Appropriate Technology
From Idea to Experiment to Sustainable Practice

Lecture at *Universidad de Puerto Rico Recinto de Mayagüez*

Mayagüez, Puerto Rico, 16 August, 2012
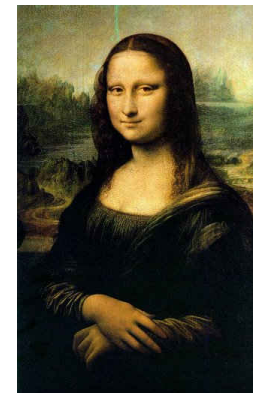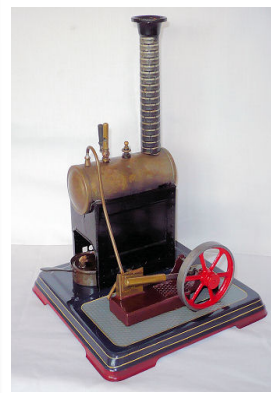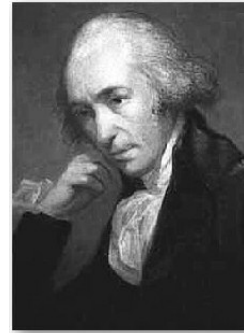
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Which of these things belong together?

Is this thing an **artifact?**

| ✗ | ✓ | ✓ | ✓ | ✓ | ✓ |

Is this thing a **technology?**

| ✗ | ✓ | ✗ | ✓ | ✗ | ✓ |

Motivation for Appropriate Technology

"We must do what we conceive to be the right thing … My only business, the only real job we have, is to look after, to the best of our ability, the little people who can't help themselves. If education and the advantages that we have had from society are only so that we might form a sort of trade union of the privileged, then our soul is so burdened with darkness that life is not worth living."

(Dr. E. F. Schumacher, 1979)

Example: Iriri, Solomon Islands; Micro-hydroelectricity and Community Development

When is a technology an "appropriate" technology?

A technology is an "appropriate" technology when it is tailored to fit the psychosocial and biophysical context prevailing in a particular location and period in time.

(Willoughby, 1990)

Before we more fully develop the concept of **"Appropriate Technology"** let's look more closely at what is meant by the word **"Technology"**

Defining "Technology" …

"We sense that we know 'technology' when we see it. And no doubt that is correct, most of the time. But it is not correct all of the time. Therein lies the delusion. You can prove that for yourself by trying to find a definition of 'technology' that everybody can agree on. The more you try, the more you will discover what a horribly imprecise concept it is."

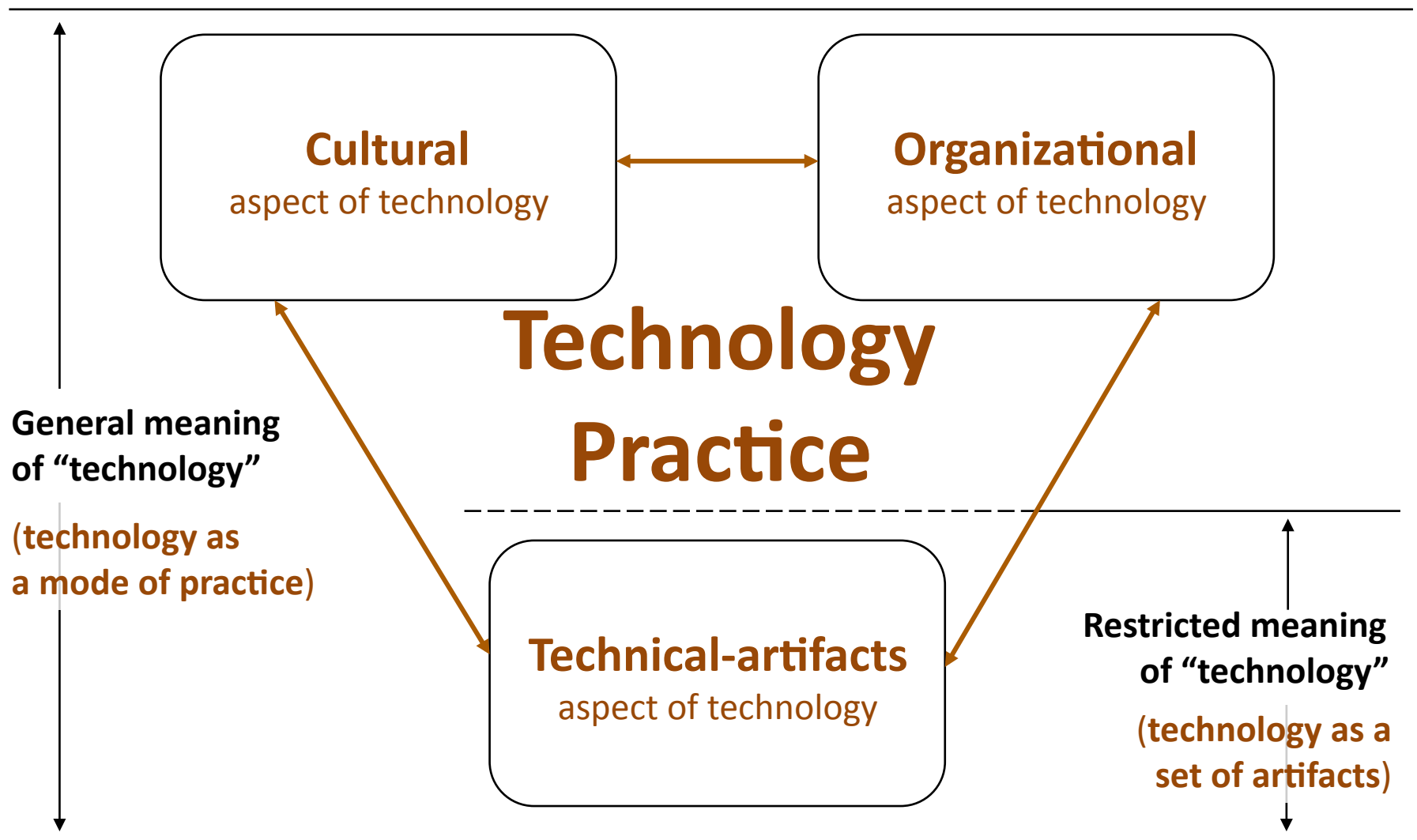Peter Prescott (Judge in the British patent courts), 2007.

Source: Philip Leigh, *Software and Patents in Europe* 6 (Cambridge Univ. Press 2007 (quoting *Patent Applications by CFPH LLC* [2005] EWHC 1589 (Pat.)).

