

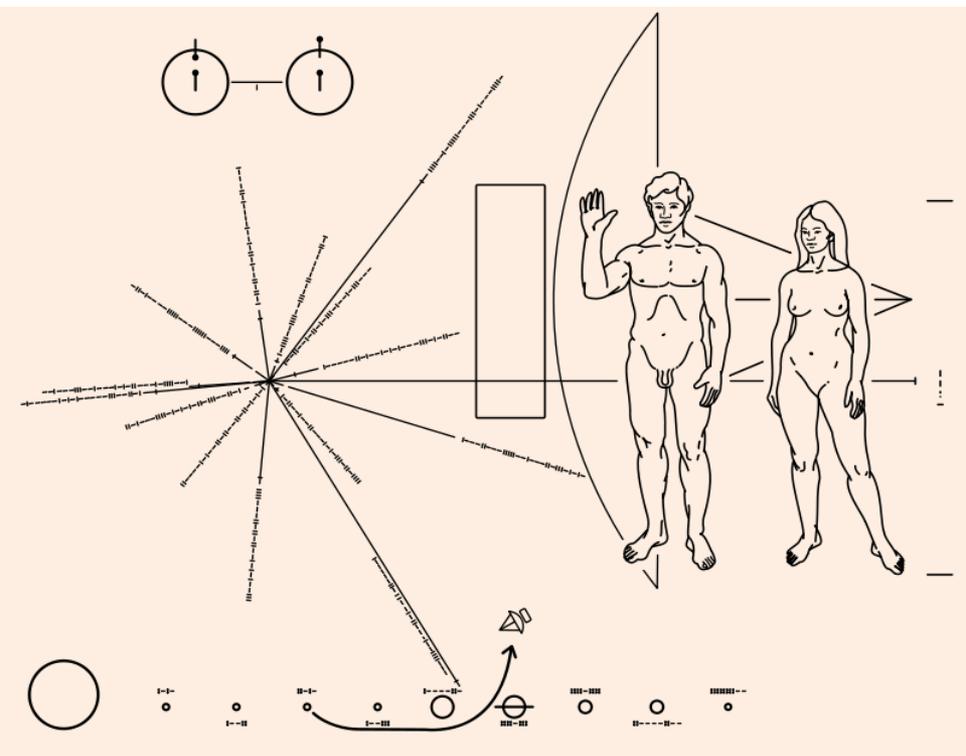
# Knowledge for the Future – Time Eats Information



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**Pioneer 10 Plate** (Start: March 3<sup>rd</sup>, 1972)  
 Source: <http://de.wikipedia.org/wiki/Pioneer-Plakette>

Testing students at a Technical University:

What is the meaning of the star like figure? (0%)

Position of sun relatively to the center of our galaxy and to 14 pulsars (lines are binary codes of pulsars rotation frequency)

What is the meaning of the dumbbell like figure? (2%)

hyper fine structure of a H atom transition

What is the meaning of the figure below? (50%)

Planetary system and planned trajectory of Pioneer



# Knowledge for the Future – Time Eats Information

1. Long Term Technologies
2. Time Eats Information
3. Stable Organizations
4. Information is not yet Knowledge
5. The Possibility to Act in a Responsible Way



# 1. Long Term Technologies

## Areas making it necessary to hand on knowledge for future generations

Disposal of waste material with long term impacts to environment and human life – important to prevent intrusion and to keep the site safe

Resting devices from military or civil technologies with potentially long term hazardous potentials – important to prevent future damages

Already existing knowledge to handle possible future disasters

Already existing knowledge to handle normal life in future - important for the self-understanding of man



# Areas making it necessary to hand on knowledge for future generations

## Disposal of radioactive waste material

Spent Fuel (U, Pu, Cs, Sr, ... )  
Scraped nuclear power plants  
Superfluous Pu<sup>235</sup> from scrapped nuclear weapons  
Material Research,  
Nuclear Research,  
Medical Applications.

## Disposal of toxic substances

Dioxin (1200 years, if not treated), ICT debris

## Release of genetically modified organisms

Knowledge of the modified DNA would be useful

**Land mines** (worldwide between 70-110 Billions) ( $t_{\text{remove}} \geq 4000$  years)

**Space debris** (about 600 000 objects > 1cm, 13 000 > 5 cm), Go down from 800km in 20-30 years, from 1500 km in some 1000 years

# Areas making it necessary to hand on knowledge for future generations

**Long term side effects** of Large Technical Systems

**Astronomic Knowledge**

**Disease prevention**, hygiene, virology

**Knowledge about contexts** for the interpretation of technological, scientific, esthetic, organizational and social documents and traditions,

**Institutional knowledge** as constitutional rules, democratic rules, "mores" and legal principles, morals and customs



# Disposal of radioactive waste material

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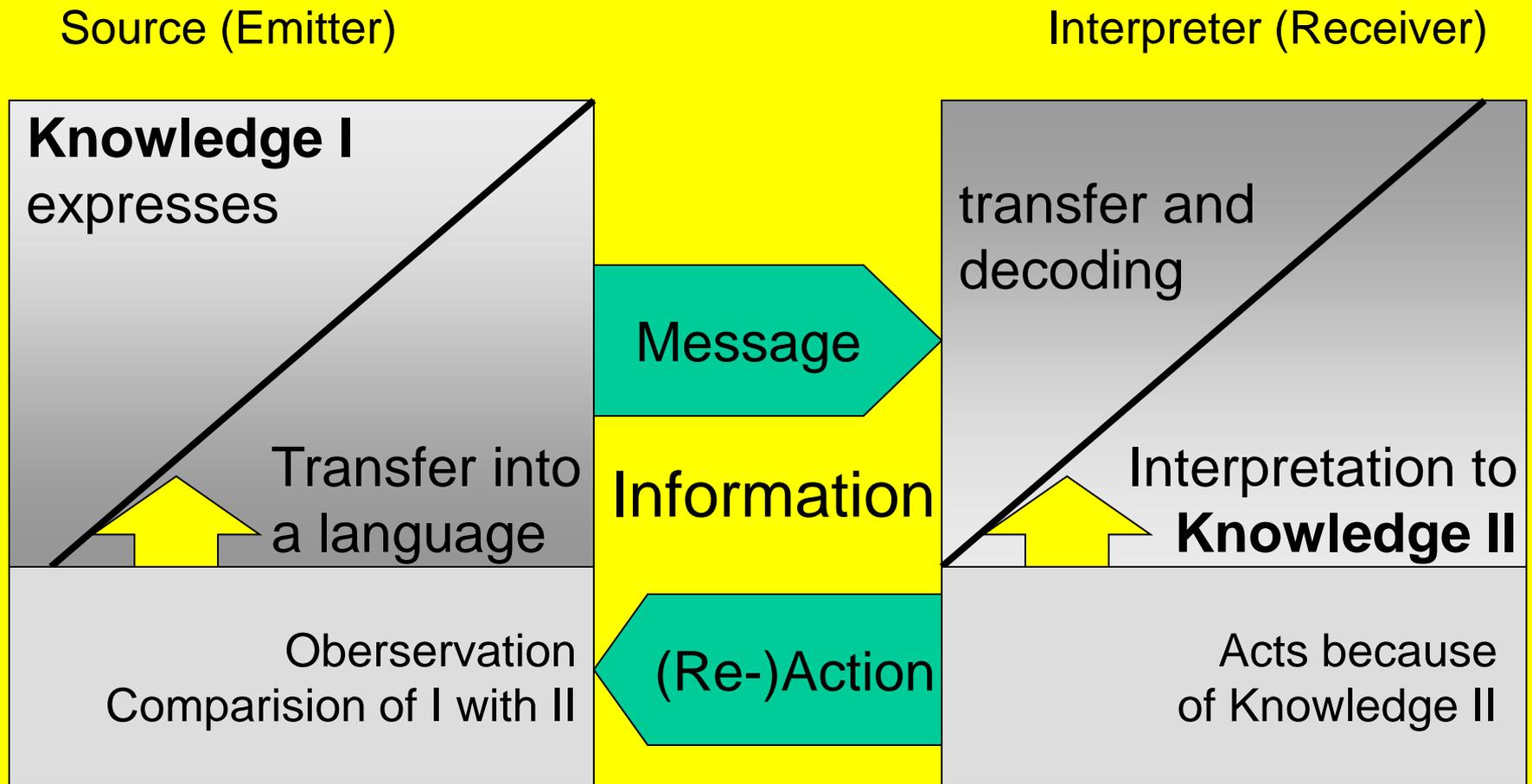
OPTIONS

