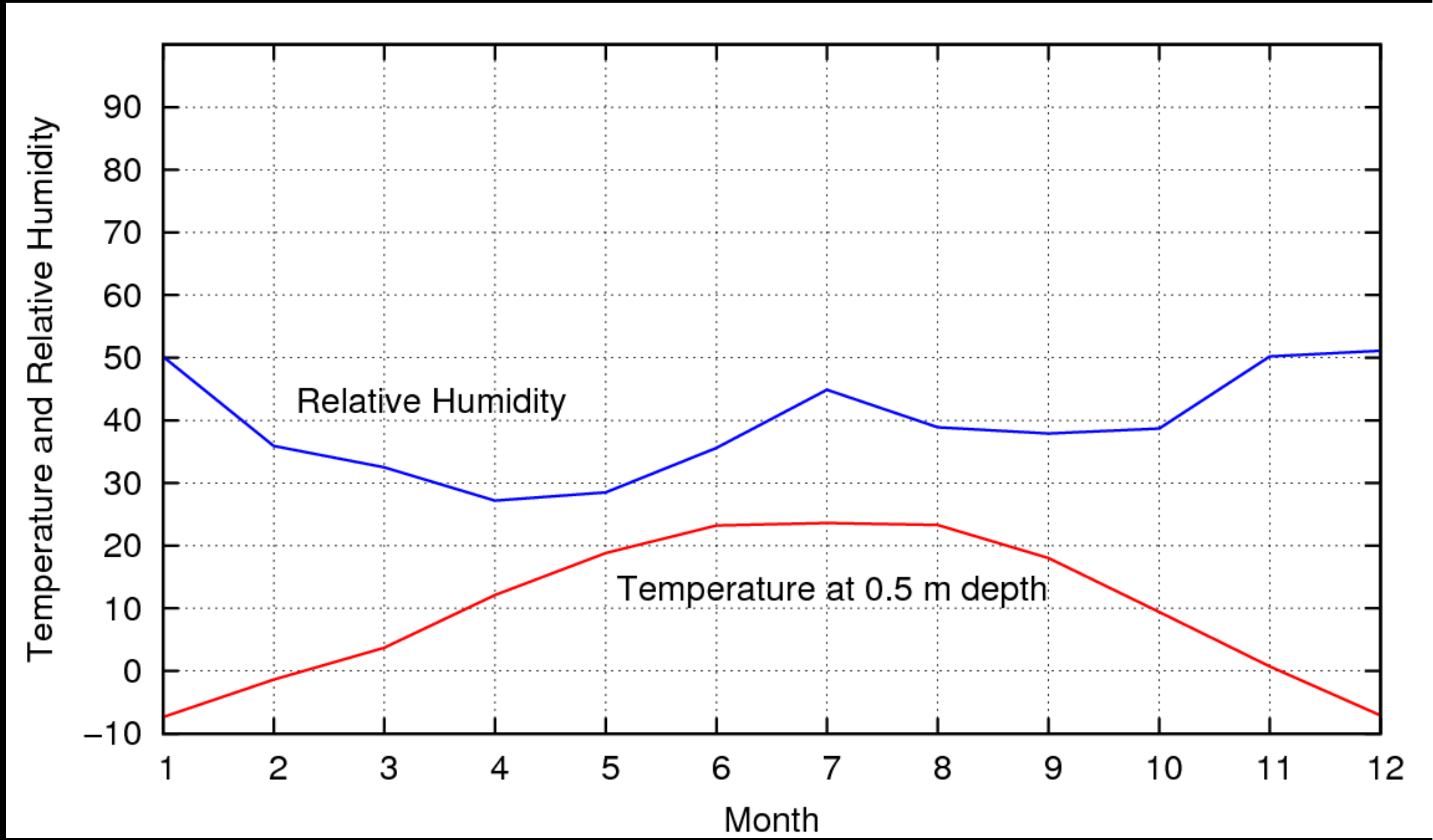


Museum standards assume unlimited energy to enforce very tight limits for temperature and relative humidity

What happened before air conditioning?
This is the Arts and Industries Museum in Washington DC,
a hot, humid climate. The single storey, high exhibition space
was originally ventilated by convection through the towers.
Later it was air conditioned. Now it is derelict, its roof destroyed
by condensation from the humidified interior.