But before we can properly understand "Technology" we need to understand the distinction between

Technology as a
set of technical artifacts

and

Technology as a
mode of technology-practice

Technology Practice

Cultural
aspect of technology

Organizational
aspect of technology

Technical-artifacts
aspect of technology

General meaning
of "technology"

(technology as
a mode of practice)

Restricted meaning
of "technology"

(technology as a
set of artifacts)

Derived by Willoughby from Arnold Pacey, 1983.

Mode of Technology-practice

- **Technology-practice**:

  The ensemble of operations, activities, situations or phenomena which involve technology to a significant extent

- **Mode of Technology-practice**:

 A particular way of practicing technology

  This term "mode of technology practice" embodies the recognition that specific technologies may be employed as part of technology-practice in a wide variety of ways, and that technology-practice itself may take a variety of forms.

"Appropriate Technology" (AT)
is a particular
mode of technology-practice.

But …
What actually is "Technology"?

?
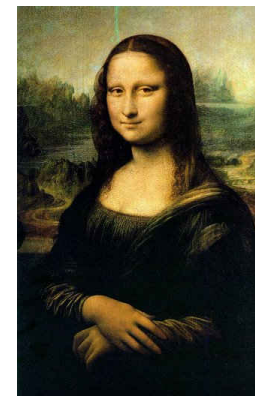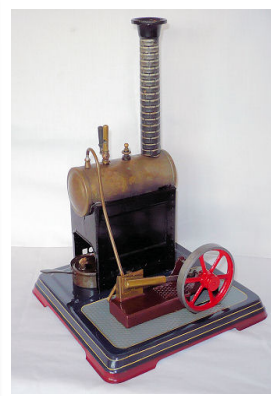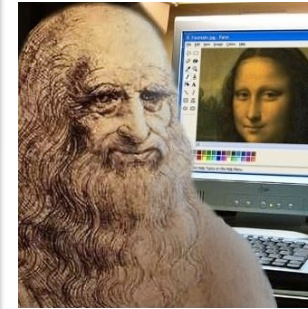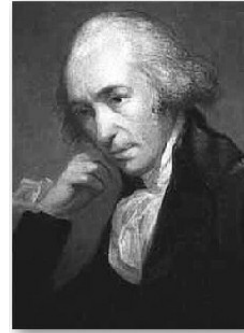
Which of these things is an **artifact?**

✗ ✓ ✓ ✓ ✓ ✓

Which of these things is a **technology?**

✗ ✓ ✗ ✓ ✗ ✓

Short-hand Definition of "Technology"

A technology is an artifact intended to function as a relatively efficient means.

Elaborated Definition

Technologies are artifacts or systems of artifacts, either tangible or intangible, intended to function as means towards the attainment of predetermined ends in a rational, efficient and causal manner.
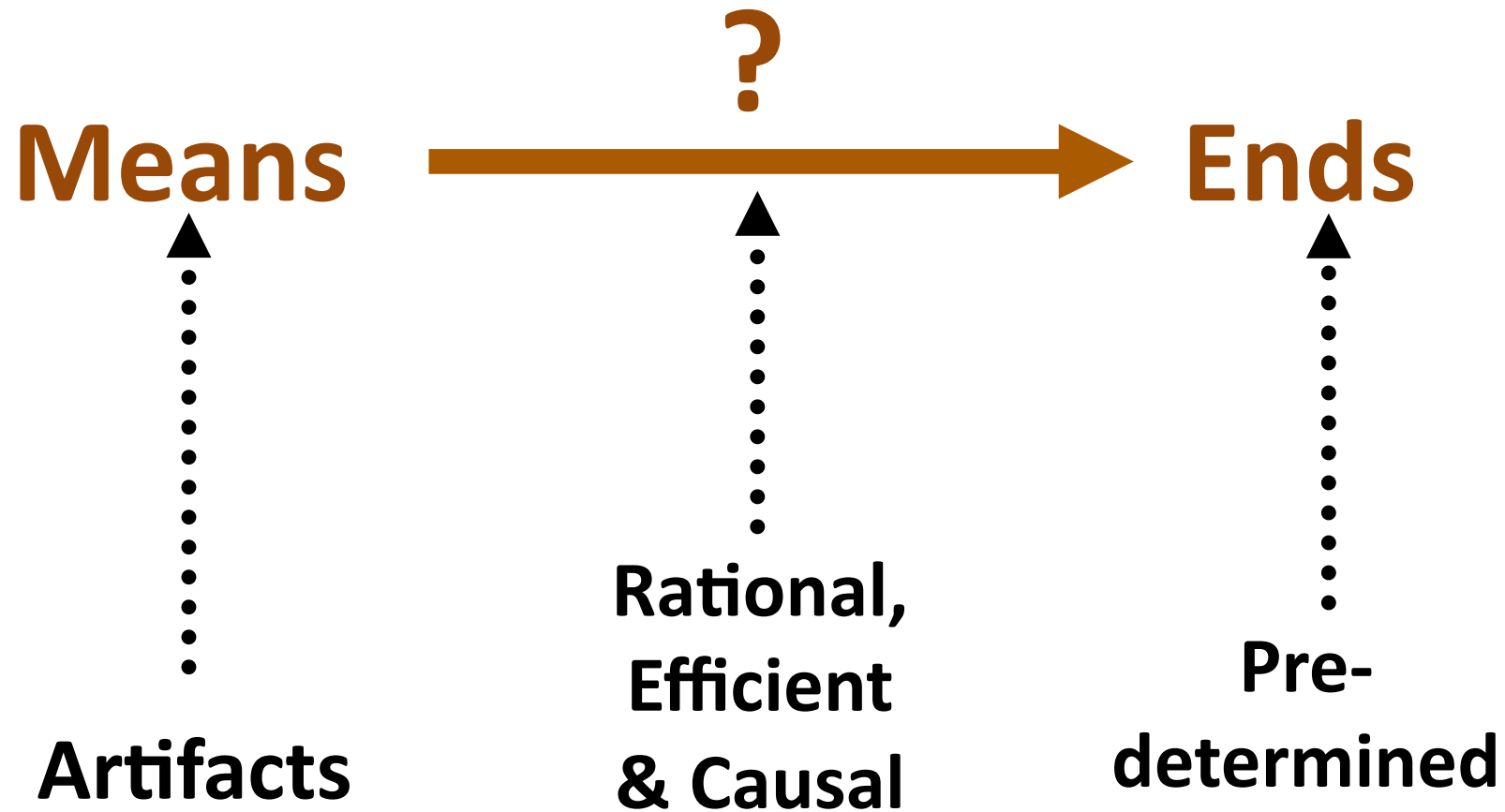
Technology

"Technicity" is the essence of technology.

Technical / instrumental relationship between means and ends

Means ⟶ **Ends**

Artifacts

Rational, Efficient & Causal

Predetermined

Technology

Means → Ends

Technical / instrumental relationship between means and ends

Zone of Technicity
(technical zone)

Artifacts

Rational, Efficient & Causal

Predetermined

Technicity (the essence of technology) is characterized by the rational, efficient and causal relationship between artificial means and predetermined ends.