Bury it and forget it
Deep repositories with retrievability
Surface storage - pending
Wait and see for better solutions
Exotic options (moon, sun, earth's core)



# **2. Time Eats Information**

# A Pragmatic Model of Communication (directly)



Semantic Closure - Context

# Model of Time Delayed Communication

Source (Emitter at Time  $T$ )

**Knowledge I**  
expresses

Transfer into  
a language

Estimation of II  
for  $T + \Delta t$

**Context I**

**Document**

*Ἐν ἀρχῇ  
ἦ οὐ λόγος*

Information

Ensuring  
Context

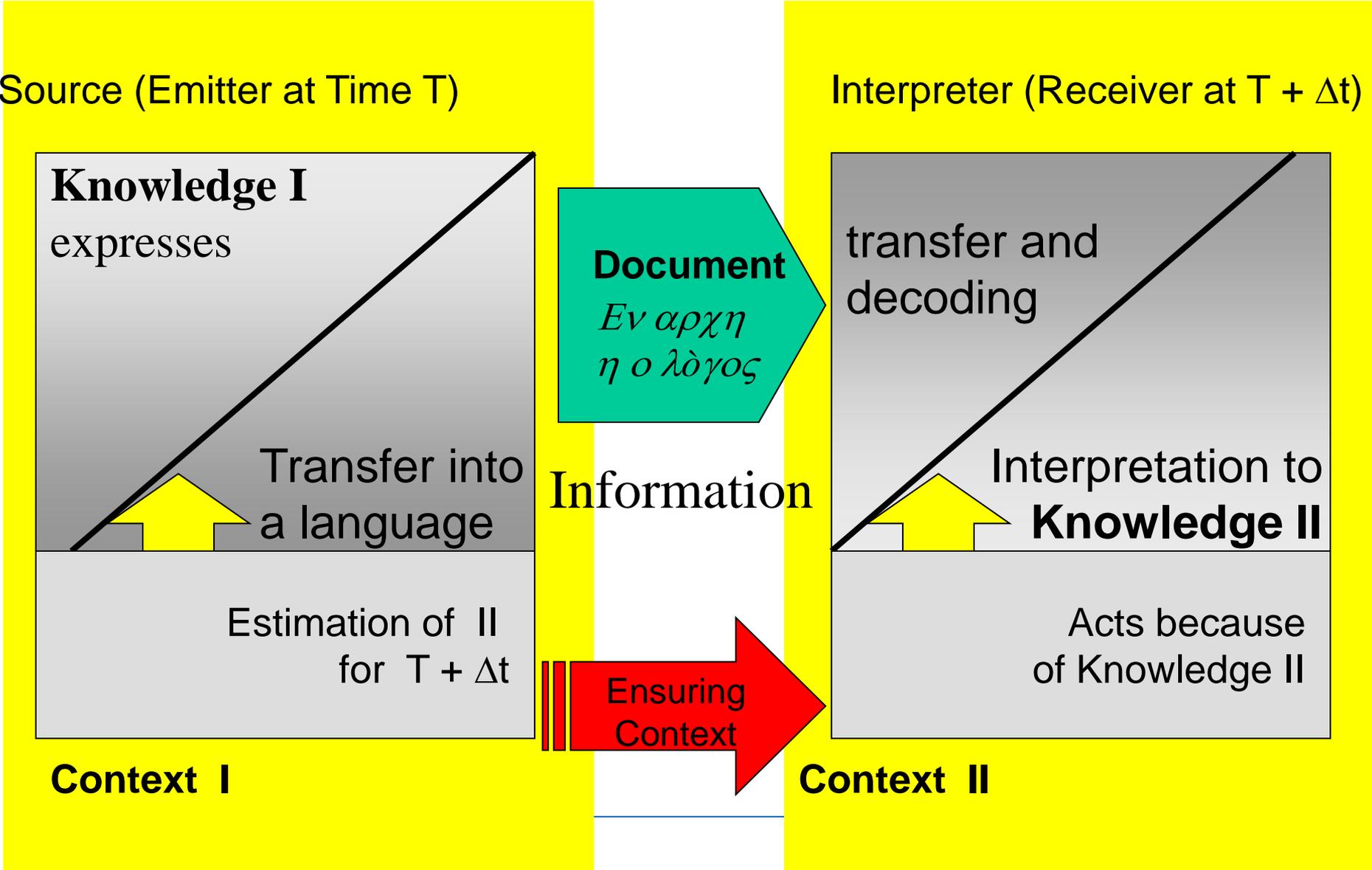
Interpreter (Receiver at  $T + \Delta t$ )

transfer and  
decoding

Interpretation to  
**Knowledge II**

Acts because  
of Knowledge II

**Context II**



## Limits of knowledge availability

Loss of personal knowledge due to disease, death and oblivion

Personal, Cognitive

Loss, decay or destruction of the information carrier (storage media), communications systems, reading and writing technologies and their organizational closure

Technical

Erosion of the timeliness and relevance

Pragmatic

Loss of ability to interpret available information into knowledge  
(**decontextualization**)

Semiotic:

Syntax, Semantic,  
Pragmatics

Change of languages and sign systems

# Durability of Information carrier

Medium	Durability in Years
Egypt. stone inscription	10 000****
Cuneiform on clay tablets	≥ 4 000*
Papyrus	≥ 2 000****
Pergament	≥ 1 000*
Books (acidic)	20-200*
Book (acid-free)	≥ 500*
Newspaper	10-30*
Microfiche	10-500**

Medium	Haltbarkeit in Jahre
Color film	30-100*
Magnettape	10-30**
Discs	5-10***
CD / DVD	30-100*
USB Sticks,	> 90 #
Hard Discs	3- >10 #
Crystal Storage	< 1000
Cloud	Lifetime of provider

\* Cf. Zimmer, D. E.: Das große Datensterben

\*\* Cf.. Grothe, A.: Verflüchtigt - Der Zahn der Zeit nagt an digitalen Daten

\*\*\* Cf.. Rothenberg, J.: Die Konservierung digitaler Dokumente

\*\*\*\* Cf. Kornwachs, K.: Haltbarkeit und Information und Tradierung von Wissen

# Cfg. [www.pc-magazin.de](http://www.pc-magazin.de)

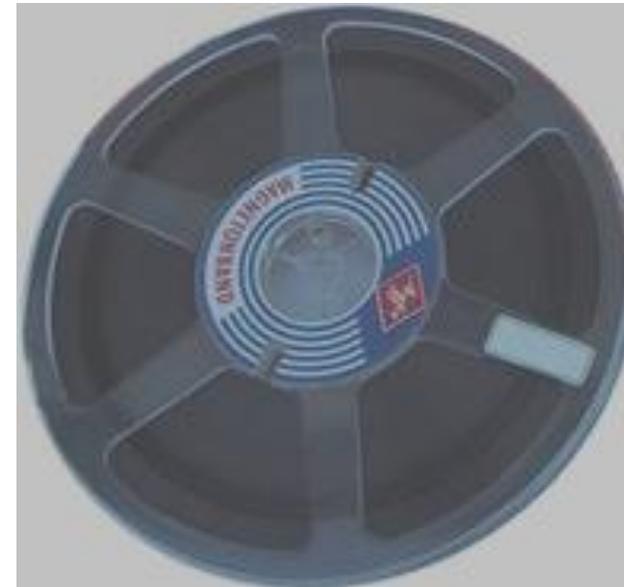
The durability of carriers depends largely on the circumstances of their storage and their frequency of use.