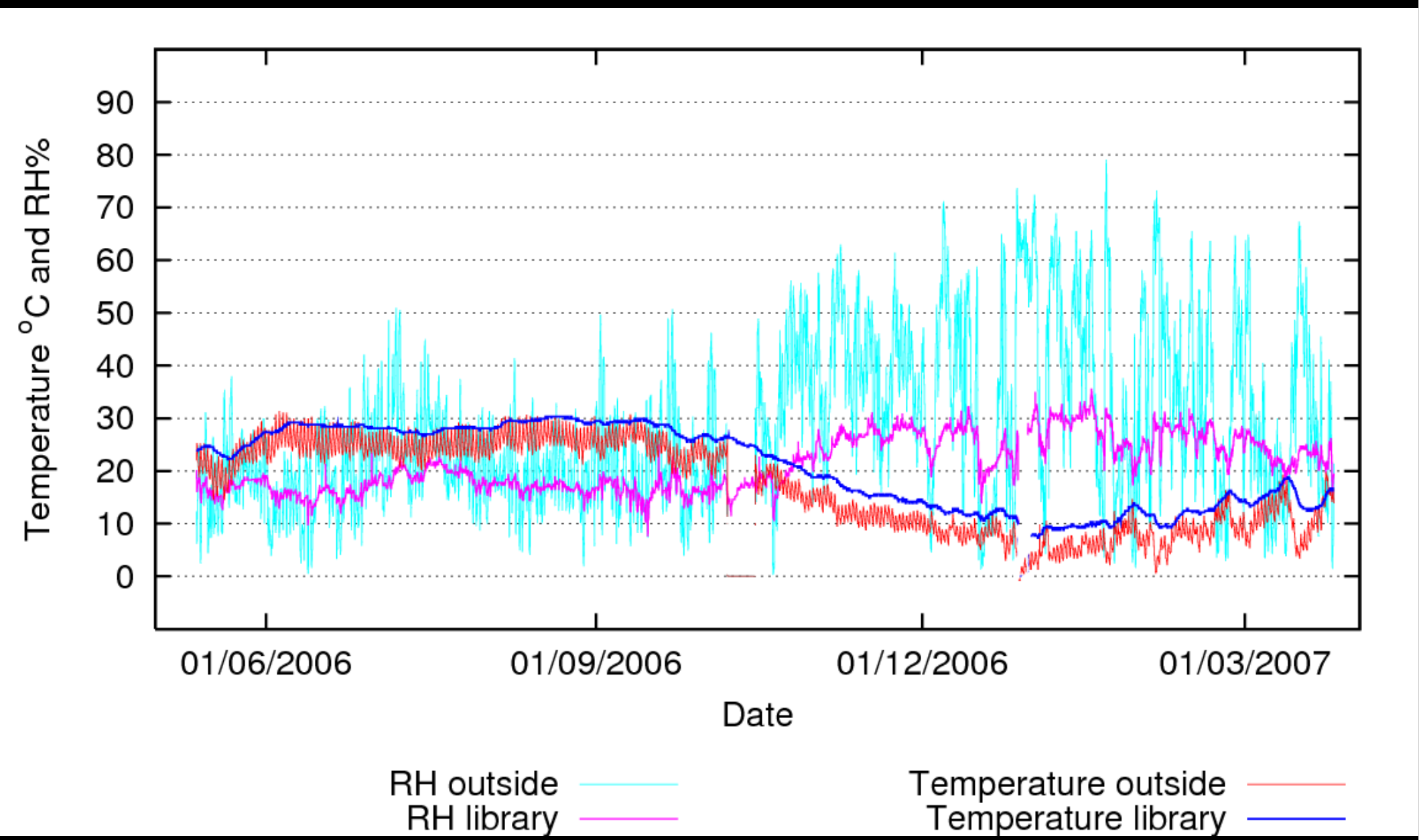
So what is the scientific evidence for the need for strict standards with no permitted variation over the year?

An archive without a roof: In 1901, Swedish explorer Sven Hedin discovered paper from the third century, perfectly preserved under half a metre of blown sand in a ruined building near Lop Nur in the Taklimakan desert of Eastern Turkestan