General Definition of "Technology"

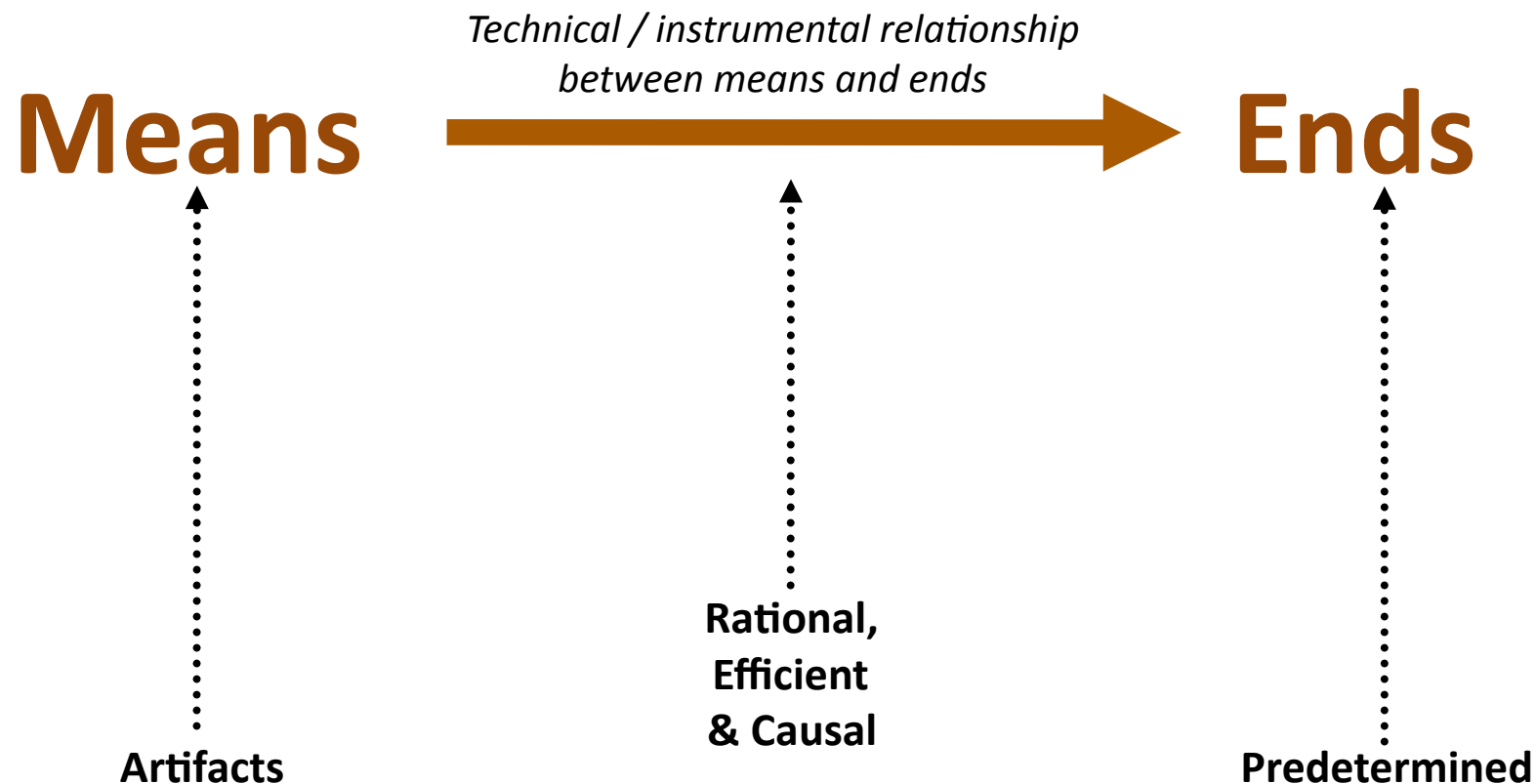Technology is the ensemble of artifacts or systems of artifacts, either tangible or intangible, intended to function as means towards the attainment of predetermined ends in a rational, efficient and causal manner.

Professor Huyke's Definition of "Technology"
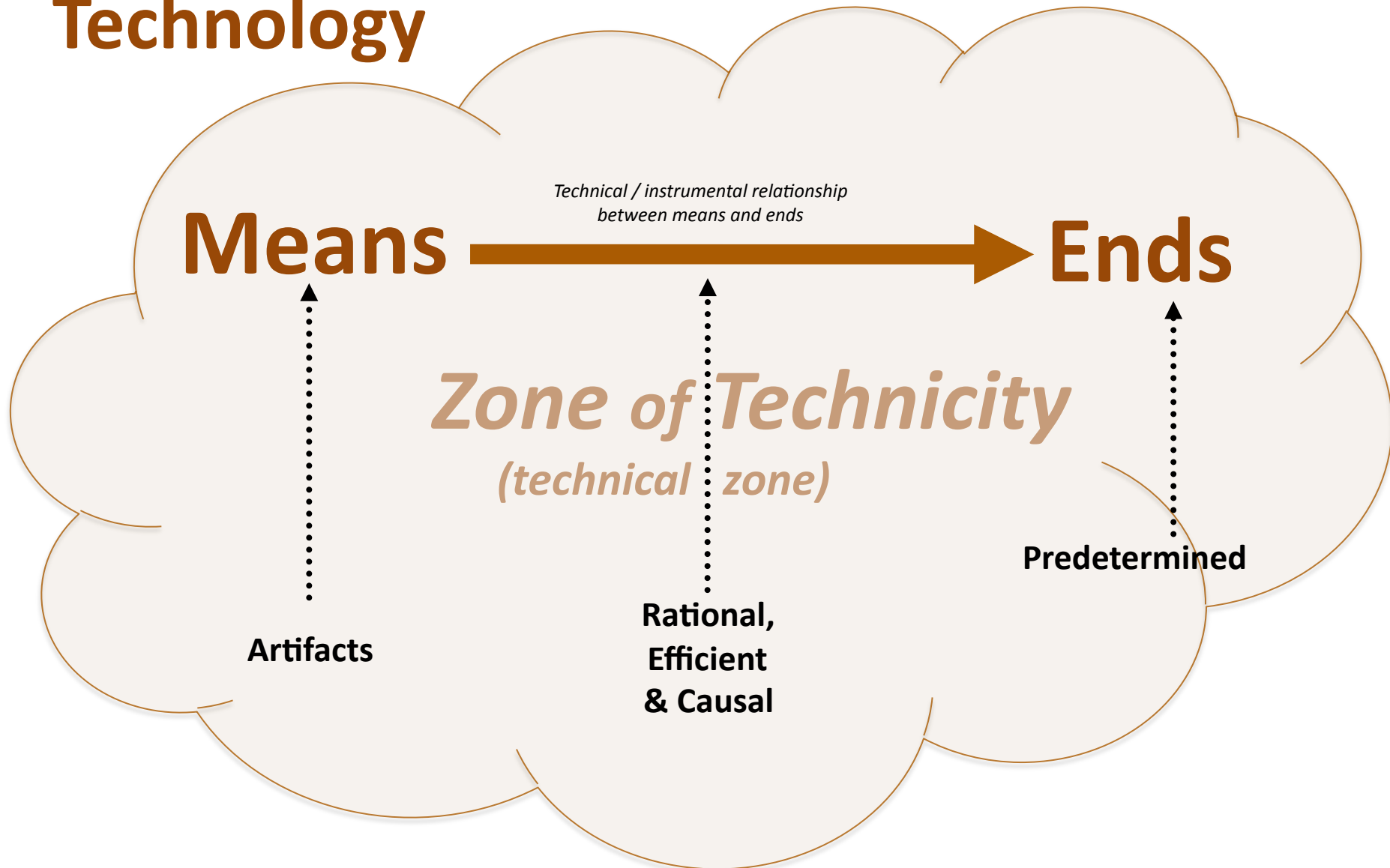
We understand by technology any type of useful thing, knowledge, or activity that is marked by an effort of optimization in a particular cultural context. "Entendemos por tecnología cualquier tipo de cosa, conocimiento o actividad con carácter útil que en un contexto cultural particular, es decir, partiendo de una forma de vida particular, muestra un marcado esfuerzo en el logro de optimización.