# Durability of Information Carrier

Codes Sinaiticus  
(Handwriting of the Bible)



Transmitted data from the NASA-Spacecraft „Viking“ 1976 \*



Carrier: Pergament  
Fonts: Greek Big Letters

Carrier: Magnet Tape

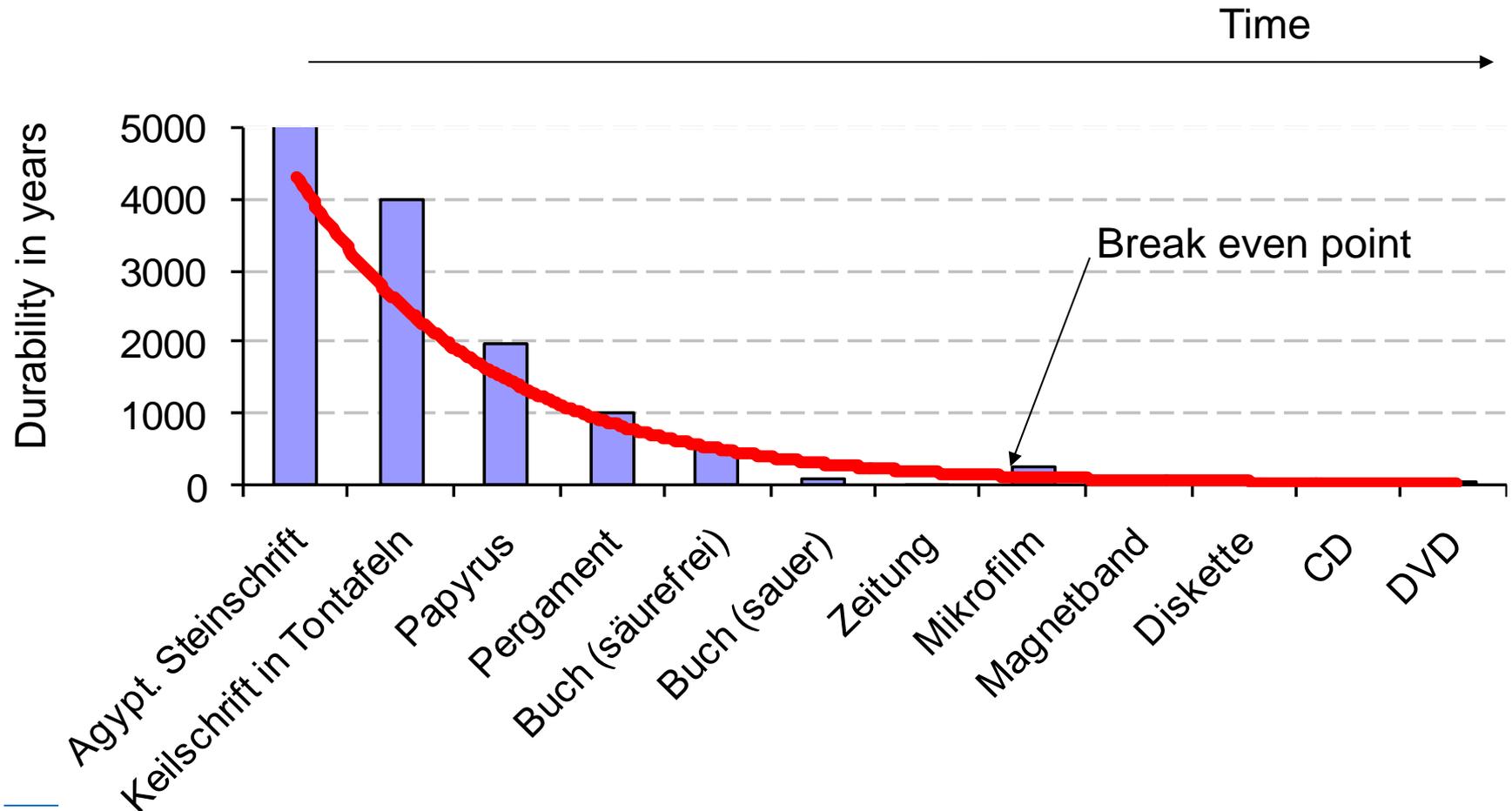
Since 1500 years the document is easily readable, if one is familiar with Ancient Greek

Since 1985 no more readable due to defects within the magnetic layer

\* vgl. Schmundt, H.: Im Dschungel der Formate

# Timing of introduction and durability of I-Carriers

Trend: Over time & history, the durability of data carriers decreased continuously.



# Basic Problem of Digital Storage of Information

**Usability is depending on::**

## **1. Availability of the information carrier**

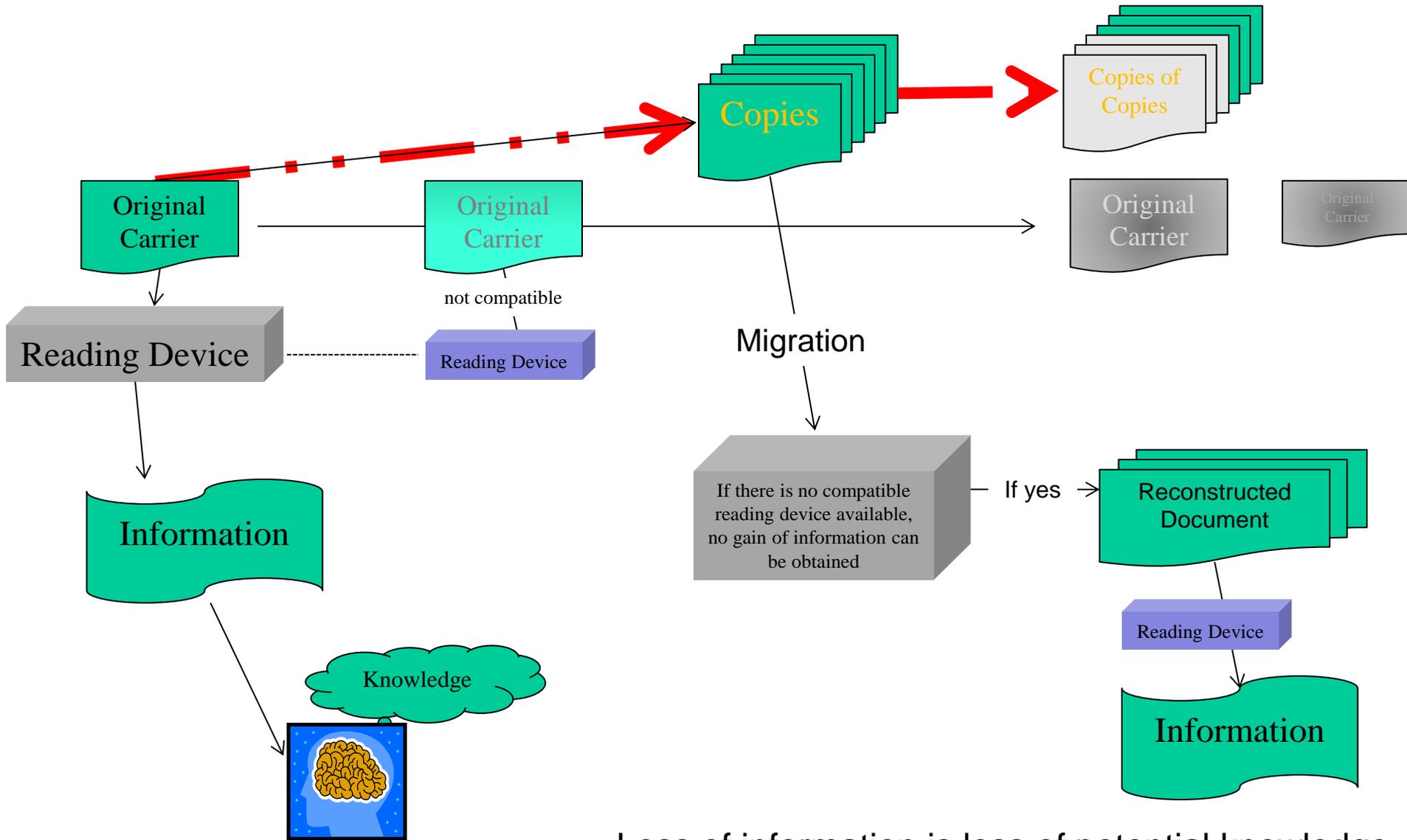
- The carrier must be readable, i.e. within the time between generation and decay

**AND**

## **2. Availability of the hardware – reading device**

- Reading device that can read the information on the carrier (same coding – encoding standard)
- I.e. for each carrier of information there must be available at least one reading device, ready to operate
- Changing architectures of reading and writing technologies, depending on computer architectures should ensure an upward compatibility