Climate at 0.5 m depth, Dunhuang, China

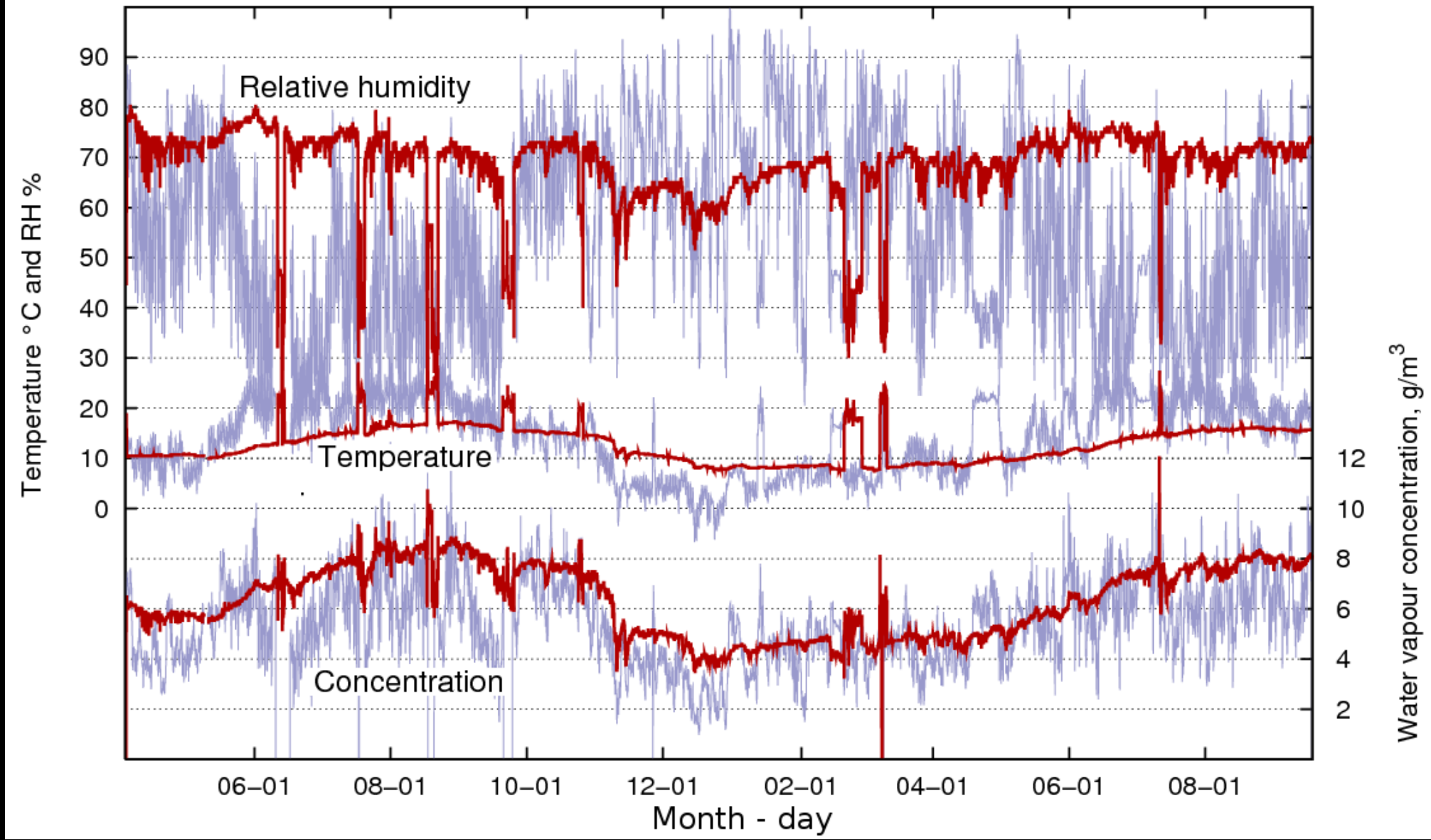
St. Catherine's Monastery, Sinai, Egypt, home to a library founded in the 6th century



The climate in the library of St. Catherine's Monastery, Sinai, Egypt

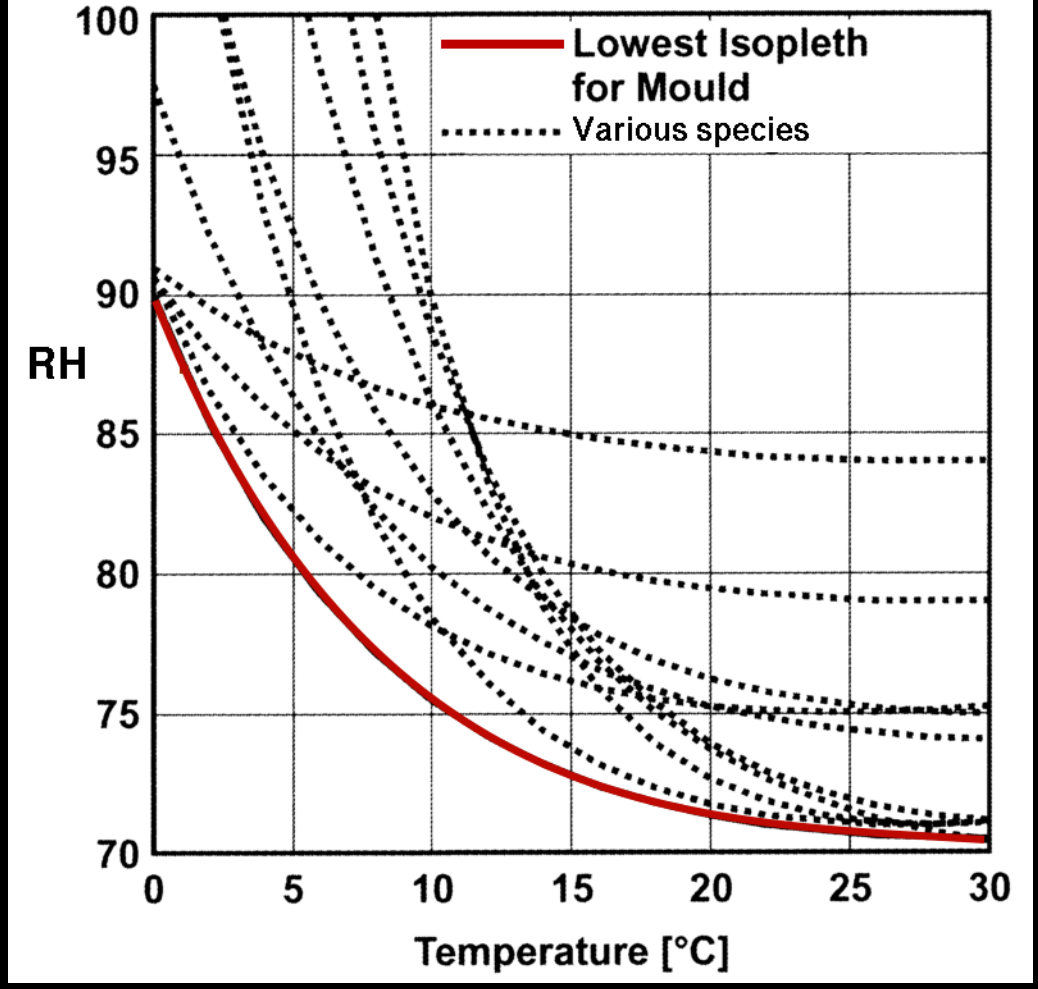
No heating, low RH, high summer temperature