(H.J. Huyke, p. 30, 2011)

Huyke, Héctor. (2011) *Tras otro progreso: Filosofía de la tecnología como si las cercanías importaran* (manuscript)

But …

why do all these deliberations about the definition of "technology" really matter?

Why does our concept of technology matter?

- Each technology embodies **intrinsic ends** (i.e., technical ends that are innate to the artifact or artifacts).

- The intrinsic ends of technologies are not necessarily equivalent to the **extrinsic ends** of human beings, communities and organizations that make use of the those technologies

- Appropriate Technology is a mode of technology-practice that aims to create a **good fit between** the *intrinsic technical ends* of technology and the *extrinsic psychosocial and biophysical ends* consciously chosen by human beings

The Fit between Intrinsic Ends and Extrinsic Ends

Technology

Technical / instrumental relationship between means and ends

Means → **Ends**

Artifacts

Rational, Efficient & Causal

Predetermined

The Fit between Intrinsic Ends and Extrinsic Ends

Technical / instrumental relationship between means and ends

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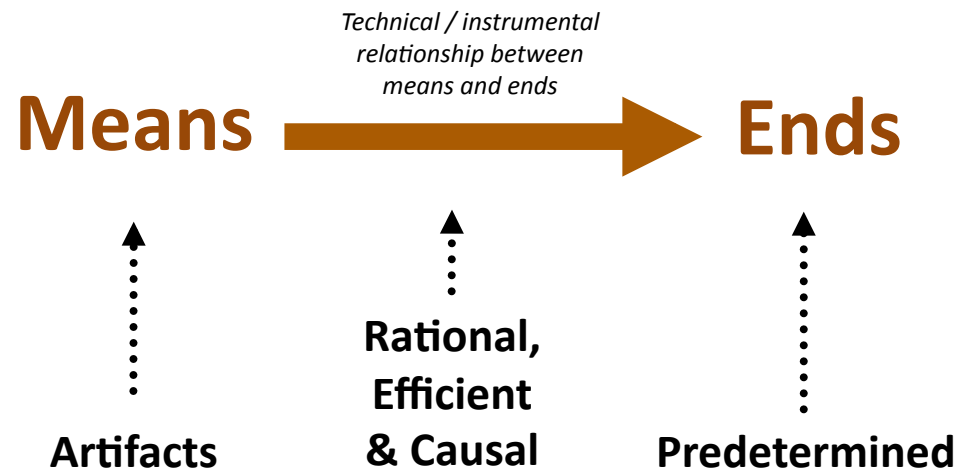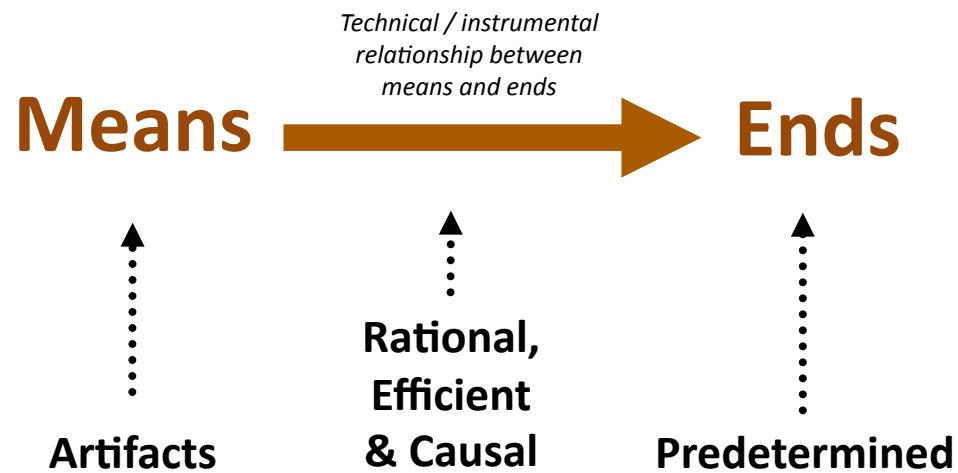
Problematic Fit Between Intrinsic Ends and Extrinsic Ends

Technical Means

Technical / instrumental relationship between **means** *and* **ends**

Intrinsic Ends

Quasi-technical practical relationship between **ends** *(qua means) and* **ends** *(qua ends)*

?

Extrinsic Ends

Artifacts

Rational, Efficient & Causal

Innate Technical Ends

Contingent, loosely-coupled or problematic

Psychosocial & Biophysical

Zone of Technicity (technical zone)

Meta-technical context

Zone of Technology-practice

("technological" zone)