# Countermeasure against loss of information: To Copy



Loss of information is loss of potential knowledge

# Compare Original and Multiple Copy of a Letter

## Physikalisches Kolloquium

Termin: 14.05.1996  
Zeit: 16.15 Uhr  
Ort: LG 1, Raum 304

### „Ferroelektrische flüssigkristalline Polymere - eine Materialklasse mit außergewöhnlichen Eigenschaften“

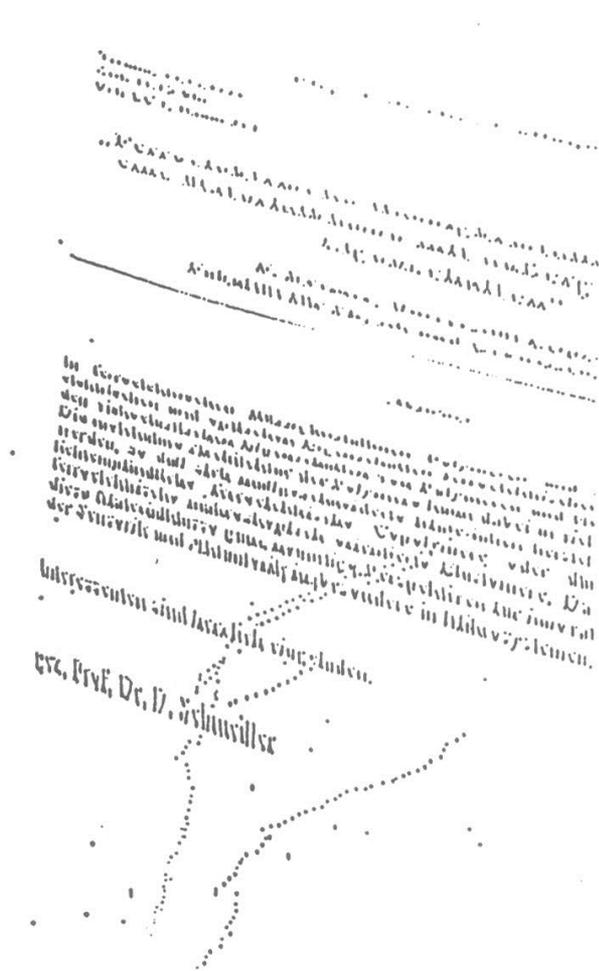
F. Kremer, Universität Leipzig,  
Fakultät für Physik und Geowissenschaften

#### *Abstract*

In ferroelektrischen flüssigkristallinen Polymeren und Elastomeren sind die elektrischen und optischen Eigenschaften ferroelektrischer Flüssigkristalle mit den viskoelastischen Eigenschaften von Polymeren und Netzwerken kombiniert. Die molekulare Architektur der Polymere kann dabei in vielfältiger Weise variiert werden, so daß sich maßgeschneiderte Materialien herstellen lassen, wie z. B. lichtempfindliche ferroelektrische Copolymere oder dünne und ultradünne ferroelektrische makroskopisch orientierte Elastomere. Damit ergeben sich für diese Materialklasse ganz neuartige Perspektiven für innovative Anwendungen in der Sensorik und Aktuatorik insbesondere in Mikrosystemen.

Interessenten sind herzlich eingeladen

gez. Prof. Dr. D. Schmeißer



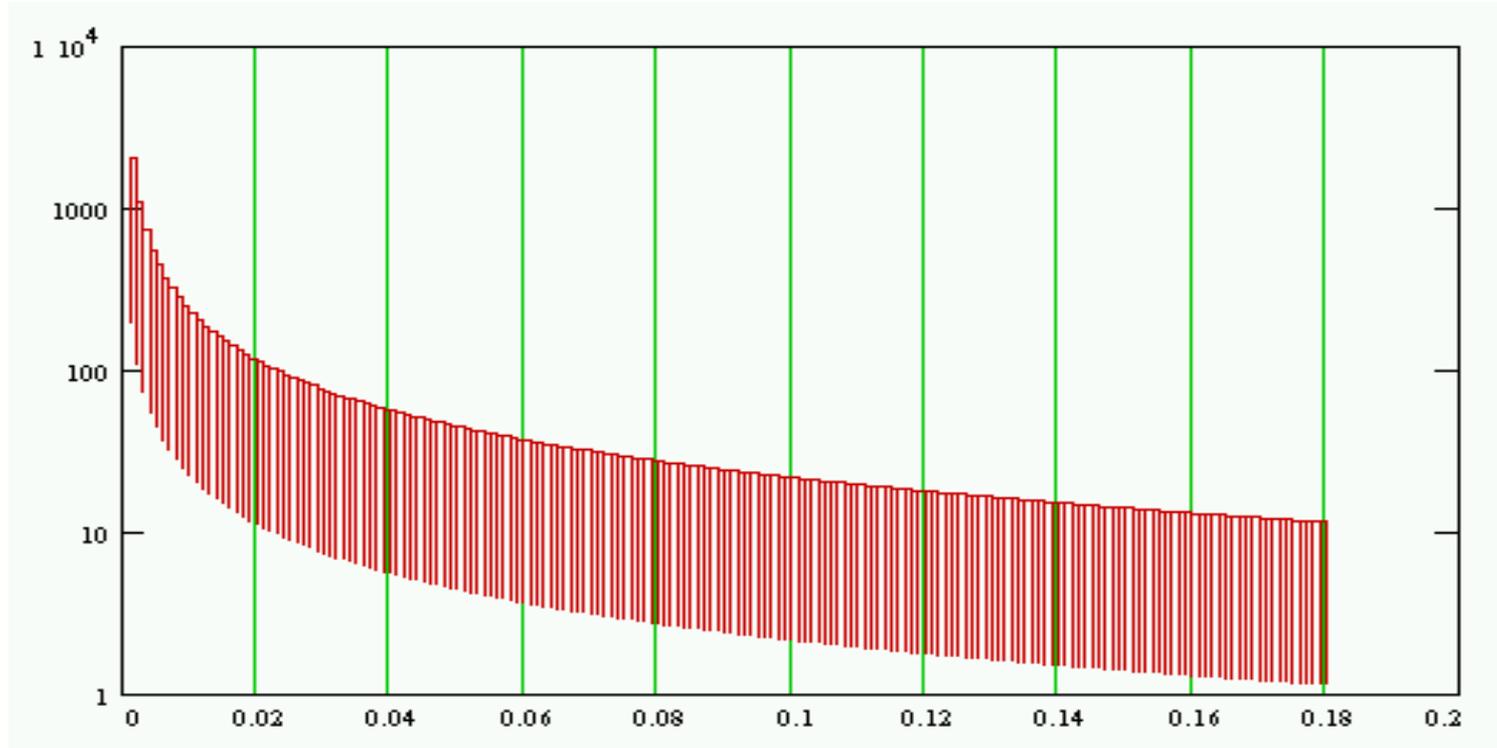
Original (left) und 82. Copy of the Copy of the Copy .... (right)\*