The Alcazar of Segovia, Spain. It contains the military archive



Alcazar archive climate over a year and a half

Naturally buffered by massive construction and paper bundles. No heating – RH perilously high but no mould growth observed.



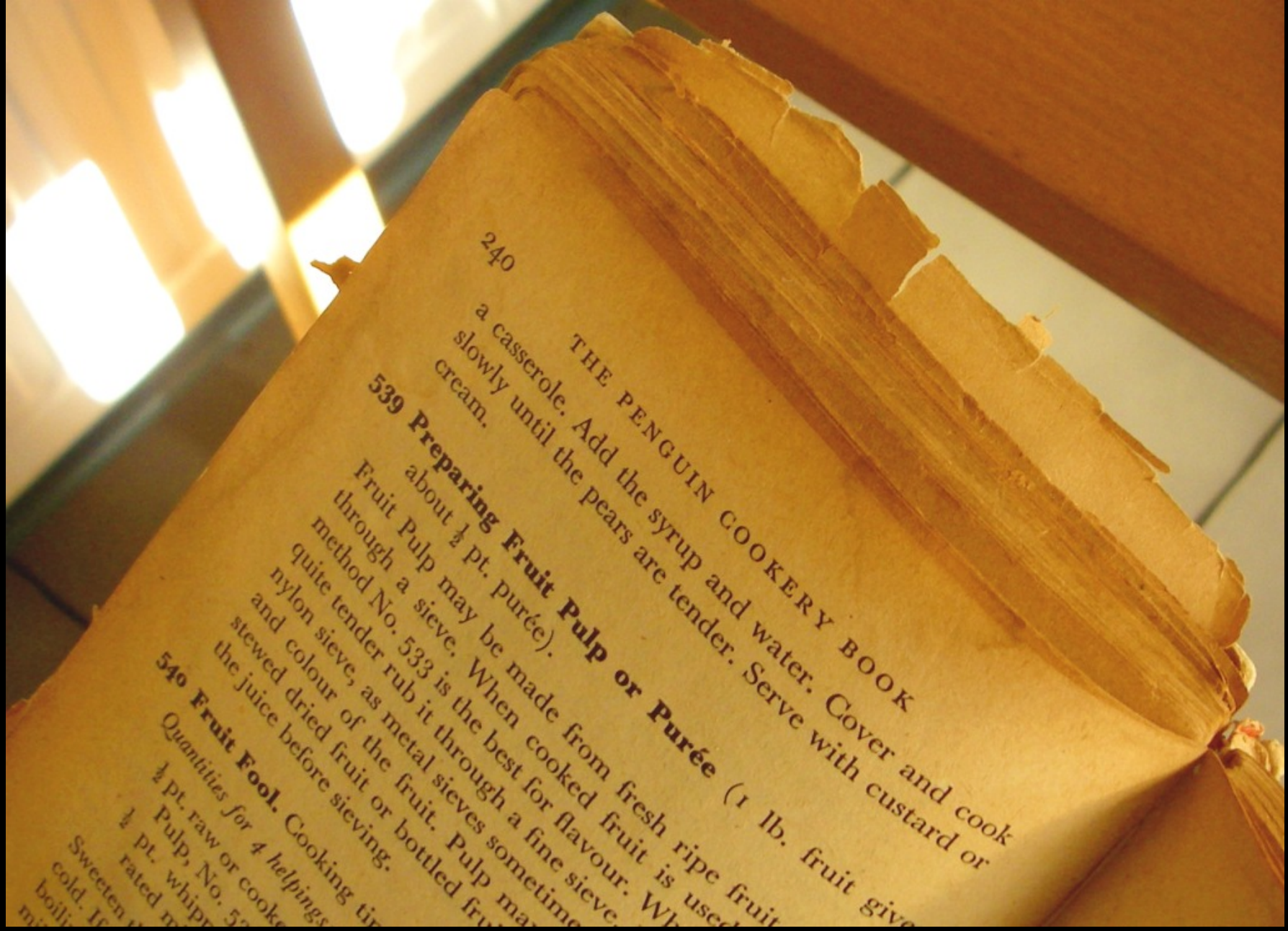
Limiting RH for fungal growth (Martin Krus)
Note the temperature dependence of the relative humidity limit for growth.