The Appropriate Technology Problem

Bridging the Gap Between Intrinsic Ends and Extrinsic Ends

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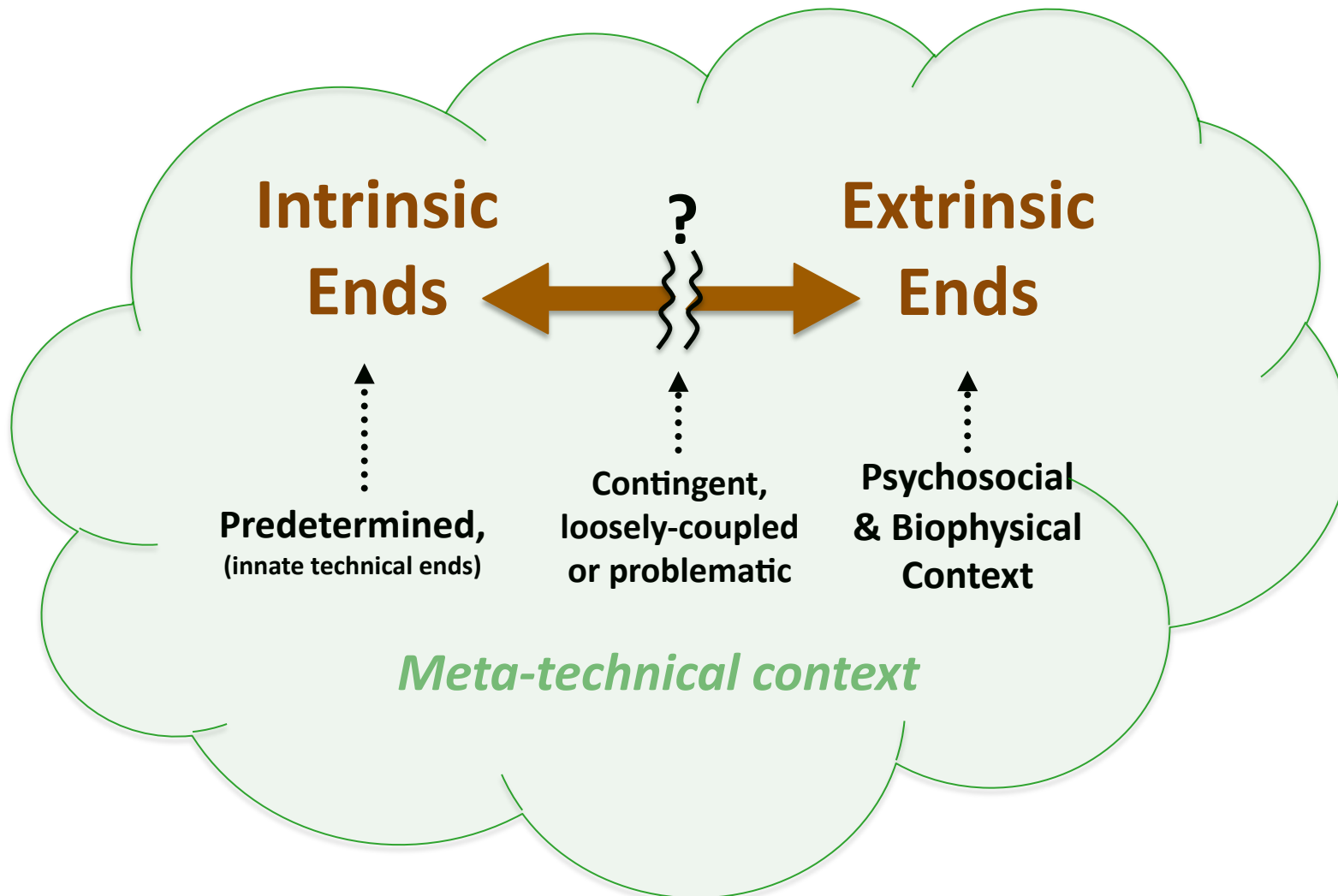
The Appropriate Technology Solution

Achieving a Good Fit Between Intrinsic Ends & Extrinsic Ends
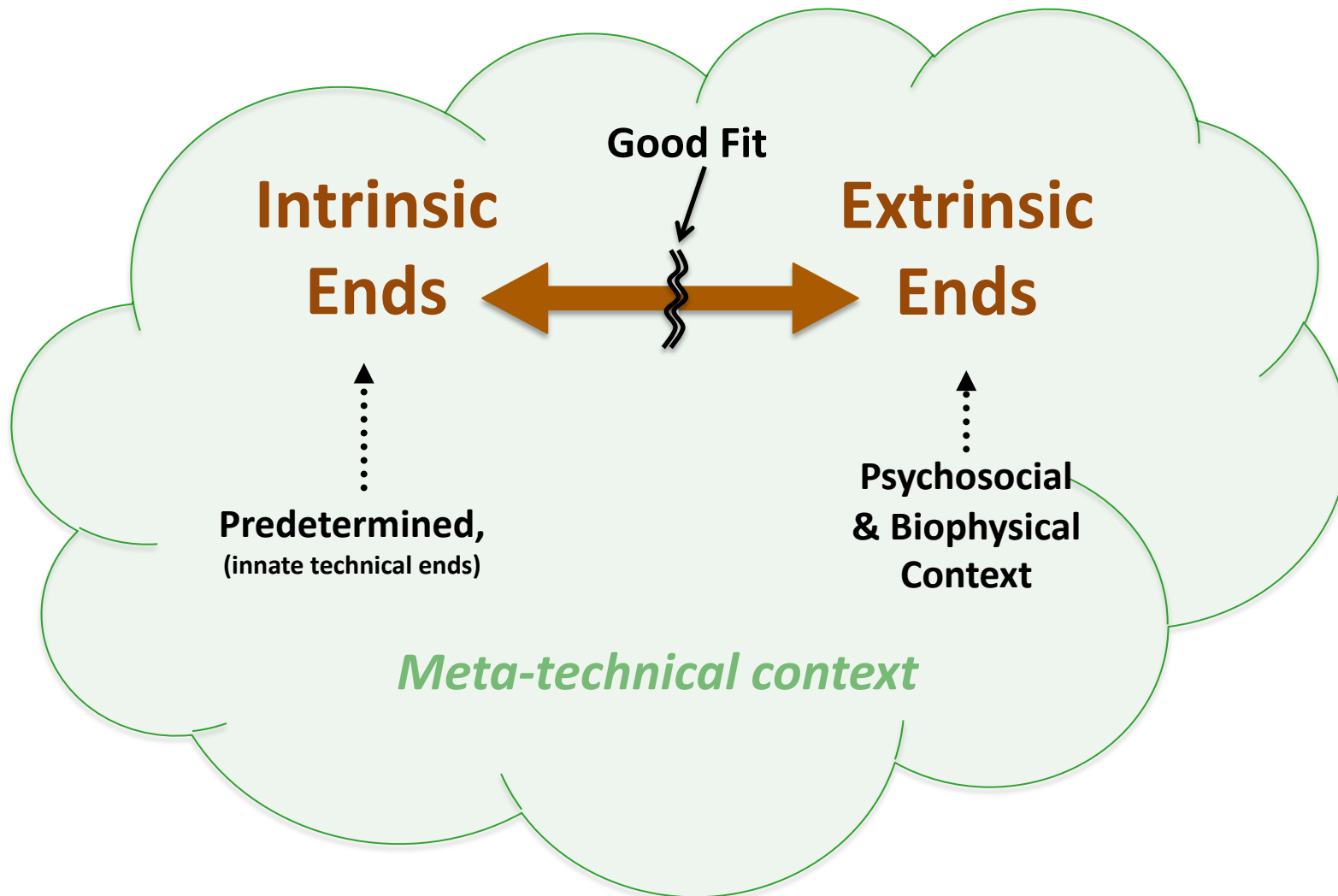
Good Fit