\* vgl. Kornwachs, K.: Wissen für die Zukunft

# Number m of copy processes

upper limit redundancy  $k = 0.8$

lower limit redundancy  $k = 0.1$



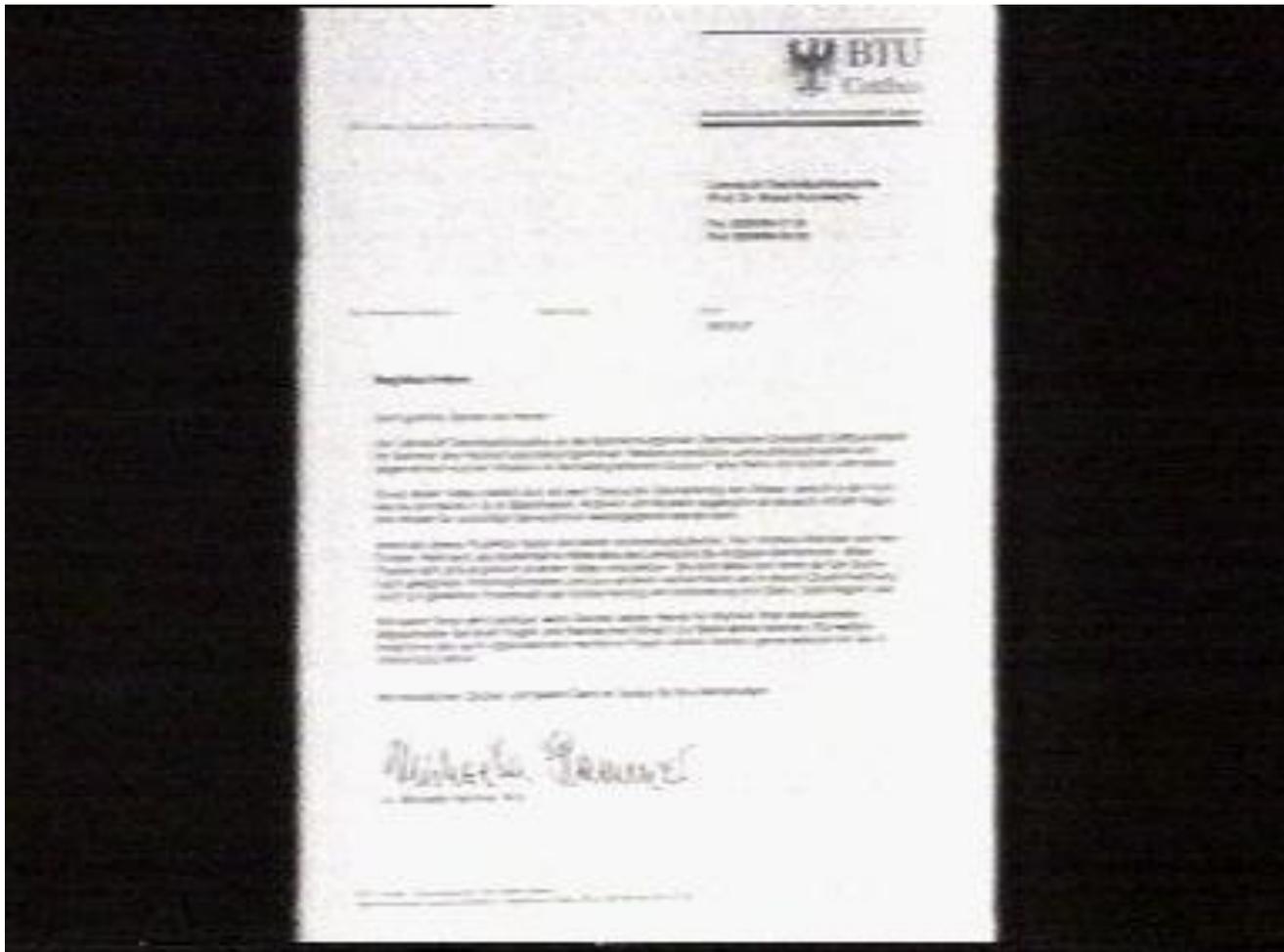
error rate  $x$

$$m \geq \frac{\log(1-k)}{\log(1-x)}$$

$k =$  redundancy

$x =$  error rate





Decay of information during a Multiple Copy Process (90 subsequent copies  
In timelaps\*)

\* Cf. Kornwachs, K.: Wissen für die Zukunft (1999)

## First Consequence:

All repair, storage, transfer, reading, writing, copying processes or data migration are information transfer processes

Each informations transfer process produces errors

In principle this holds also for digital copies (in the mean) with a better factor  $10^{-6}$  for solid state storage.

No IC – Technology known today is potentially able to keep information stored over  $10^5$  years

Facing long term effects of today technologies we have to generate again (re-generation) the information for each generation



## Re-generate the information for each generation

Ensure the readability of existing documents and information carriers by

Prolongation of the durability of carriers

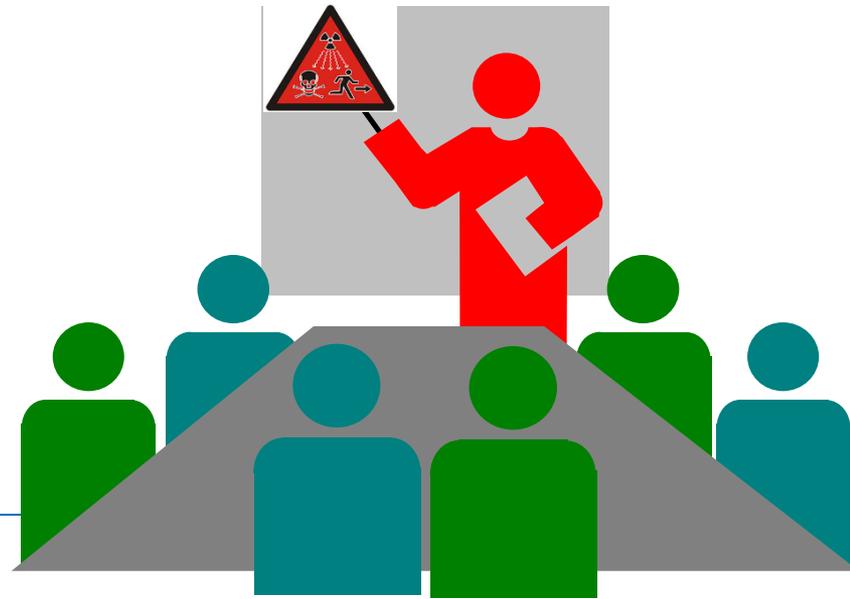
Establishing a long living adequate reading- and writing-technology for those carriers

Making copies as much as possible according to a suitable choice of time structure respecting decay times of carriers and reading and writing technologies

Produce permanently new information about existing knowledge, about the context conditions for its interpretation and about the importance of the information



What may be better?



Klaus Kornwachs  
Office for Culture and Technology

# **3. Stable Organization**

One can only try to pass knowledge on to future generations via institutions.

- An organizational solution via institutions will not be effective, unless we know what kind of knowledge will be important in the future. Thus, selection processes need to be managed. This selection is value based.
- There is no material institution thinkable / known with a stable durability for a time period more than more than ca. 3000 years.
- The solution must be the establishing of a suitable institution, using already existing ones, which may produce subsequently new institutions and so on over long time period – no everlasting eternal temple or elite

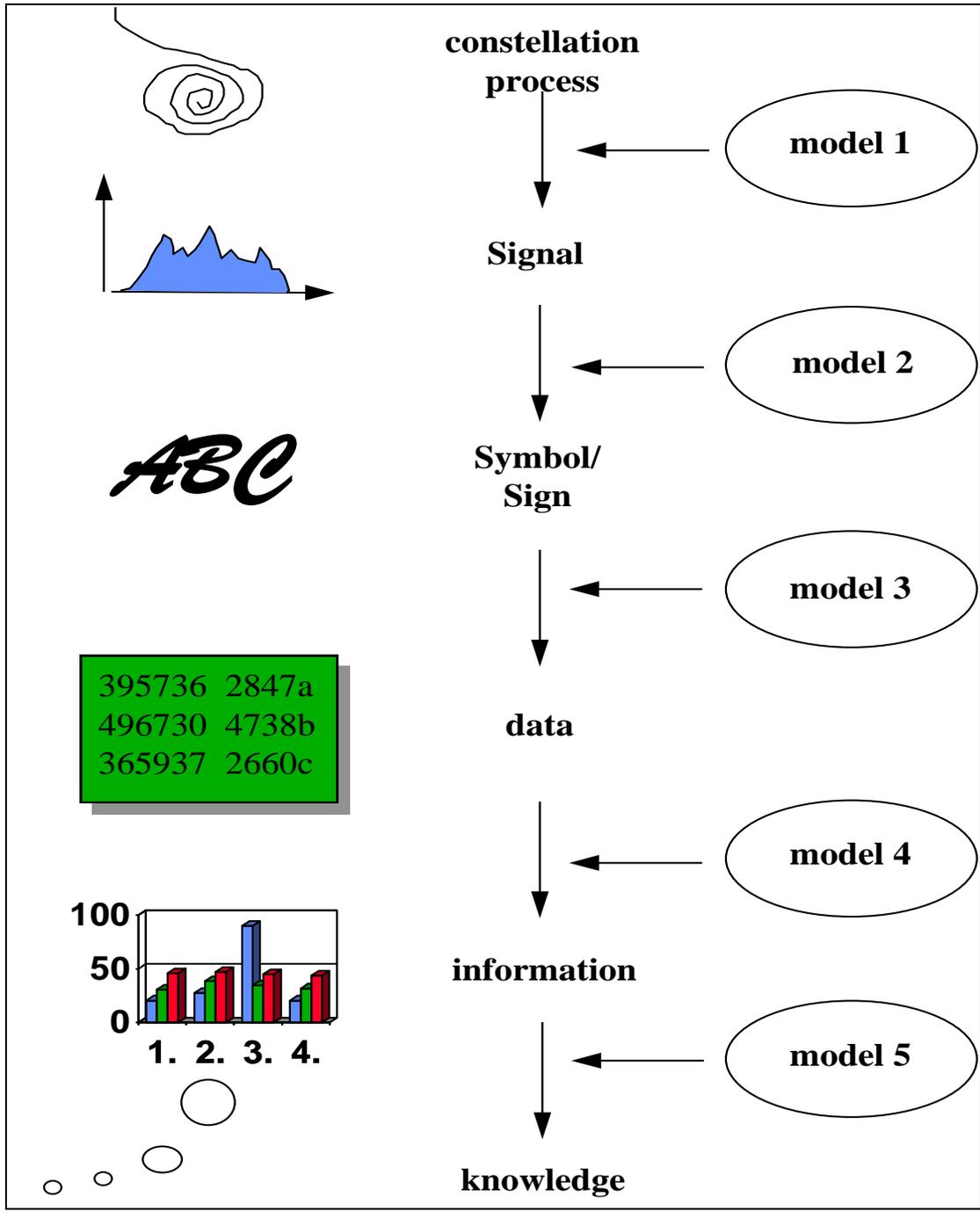
## Three Conditions:

- (1) We have to collect the information about nuclear waste sites with the help of stable institutions, which are responsible for the appropriate availability of the data.
- (2) We have to transfer not only the scientific and technological information, but we also have to ensure that it might be understood in an adequate way.
- (3) The option “*bury it and forget it*” doesn’t seem to be a reasonable one. All sites should be kept in a reversible mode. If new scientific or technologic findings will become available, one should have the possibility to manage the waste problem under new points of view. Hence, any information handed on should include the reversibility of the relevant technology.



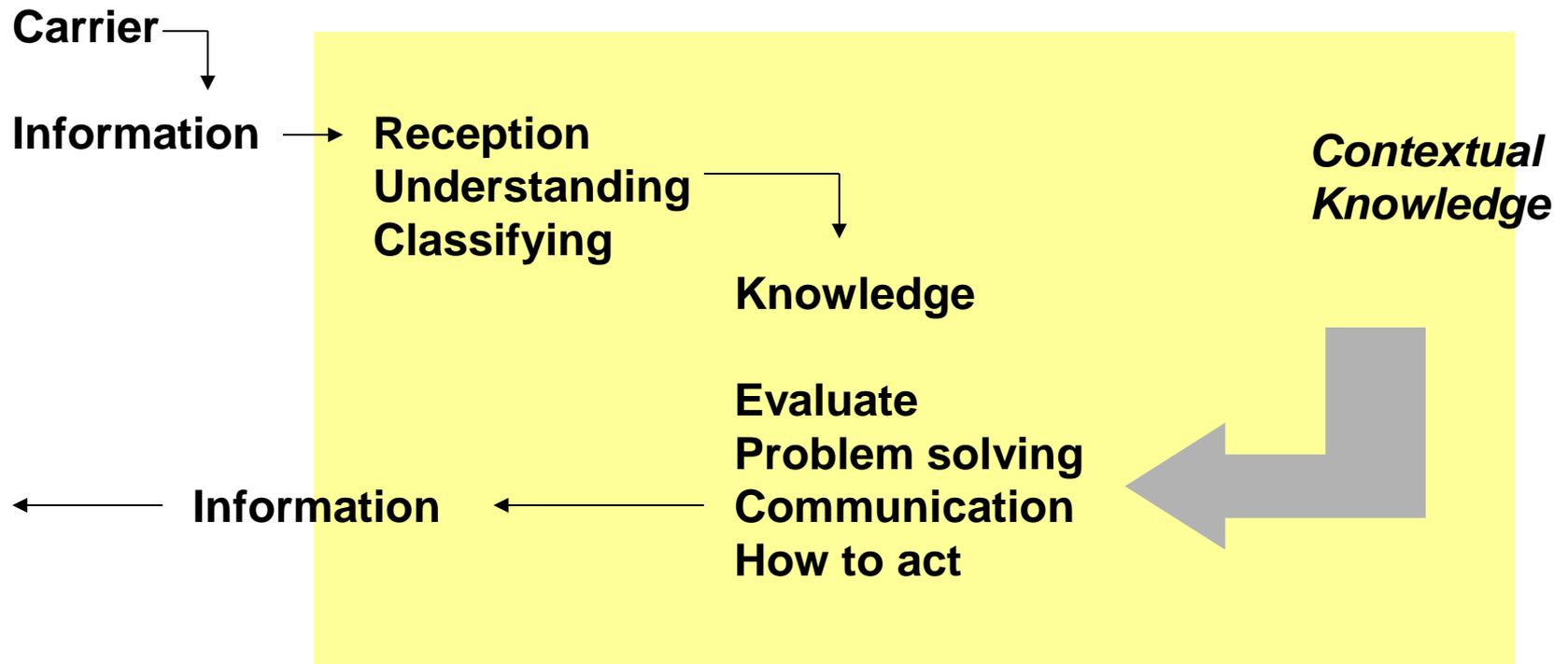
<b>Institution</b>	<b>Life Time</b>	<b>Stability Criteria</b>
Buddhism	since 600 B.C. ca 2600 years	no succession, but rebirth
Roman Catholic Church	0 - 2000	strong succession strictly value oriented
Monastery <i>Monte Casino</i>	529 A.C.	Benedictus of Nursia
Roman Empire	1000 years	Decay west east after 300
Academy of Platon	385 BC . 529 AC 914 years	consulting, policy closed by Justinian
Universities	since 870 years	Knowledge as value
Breweries	since 500 years in immediate succession (families)	“Reinheitsgebot” purity of beer
Scientific Academies	> 314 years Berlin—Brandenburg.	scientific method
Well established firms	since 300 years	quality, traditional values
Small and mean enterprizes (KMU)	since 170 years	quality, market. handicraft
Socialism	1917-1990 ca 75 years	world revolution, unified ideology
Period of peace in middle europe	since 1945 > 55 years	nuclear balance
Constituted countries	30-40 years	democratic values enlightment, even monarchies
Research Institutes	120 years	science
Deutsche Gesellschaft der Naturforscher und Ärzte	122 years	science

# **4. Information is not yet Knowledge**



# How to deal with Knowledge

## Information $\neq$ Knowledge



New knowledge is generated by a cognitive process when information has been received and understood. This new knowledge is going to be integrated into already known knowledge.

Knowledge can be expressed by producing information and thus it can be communicated

Stored information is not yet knowledge

We have to take into account  
necessary time for  
I2K = Information to Knowledge



# **5. The Possibility to Act in a Responsible Way**

Finally, we need to clarify the ethical foundation of any obligation to future individuals, whom we would force to deal with our technological heritage.

- We are responsible towards our children to manage good conditions for a good life.
  - We can assume that our children feel responsible to their children to manage good conditions for their good life.
  - Good conditions for a good life include that one is able to manage good conditions for a good life for the own children.
  - Good conditions for a good life are also the possibilities to act in a responsible way for oneself and the others respectively .
-

Thus we have the duty to imagine: what could be the accepted norms for future generation? We should not act in way that may force future generation to act against their norms and values.

## **Principle:**

Act in such way, that the conditions for the possibility to act in a responsible way is preserved for all individuals involved



The conditions for the possibility to act in responsible way are:

- not to be forced to violate own convictions, beliefs and moral principles
- not to be forced to decide a dilemmatic situation in which all options will lead to unacceptable consequences
- to be free
- to know everything that is necessary to make a morally satisfying decision
- to know if one is responsible towards whom for what an issue



There is a simple ethical reason:

We should not lead future generations into dilemmatic situations in which they cannot act in a responsible way anymore.

We have also to hand on the **strong conviction** that the dissemination of information about the nuclear waste problem is essential for each subsequent generation in order to enable knowledge for them.



The least we can do is to keep them informed effectively.

The next generation will have the same task, and so on and so on. (Induction from  $n$  to  $n+1$ )

Any long term solution must start with a short term solution

Nevertheless, this will be only a necessary condition for them to keep the possibilities open to act in a responsible way today and in far future years.