There is no evidence that air velocity influences fungal growth, but nutritious substrates do encourage growth at a slightly lower RH.

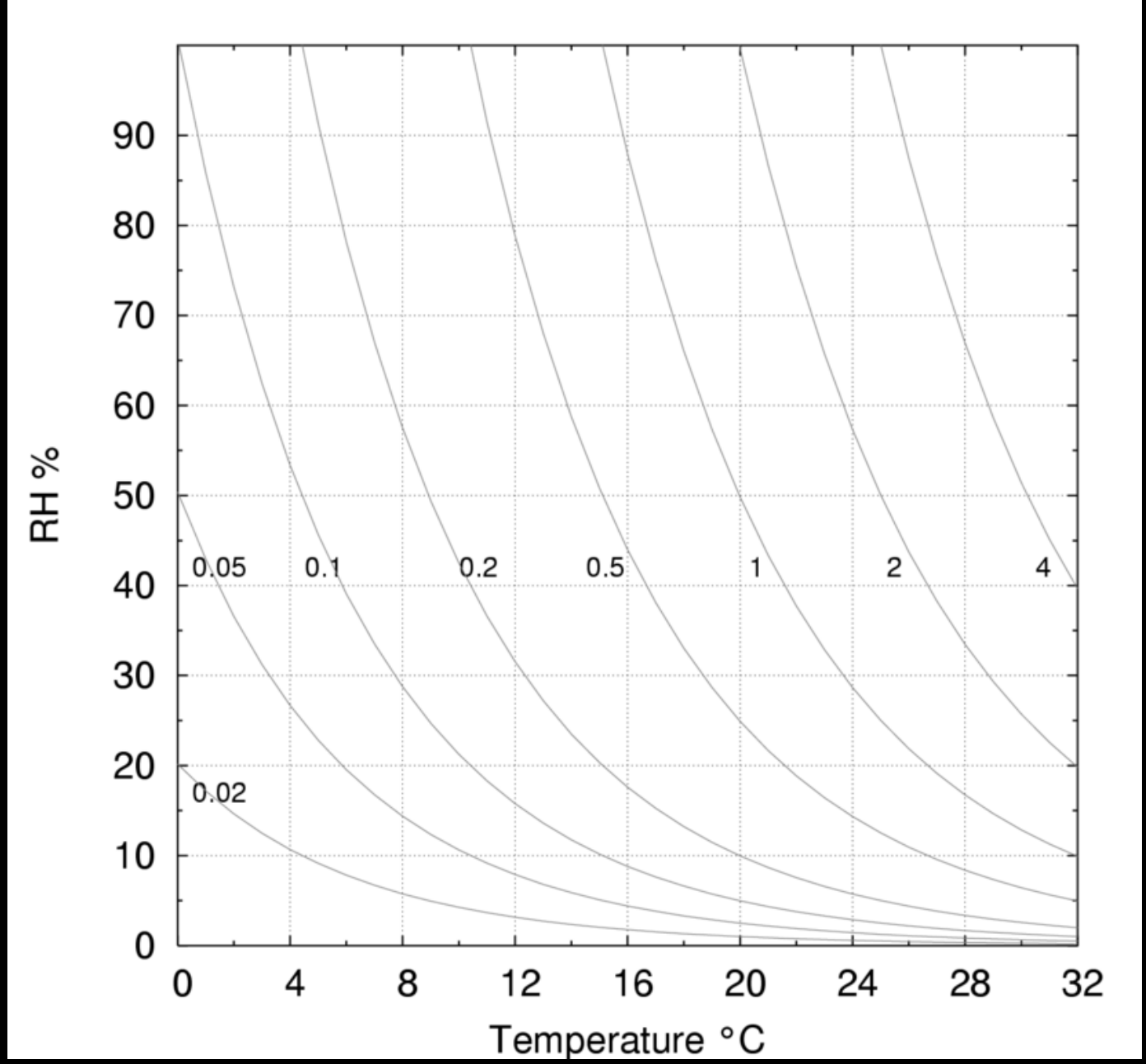
Movie film is stored at –20°C without damage but...

One out of tens of thousands of items plunged to –30°C (to destroy bugs) has been reported damaged.