Intrinsic Ends

Extrinsic Ends

Predetermined,
(innate technical ends)

Psychosocial & Biophysical Context

Meta-technical context

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Characteristics of Technology in Society

- Technology is not socially "neutral" or politically "neutral"
  - technology exerts a significant determining influence in society
  - at the same time, technology also embodies social interests, social influences and other non-technical influences

- Choice from amongst technological alternatives is necessary to ensure that the technology-society relationship is healthy

- Conscious human effort in the choice of technology is required for success with Appropriate Technology

The Principle of Technology Choice

- There is frequently a range of alternative technological means available which are suitable for the attainment of primary ends within a given field

- The number of alternatives in the range may be increased over time by conscious human effort

- Alternative technological means of similar suitability, for the attainment of certain primary ends, may vary widely in their suitability for the attainment of secondary ends

- The informed selection of technological means, taking into account secondary ends as well as a primary ends, combined with long term efforts to expand the range of available alternatives, is an important element of social, economic and environmental policy.

Appropriate Technology and Technology Choice

- **Appropriate Technology ("AT")** is a mode of technology-practice aimed at ensuring that technologies are compatible with their psychosocial and biophysical contexts.

- **Appropriate Technology** aims to achieve a good fit between the intrinsic ends of technology and the extrinsic ends of technology.

- **AT**, as a mode of technology-practice, requires intelligent implementation of the principle of **Technology Choice**.

- An **"appropriate technology"** is a particular technology tailored to fit the psychosocial and biophysical context prevailing in a particular location and period in time.

Two Basic Approaches to Defining "Appropriate Technology"

- General Principles approach

- Specific Characteristics approach

Examples of "General Principles" Definitions

- *'Appropriate technology' means simply any technology that makes the most economical use of a country's natural resources and its relative proportions of capital, labour and skills, and that furthers national and social goals. Fostering AT means consciously encouraging the right choice of technology, not simply letting business men make the decision for you.*
(Waldop, 1983)

- *The concept of appropriate technology [is] the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology [is] a dynamic and flexible concept which must be responsive to varying conditions and changing situations in different countries.*
(Harrison, 1979)

- An appropriate technology is a technology tailored to fit the psychosocial and biophysical context prevailing in a particular location and period in time.

*This definition (by Willoughby) is an example of the "**General Principles**" approach to defining Appropriate Technology*

Examples of "Specific Characteristics" Definitions

- *An appropriate technology is relatively inexpensive and simple to build, maintain and operate; uses renewable resources rather than fossil fuels, and does not require high energy concentrations; relies primarily on people's skills, not on automated machinery; encourages human scale operations, small businesses and community cohesion; is protective of human health, and is ecologically sound.*
  (National Center for Appropriate Technology, USA, 1983)

- *In order to concentrate on specific aspects of small AT businesses, the author is defining appropriate technology in terms of products and technical systems - solar collectors, composting toilets, recycling, organic agriculture, wood stove manufacturing, small-scale hydropower, energy conservation, methane, greenhouses, adobe, and so on.*
  (Stewart, 1983)

Problems with the Specific Characteristics Approach

"This (i.e., the adoption of so-called "appropriate technology" which does not serve a region's actual needs) might arise because the technology with appropriate characteristics was very inefficient in a technical sense (of low productivity) compared with one with inappropriate characteristics. In some cases, the technology with appropriate characteristics might still be the best choice if its effects on some objectives … outweighed its low productivity. But in others this might not be so, and therefore *the technology with inappropriate characteristics should be preferred*."

(Dr. Francis Stewart, Oxford University, 1983)
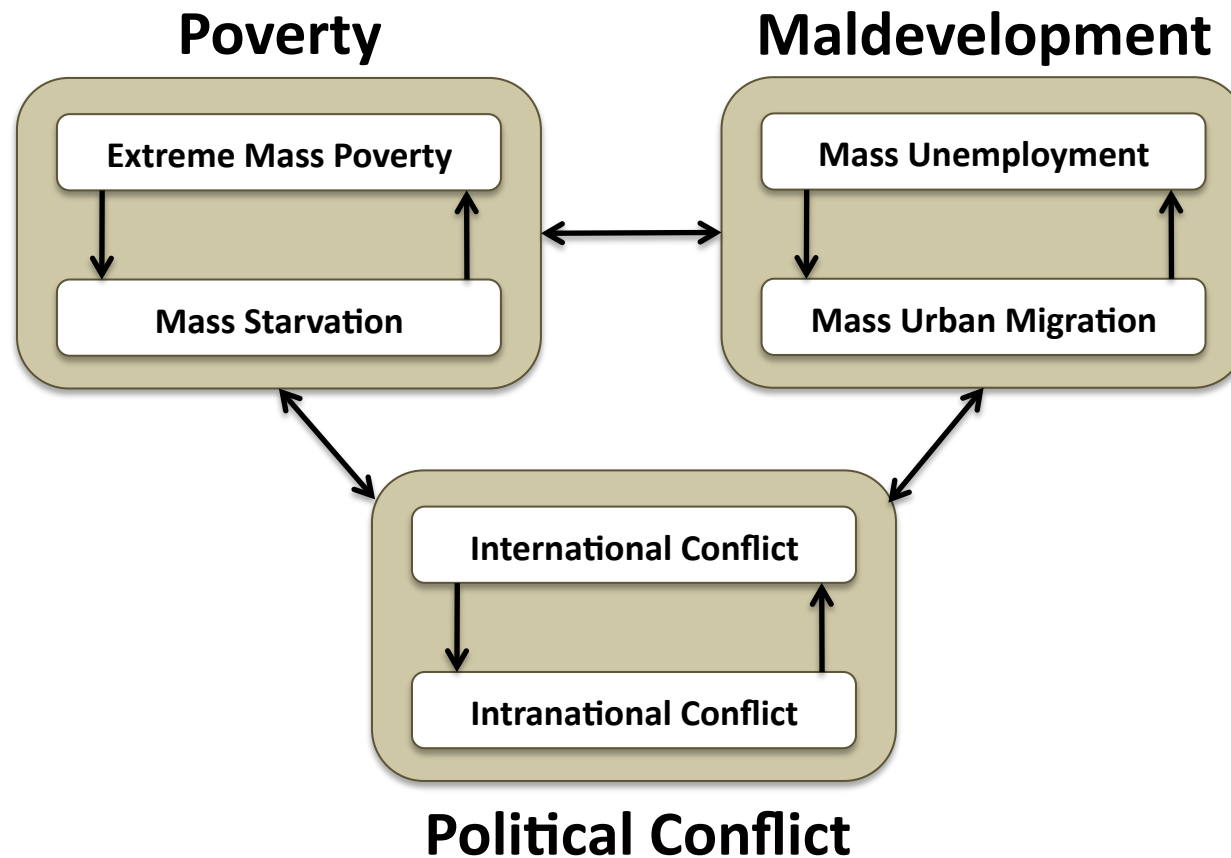
General Principles vs. Specific Characteristics

- The theory and practice of Appropriate Technology during will be enhanced by employing only the general-principles approach for general definitions and by restricting the use of a specific-characteristics approach to specific contexts for which the circumstances are clearly defined.