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Bereich	Zyklen	Vorhersagehorizont bzw. typische Zeiträume	Planungs- horizont
Sonnenzyklus	11,2 Jahre (gemittelt)		
Wetterbericht		2 Std. - 2 Tage	
Verkehrschao		2 Std. - 1 Woche	
Wahlrends		2 Monate	4 Jahre
Konfliktforschung, Geheimdienste	6 Jahre Häufung bewaffneter Konflikte gemittelt über 2557 Jahre	2 Monate	2 Monate - 5 Jahre
Börsengeschehen	4 Jahre, Aktienpreise	1 Std. - 4 Monate	< 1 Std. - 4 J.
Großwetterlage	Jahreszeiten, 3 Monate	2 Monate bis ein Jahr	„Bremsweg 150 Jahre“ <a href="#">[2]</a>

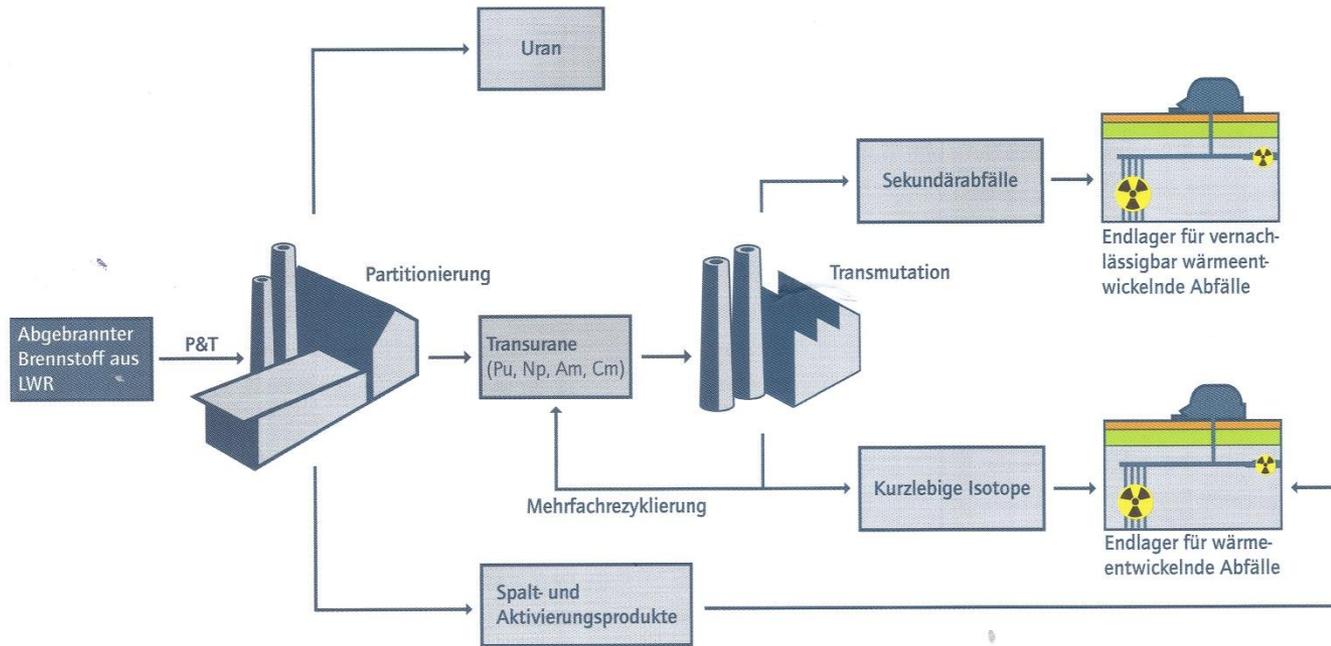


Bereich	Zyklen	Vorhersagehorizont bzw. typische Zeiträume	Planungs-horizont
Technikfolgenabschätzung (I&K, KKW, Raumfahrt)	Innovationszyklen (produkt- und technologiespezifisch) 2-10 Jahre	2 - 5 Jahre	z.T. bis 30 Jahre
Dokumentation von Software		5 Jahre	3-4 Jahre
Automobilfirma		10 Jahre Entwicklungszeit	20 Jahre
Seuchenprävention, Hygiene		12 - 30 Jahre	5 - 6 Jahre
Technisches Wissen		30 Jahre	50 Jahre
Wissenssicherung	Backup alle 30 Jahre	50 Jahre (Kulturgüter)	Soll: 10000 J (?)
Tradierungszeiten schrift- licher sprachlicher Überlieferung	mittlere Lebensdauer einer Sprache ca. 6000 Jahre	2500 bis 4000(?) Jahre	
Zyklentheorie (Kondratjeff)	52 - 54 Jahre	z. Zt. Informations-Kondratjeff, Übergang zur Biotechnologie	50 Jahre
Philosophie	Ethik-Boom immer am Ende eines Jahrhunderts, also ca. 100 Jahre	100 - 200 Jahre Entwurfshorizont bzw. durchschn. Dauer von Epochen	?
Klimatische Veränderungen	A: 230-1000 Jahre B: 1000-3600 Jahre C: 21000 Jahre	max. 100 - 200 Jahre	?
Radionuklide	Klaus Kornwachs Office for Culture and Technology	Halbwertszeiten von 1 $\mu$ sec bis > 20000 Jahre	



Bereich	Zyklen	Vorhersagehorizont bzw. typische Zeiträume	Planungs-horizont
Astronomisches Wissen		5 10 <sup>9</sup> Jahre	30 - 40 Jahre im Sonnensystem
Toxische Stoffe (Deposit)		?	?
Gentechnisch veränderte Organismen		?	?
Softwareanwendung	2 - 20 Jahre	?	10 Jahre ?
Aufbewahrungspflicht betrieblicher Dokumente (Steuerrelevant)		10 Jahre	
Techn. Lebensdauer	Elektronik: kleiner 10 Jahre, Bauwerke: durschn. 80 Jahre	5 - 10 Jahre moralischer Verschleiß nach 80 Jahren, Restaurierung nach 100 Jahren	20 Jahre
Entsorgung (Müll)		Soll: 10 - 20 Jahre	Soll: 500 Jahre
Überbevölkerung	Verdopplungsdauer sinkt rasch	100	200
Ende der menschlichen Zivilisation		100000 Jahre	





# Lebensdauern von Informationsträgern

durchschnittliche Haltbarkeit  $t_{\emptyset} = 1/\lambda$ , mit  $\lambda$  als der jeweiligen Zerfallskonstanten, mittlere Lebensdauer der damit verknüpften Lese- und Schreibtechnologie  $\Delta t_T$ , geordnet nach der Reihenfolge der technischen Entwicklung. Angaben entnommen aus (a) Scriba (1993), (b) Weber (1992), (c) Rothenberg, Bild 2 in (1995), (d) Behrens (1995), (e) Bogart (1995), (f) eigene Schätzung Kornwachs (1995(a)), (h) Schilling (1998), (i) Petersen (1998), (k) Liers, Dose (1998), (l) Nowotka et al. (1998). Angaben mit (\*) beziehen sich auf die Haltbarkeit bei extremer Beanspruchung wie Dauerbetrieb.

Medium	durchschnittliche Haltbarkeit $t_{\emptyset}=1/\lambda$	Ref	$\Delta t_T$
menschliches Gedächtnis	70-120 Jahre	<i>f</i>	-
Felsmalerei	20 000 - 10000 Jahre	<i>f</i>	-
Steintafeln (z.B. Stein von Rosette) (Hieroglyphen)	10 000 - / 2500 Jahre	<i>a,f / c</i>	-



<b>Medium</b>	<b>durchschnittliche Haltbarkeit <math>t_{\emptyset}=1/\lambda</math></b>	<b>Ref</b>	<b><math>\Delta t_T</math></b>
Papier (Papyros) , Handschriften (Qumran)	2500 - 2000 Jahre	<i>a, f</i>	-
Papier Mittelalter (Pergament)	1000 Jahre/ >1200	<i>a / b</i>	-
Hadernpapier	> 1000 Jahre	<i>b</i>	
Papier, säure- und ligninfrei, gepuffertes, alterungsbeständig, //entsäuert oder alkalisch	300 - / mehrere $10^2$ Jahre // 300 - 400 Jahre	<i>a / i</i> <i>//b, i</i>	-
Papier, holzschliffhaltig, säurehaltig bzw. saure Leimung (jünger als 150 Jahre)	100 - 200 Jahre, /50-80 Jahre // 30-40 Jahre	<i>a, b</i> <i>/d, k</i> <i>// i</i>	-
Papier, Recycling	10-20 / 30 Jahre	<i>i / a,</i> <i>b</i>	-
Papier, Thermo für Fax	2 - 10 Jahre	<i>f</i>	< 50 J



<b>Medium</b>	<b>durchschnittliche Haltbarkeit <math>t_{\emptyset}=1/\lambda</math></b>	<b>Ref</b>	<b><math>\Delta t_T</math></b>
Nitrofilm (alt)	20 - 50 Jahre, konserviert > 104 Jahre[1]	<b>a</b>	70 J
Filme, Silberhalogenid auf Acetat-Basis (Mikrofilme)	300 Jahre	<b>b</b>	> 100 J
Farbfilm, chromogen, gekühlt	250 Jahre		> 100 J
Farbfilm (Farbechtheit)	50 Jahre	<b>a</b>	> 100 J
Farbfilm, chromogen, Diazo-Vesicular-Mikrofilme	100 Jahre	<b>b</b>	60-70J
Farbfilm im Farbbleichverfahren "Cibachrome-Micrographics"	400 Jahre	<b>b</b>	?
Film Silberhalogenid auf Polyester-Basis	1000 Jahre	<b>b</b>	> 60 J[2]
konservierter Film	100 Jahre	<b>a</b>	?