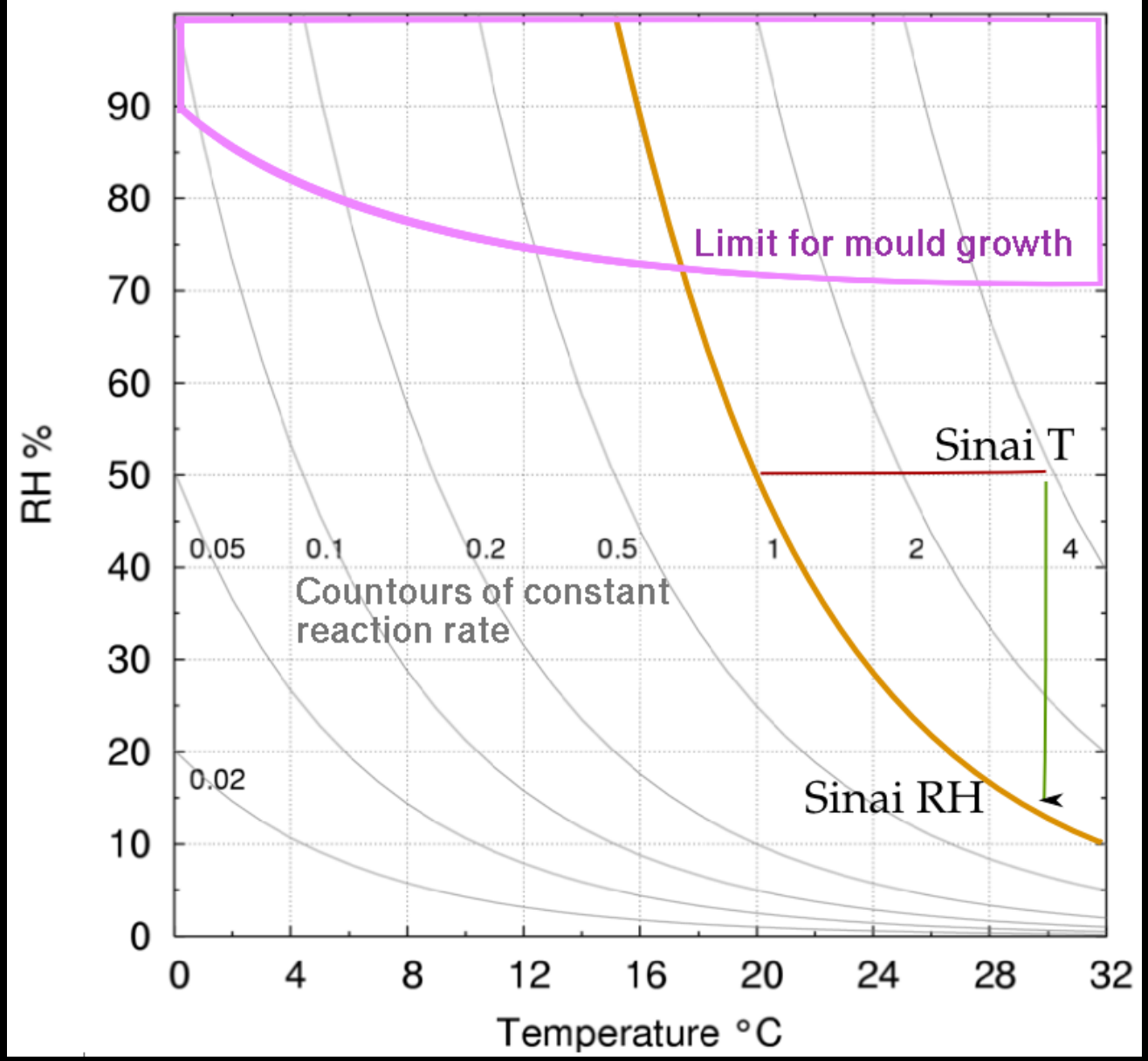
This is a silver mirror which delaminated.



There are unstable materials in collections. High temperature and high relative humidity accelerate decomposition reactions.