Example: Intermediate Technology

- **Intermediate Technology** is a specific application of the general-principles approach to Appropriate Technology (promulgated by E. F. Schumacher) to a specific set of circumstances that prevailed in poor countries mid-way through the 20th century

- According to Schumacher, those circumstances were characterized by the problem of the "mutual poisoning of the dual economy"

  (argued by Willoughby to be a primary facet of the *"Development Problematique"*)

The *"Development Problematique"*

Vicious Circle of Problems Evoking Intermediate Technology

Poverty

- Extreme Mass Poverty
- Mass Starvation

Maldevelopment

- Mass Unemployment
- Mass Urban Migration

Political Conflict

- International Conflict
- Intranational Conflict

Action Principles for Addressing the *Development Problematique*

- Workplaces have to be created in the areas where the people are living now, and not primarily in metropolitan areas into which they tend to migrate;

- These workplaces must be, on average, cheap enough so that they can be created in large enough numbers without this calling for an unattainable level of savings and imports;

- The production methods employed must be relatively simple, so that the demands for high skills are minimized, not only in the production process itself but also in matters of organization, raw material supply, financing, marketing and so forth;

- Production should be largely from local materials for local use.

- The key to success in applying the above four action principles is the adoption of "intermediate technology" in non-agricultural industry in rural areas.

"Intermediate Technology"

"The task is to re-establish a healthy basis of existence for these 85 percent by means of an "intermediate technology" which would be vastly superior in productivity to their traditional technology (in its present state of decay), while at the same time being vastly cheaper and simpler than the highly sophisticated and enormously capital-intensive technology of the West."

(E. F. Schumacher, 1964)

Intermediate Technology (cont.)

- For mass creation of employment to be feasible, income per person and capital investment per workplace need to stand in an organic relationship to each other, a relationship which can be "stretched" to some extent – for instance with the help of foreign aid – but cannot be disregarded.

- Technology ought to be chosen so that the average capital cost of a workplace is affordable in terms of the average per capita income of people in a given development district.

(E. F. Schumacher, 1964)

Primary Feature of Intermediate Technology

"Rule of thumb" design criterion for Intermediate Technology

Capital cost of creating one workplace through the implementation of new technology	=	**Average annual income of an able and ambitious employee in the enterprise to be created**

Technology type	Capital Cost per Workplace
Typical Indigenous Technology (South)	$10
Typical Industrial Technology (North)	$10,000
Intermediate Technology	$100 - $1,000

Secondary Features of Intermediate Technology

- Affordable capital-cost per job

- Small scale

- Simplicity

- Non-violence

(E. F. Schumacher, 1973)

Example of Intermediate Technology
(India, 1964)

Choice of Technology in the Manufacture of Agricultural Equipment

Technology	Handicraft Technique (existing)	Power-driven Machinery (existing)	Power-driven Machinery (improved)	Hand-operated Machinery (improved)
Capital equipment (Rs)	150	25 000	31 000	7 200
Total employees	1	30	36	32
Production (units/month)	25	850	1 900	1 500
I/O ratio (Rs/units/month)	6.0	29.0	16.0	5.0
I/L ratio (Rs/job)	150.0	835.0	860.0	225.0
Cost per unit (Rs)	14.0	15.0	13.0	12.75

Example of Intermediate Technology

Efficiency and Scale in Production of Animal Feeds (India 1971)

Technology	A	B	C	D
Scale (output - tons per annum)	2 400	6 000	10 500	16 800
Capital requirements (£)	42 096	105 213	168 236	254 518
Cost per ton (£)	37.3	36.0	37.2	36.5

Efficiency, Labor-intensity and Capital-cost in Production of Salt (Thailand 1973)

Technology	Partially Mechanized (labor-intensive)	Fully Mechanized ("intermediate")	Vacuum Pans (capital-intensive)
Fixed capital (U.S. $ million)	4.97	5.15	7.10
Employment (jobs)	893	364	250
Av. output cost (U.S. $ per ton)	8.41	8.55	18.50
I/O ratio ($/$ per year)	4.0	4.1	5.6
L/O ratio (jobs / 000 tons)	6.0	2.4	1.7
I/L ratio ($ / job)	5 600	14 100	28 400

Key: I = investment cost; L = employment; O = output.

Intermediate Technology: Insight

- Intermediate Technology is part of an Appropriate Technology innovation strategy aimed at **incrementally increasing the capital intensity** of the technology in industry over time for a particular community or population in a particular relatively poor region.

Example of the Application of the Appropriate Technology Concept to a Rich Country (United States)

"Intermediate Technology" in Minnesota, 2005

Bottled water, available in US grocery stores

2005.

Example of Commercially Viable "Appropriate Technology" in Practice

- **Cargill, Inc.**
  - World's largest privately owned company (2005)
  - Headquarters in Minnesota, USA
- Polylactic Acid (PLA) & bio-materials
- Produced though a wholly owned subsidiary of Cargill, NatureWorks, LLC

NatureWorks LLC

- **Established as a JV in late 1998 by Cargill, Inc. & Dow Chemical Co., but 100% Cargill owned since early 2005**

- **~ 250 employees (~1/3 R&D)**

- **Headquartered in Minnetonka, MN (USA)**
  - *Overseas offices in Amsterdam and Tokyo*
  - *Representatives based in Charlotte (NC), the U.K., Milan, HK, Taipei, Seoul, Singapore, Melbourne & Auckland (NZ)*

- **140,000mt PLA & 180,000mt lactic acid plants (Blair, NE)**

- **Over 600 patents; most are manufacturing-related**

- **Global technology alliances (biotechnology to fabricated products)**

- **Products: PLA resin & lactide (NatureWorks), sheet, film, staple fibers, filament yarns**

What is PLA?