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[1] Der älteste Film im Deutschen Filmmuseum ist auch der älteste deutsche Film überhaupt, hergestellt 1895 von den Gebrütern Stadanowski (Koppe 1998). 47 Die Formate beim photographischen Film sind noch sehr vielfältig, beim CineFilm sind nur noch 75mm, 35mm, Super16 und Super8 üblich, für Normallicht, 9,5mm und 17,5 mm gibt es so gut wie keine Projektions- oder Kopiermöglichkeiten mehr (Koppe 1998).

<b>Medium</b>	<b>durchschnittliche Haltbarkeit <math>t_{\emptyset}=1/\lambda</math></b>	<b>Ref</b>	<b><math>\Delta t_T</math></b>
Magnetplatte, Diskette	5 - 10 Jahre / 10 - 30 Jahre // 50 Jahre [1] /// 50- 100 Jahre	<i>c/e,</i> <i>b//l/</i> <i>//a,</i>	5-10 J
Magnetband, Tonband, Video	6 Jahre*/10 - 30 Jahre // 50 - 100 Jahre /// 1-2 Jahre*	<i>f</i> / <i>h/a,</i> <i>f// e</i> <i>//c</i>	10- 50 J
Laser Disk, CD	2-3 Jahre*/10 - 30 Jahre // 20 - 100 Jahre	<i>h/a,</i> <i>f,h//</i> <i>e</i>	20 J
Chip	20 Jahre	<i>f</i>	10- 20J
Stahlplatte Voyager	1 000 000 Jahre (Vakuum)	<i>a</i>	-

[1] Firmen wie Kodak geben auf magnetische Träger eine Garantie von 50 Jahren (Nowotka et al. 1998).



Medium	Erstellungsaufwand	Erschließungsaufwand
Stein von Rosette	Gravur als Schrift oder Bild	i.A. direkt visuell, d.h. niedrig, sprachlich ggf. sehr hoch wegen Entzifferung
Pergament	Schreiben (manuelles Auftragen von Farb- oder Kontraststoff auf Oberflächen)	ggf. Kontrastverstärkung, visuell, sonst: nur sprachlicher Aufwand
Papier	Druck, mech. oder elektronisch Setzen	visuell, ggf. Kontrastverstärkung, „Lupe“
Mikrofiche, Film	Photographieren, Verkleinern	Vergrößern, künstliches Licht
Magnetische Speicherung (Band, Diskette etc.)	elektronische Codierung, Hardware, Software	elektronische Decodierung Kontext bezüglich Hardware und Software erforderlich
Denkmäler	baulicher Aufwand	unübersehbar, haltbar, aber ohne Kontext nicht zu entziffern
Genetische Speicherung	evolutionär veränderlich, Molekularbiologie, DNS-Sequenzen	Das „Lesen“ ermöglicht erst die Ontogenese - der Organismus liest seinen eigenen Bauplan, indem er wächst



## Normen einer Wissensweitergabe an die Zukunft

**Grundnorm der Zukunftsethik:** Die Handelnden dürfen zu den Zukünften beitragen (besser: dürfen die absehbar langfristigen Projekte beginnen), in denen ihre Handlungen und deren absehbaren Folgen keine heute akzeptierten und in Zukunft vorstellbaren Normen verletzen. D.h. daß die Projekte (oder besser Trajekte) so angelegt sein müssen, daß sich die Situation für die vorgestellten zukünftigen Menschen nicht derart verändert, daß diese gezwungen wären, in ihren Handlungen heute als gültig akzeptierte oder in Zukunft vorstellbare Normen zu verletzen. Dies könnte man als eine Grundnorm der Zukunftsethik ansehen.

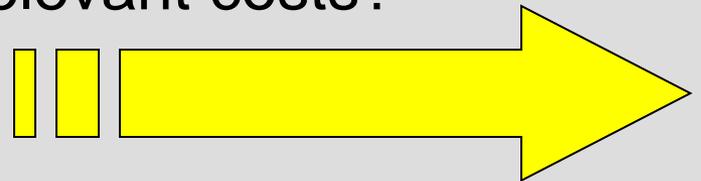


# Problem of Selection

What is necessary to be known for future generations  
- Debate about Curricula for the next generation

What may be worth to be printed, distributed, stored,  
broadcasted, archived with relevant costs?

What is a reasonable time span?



Do we have the knowledge we need and do we really the  
knowledge we have?



PROKON TV-Kampagne



## Strong Sustainability

All kind of knowledge should be handed on in order to preserve options

If there is knowledge which has been decided to be essential, it must be handed on

There are limits of substitution: certain knowledge cannot be substituted by another one – e.g. codes, signatures, natural science etc.

Formal Institutions	Material Institutions
<p>Abstract Concept</p> <p>Rules</p> <p>Leading Principles</p> <p>Independent upon actual historic events or individuals</p> <p>Plays a role in history of ideas</p>	<p>Concrete Concept</p> <p>Adress</p> <p>Organisation, Members, Foundation and Dissolution (History)</p>
<p>A kind of carrier is necessary</p>	<p>Act as a subject</p>
<p>Example: To be married, School as an educational must, some habits in groups</p>	<p>Authority, Adminstration, Churches, Universities, Academies. Monasteries etc.</p>
<p>Rules and rituals</p>	<p>Strong rules for succession in leadership</p>
<p>Memory by rituals, festivals, celebration</p>	<p>Passing on of knowledge by handling the conservation, coping of documents, education, teaching and examination</p>
	<p>Constant structure of values and priorities between them over a long time</p>
<p>Preference of historic grounding</p>	<p>Resilience against political changes</p>
	<p>Production of new knowledge according the correspondence principle</p>

Institution	Reason of the end historical / potential	Knowledge handling
Buddhism		oral tradition, written texts, monasteries, life span being monk
Jewish Culture		periodical rites, worships and text reading
Roman Catholic Church		same
Monastery Monte Casino		copy and handwriting books
Roman Empire	extension versus inertia, wrong decision by Diocletian	scriptures, monuments schools
Academy of Platon	political reasons religious reasons	dialog against <i>scriptism</i>
Universities	some closed due to finance / political reasons	unity of learning and teaching people
Breweries	market	know how, secret “receiptures”
Scientific Academies	public budget	publication
well established firms	market	confidence, trust
little and mean enterprizes (KMU)	market	
Socialism	world economy	unified interpretation of natural world, history and social issues
period of peace in Middle Europe	migration, civil conflicts	knowing each other secret services
constituted countries	changed policy	trading constitutions
Research Institutes	ineffectiveness, change of sc. paradigms	publications transparency
GDNÄ		publication, meetings

$k \in \{0,1\}$	Redundancy,
$N \in \mathbb{N}$	Number of digits or signs
$x \in \{0,1\}$	Error rate
$m \in \mathbb{N}$	Number of copy from the copy from the copy ...

Each copy process delivers  $x \cdot N$  disturbed signs and  $N(1 - x)$  undisturbed signs.

The number of still undisturbed signs after  $m$  copy processes will be  $N(1 - x)^m$ .

If the number of still undisturbed signs falls under the rate of a minimal amount given by redundancy  $k$ , i.e.  $(1 - k) \cdot N$ , each subsequent copy process will produce a loss of information.

Only if  $N \cdot (1 - x)^m \geq (1 - k) \cdot N$  we have no loss of information up to the  $m$ -th document. Thus the utmost number of copy you can make is

$$m \geq \frac{\log (1 - k)}{\log (1 - x)}$$