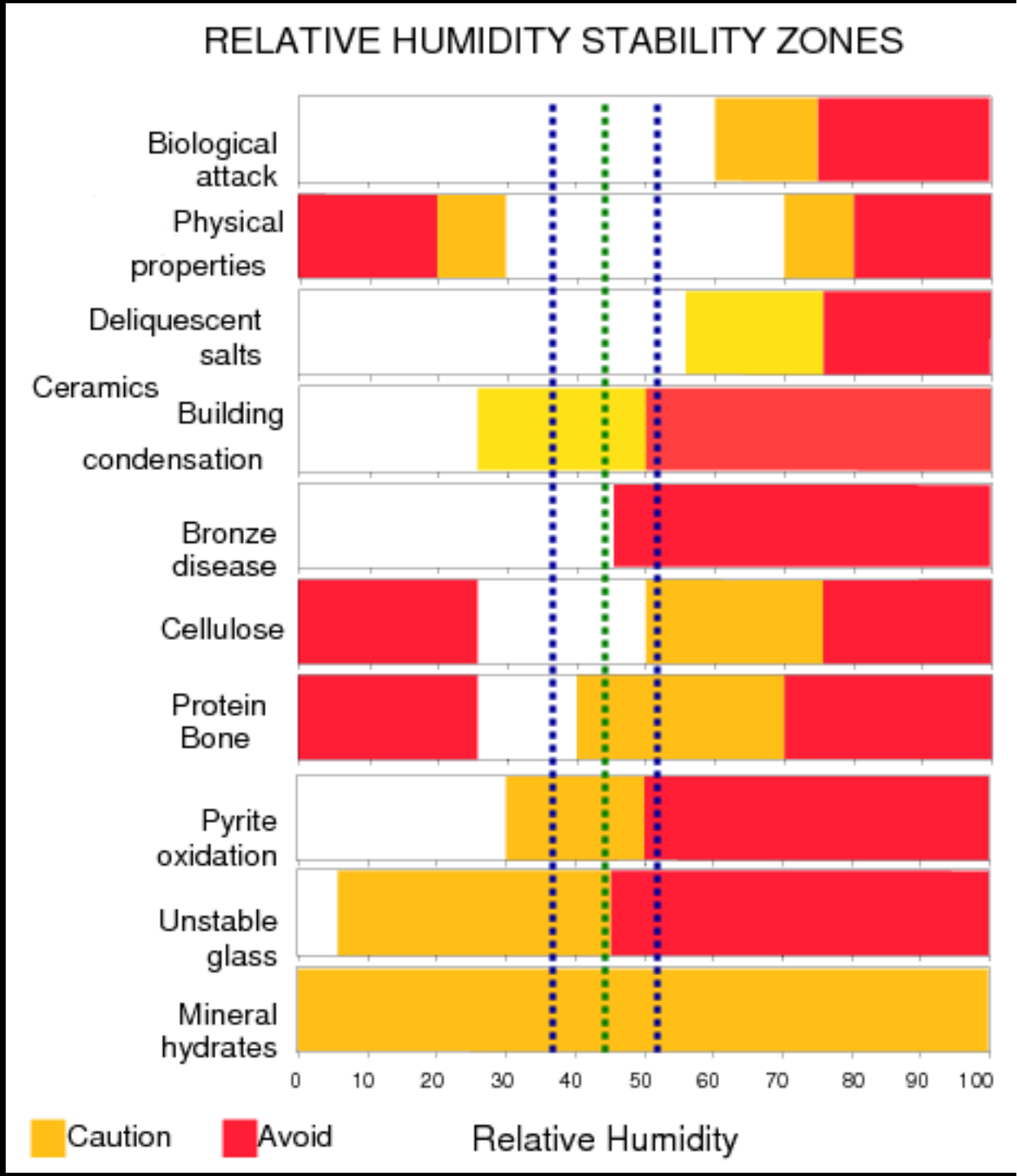
The influence of temperature and RH on the rate of a typical hydrolysis reaction (after Sebera). Curves mark constant relative reaction rate compared to the rate at 20°C and 50%



The reaction rate graph with the limit for mould growth added. The low RH in Sinai compensates for high summer temperature. The reaction rate relative to that imposed by the standard climate can be used as a figure of merit for a storage or exhibition room.

There are other causes of deterioration which are dependent on the RH.

(after Erhardt and Mecklenburg)



7.3 Recommended storage temperatures and relative humidity

7.3.1 *Storage temperature for frequently-handled material*

The temperature for the storage of frequently-handled paper and parchment should be as constant as possible. In order to avoid the need for acclimatization (see **7.3.4**) when documents move from storage to reading room and back, the temperature should be at a fixed point between 16 °C and 19 °C with a tolerance of 1 °C on either side, but ranging neither below the minimum nor above the maximum. Documents in transit should be protected against the effects of any unsuitable environment between the repository and the reading room, and the distance between the two should be minimized

7.3.2 *Storage temperature for infrequently-handled material*

Little-used material will benefit from being stored at cooler, constant temperatures. The temperature should be at a fixed point within the range of 13 °C to 16 °C with a tolerance of 1 °C on either side. The material should be allowed to acclimatize before use in a transitional environment such as that recommended in **7.3.1**.

The evidence for robust endurance of varying climates has not convinced the experts.

Extract from BS5454:2000

7.3.3 *Relative humidity*

Relative humidity should be at a fixed point between 45 % and 60 % with a tolerance of 5 % on either side, but ranging neither below the minimum nor above the maximum. Rapid changes should be avoided. Little-used paper not in bound volumes may be stored at a relative humidity of 40 %, but should then be acclimatized before use (see 7.3.4)

...

7.4 Ventilation

NOTE See also 5.2.2 for reducing air infiltration.

7.4.1 *General*

The air within the repository should not be stagnant. There should be sufficient air movement to avoid pockets of stagnant air.

NOTE Air movement removes off-gassing of organic materials and prevents a build-up of pockets of high relative humidity.