- PLA is a polymer made from lactic acid
  - Lactic acid is a <u>natural</u> product
  - It is found in the body, yogurt, & many other foods

- Lactic acid is made from fermentable sugars
  - Sugars are found in plants
  - NW uses <u>corn sugar</u> (dextrose) today to make lactic acid

- Sugars are made from CO_2 via <u>photosynthesis</u>
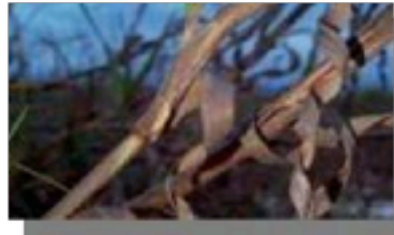 - Photosynthesis involves <u>carbon</u>

PLA Processing Steps

NatureWorks
Cargill Dow Polymers LLC

NatureWorks PLA Plant, Blair, Nebraska, USA

$300 Million Capital Investment
19 months from ground breaking to prime product
10 years to develop technology, know-how, and receptive market

PLA Plant
Blair, Nebraska
January, 2002

Cargill

Dimensions of Technology Innovation

	Intangible technology *(soft technology "A")*	Soft-impact technology *(soft technology "B")*
Process technology	**Intangible process technology capabilities** (dimension #1)	**Soft-impact process technology** (dimension #3)
Product technology	**Intangible product technology assets** (dimension #2)	**Environmentally benign and humanly benign technology products** (dimension #4)

Cargill / Natureworks - PLA

	Intangible technology *(soft technology "A")*	Soft-impact technology *(soft technology "B")*
Process technology	- Cargill's biotechnology R&D capabilities - Cargill's technology commercialization process - Cargill's widespread use of collaboration and global learning	- Natureworks LLC, PLA bio-polymer process -Biomass production (renewable resource) - Controlled fermentation system - Monomer production - Polymer production - Polymer conversion
Product technology	- Over 600 patents - Many trade secrets - Trade marks	- PLA packaging, PLA bottles, PLA fibers for clothing and bedding. - PLA blended with other plastics to make casings for electronic devices. -PLA can be composted in industrial composting systems. It can also be recycled. It will degrade in nature.

Cargill / Natureworks - PLA
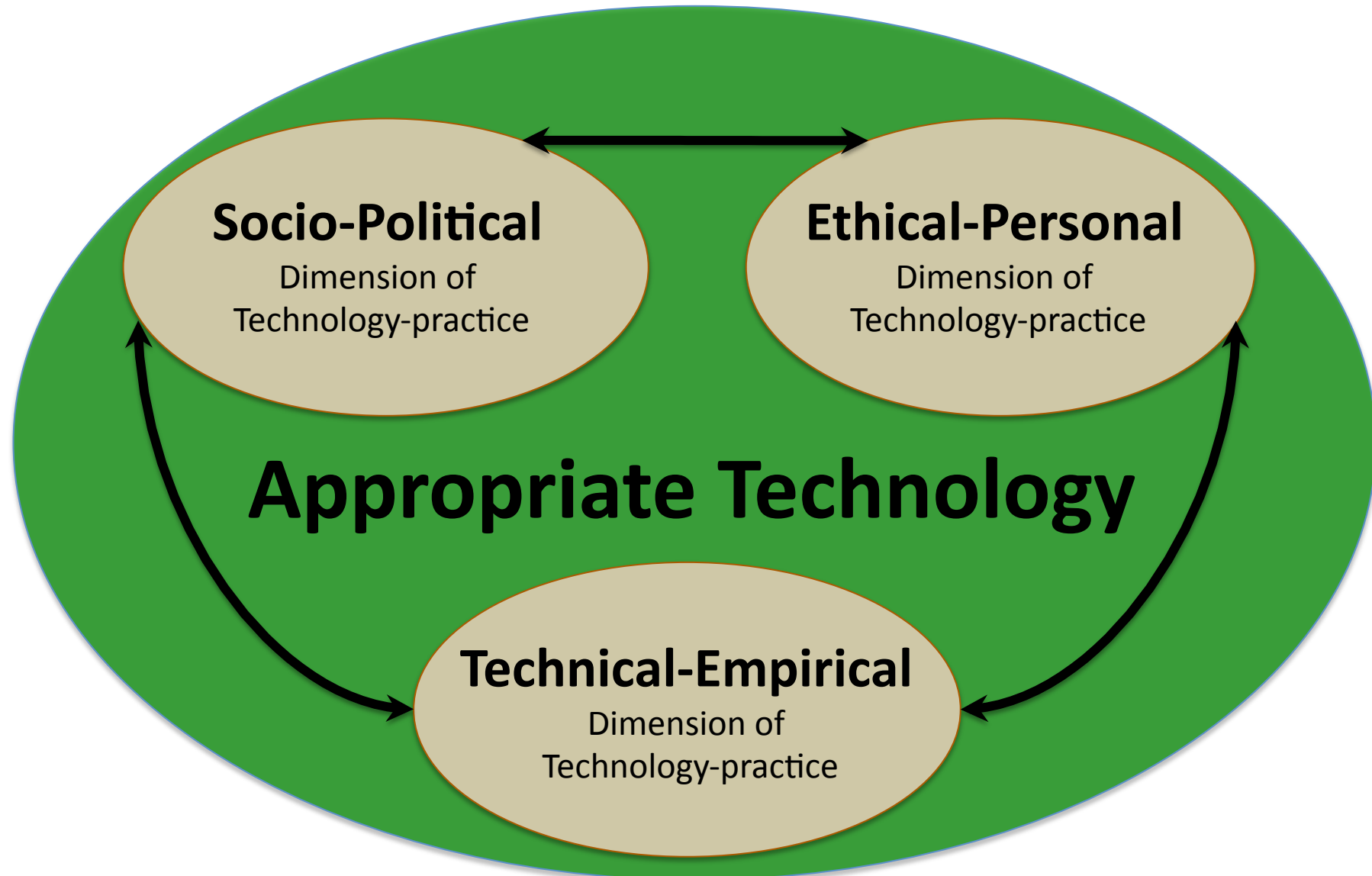## Appropriate Technology Strategy

	Intangible technology *(soft technology "A")*	Soft-impact technology *(soft technology "B")*
Process technology	**Intangible process technology capabilities**	**Soft-impact process technology**
Product technology	**Intangible product technology assets**	**Environmentally benign and humanly benign technology products**

Key to Success with Appropriate Technology

- Appropriate Technology (understood as a mode of technology-practice) consists of at least three complementary dimensions:
  - Technical-empirical dimension
  - Socio-political dimension
  - Ethical-personal dimension
- The three complementary dimensions of Appropriate Technology need to be harmoniously integrated.

Key to Success with Appropriate Technology

Harmonious Integration of Three Dimensions of Technology-practice

Socio-Political Dimension of Technology-practice

Ethical-Personal Dimension of Technology-practice

Technical-Empirical Dimension of Technology-practice

Appropriate Technology

Trends during the last several decades that affect strategy for Appropriate Technology

- Emergence of computer software as a core domain of technology

- Recognition of intangible technology (methods/techniques) as part of technology

- Prominence of large scale technical systems

- Role of technical standards

- Growth of global trade

- Power and scope of intellectual property.

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