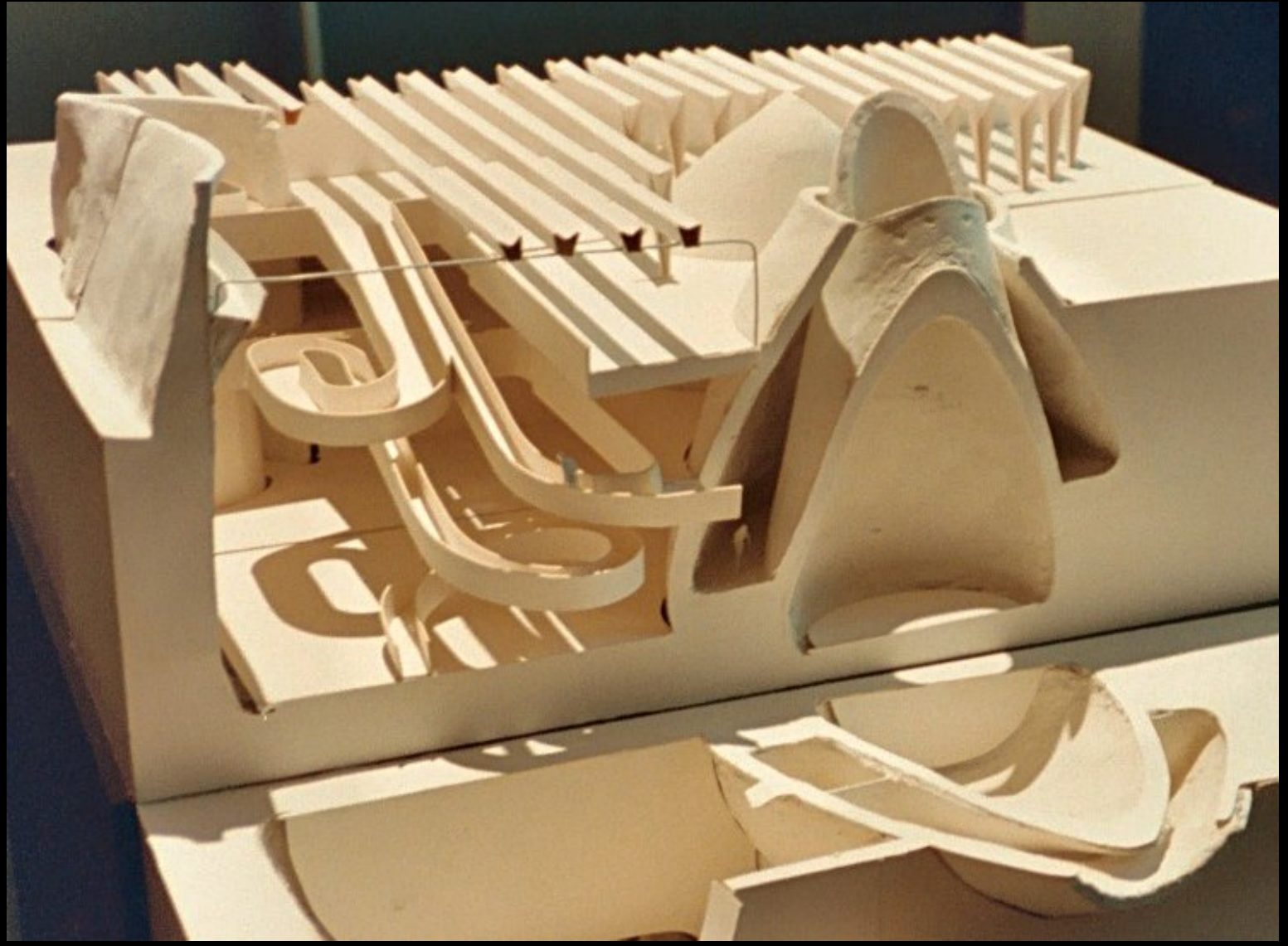
If a mechanical ventilation system is provided, it should be designed to reduce pollutant concentration by introducing a proportion of fresh air (see 7.5.3) and by providing air distribution that will avoid areas of stagnation. Care should be taken over the location of air diffusers since loaded shelves create barriers to air circulation.

Extract from BS5454:2000

Confused explanation for ventilation need

It's safer for the conservator to insist on conforming to the standard. It's easier, but costly, for the engineer to provide a constant climate. The running cost is no concern to the people transiently involved in the building project.

Museum architecture has metamorphosed into a sculpture competition. The engineer is given the job of fixing the climate, and the roof. In this case, the Royal Ontario Museum, the conservators gave up hope of influencing the architect and piped conditioned air to every showcase.



Fine architecture can also protect the exhibits. This is the model for Jørn Utzon's Silkeborg museum (1963) for displaying the art of Asger Jorn. Built underground, with natural lighting, it would have provided a naturally good climate. It was never built.