centre de développement pédagogique
*pour la formation générale en science et technologie*

# MATERIALS FILE

May 2008

**WORKING DOCUMENT**

The study of materials allows the following question to be answered:

## What is my object made of?

Observing and recognising the materials in the technical object allows the following question to be answered:

**What is this material called? To which family does it belong?**

Knowing the characteristics and testing the properties of certain materials allows the following question to be answered:

**Why is this material used?**

Evaluating a material by its capacity to be recycled or destroyed allows the following question to be answered:

**What becomes of this material after its use?**

**The study of materials in the technical object leads one to identify and resolve 5 technological problems:**

Problem 1.
Of how many different materials is the object made and how can we spot them?

Problem 2.
To which family do the materials used in the object belong?

Problem 3.
What are the physical and mechanical properties of these materials?

Problem 4.
Why did the manufacturer choose these materials to make this object?

Problem 5.
What impact do these materials have on the environment?
What do we know about recycling them?

Drawn from the following website: http://phares.ac-rennes.fr/techno/techno6/exi6.ppt

# PLASTICS

The **notion of plastic matter** in the broad sense includes:
Organic materials that are:
- composed of macromolecules
- produced by the modification of natural substances by direct synthesis starting from substances extracted from petroleum, natural gas or coal.

Some elements that could enter into the composition of plastics: CHONS.
(C) carbon, (H) hydrogen, (O) oxygen, (N) nitrogen, (S) sulphur

FIELD OF ORGANIC CHEMISTRY: Macromolecular substances.

**Natural substances:** Cellulose (wood), horns (hard protein material), vegetal resins, rubber (tree)
**Artificial substances**: Vulcanised rubber (sulphur treated), vulcanised fibre (hydrocellulose treated with zinc chloride), celluloid (nitrocellulose treated with camphor), galalith (casein treated with formaldehyde).

Here is a website where you will find excellent documents that you can order free of charge, including a comic strip on the history of plastics.
http://www.spmp.org/

and the **synthetic substances** below:

## THE MOST COMMON FAMILIES OF PLASTICS

| **THERMOPLASTICS :** They can be heat molded without chemical modification and reversibly. They soften when heated. | |
|---|---|
| POLYOLEFINS | PE (polyethylene)<br>PP (polypropylene) |
| POLYVINYLCHLORIDES AND THEIR DERIVATIVES | PVC |
| STYRENES | PS (polystyrene)<br>EPS (expanded polystyrene)<br>BS (butadiene styrene)<br>ABS (acrylonitrile butadiene styrene) |

| | |
|---|---|
| POLYACRYLICS | PMMA (poly methyl methacrylate)<br>PAN (polyacrylonitrile) |
| POLYCARBONATES | PC |
| FLUORO POLYMERS | PTFE (Polytetrafluoroethylene) Teflon® |
| SATURATED POLYESTERS | PETP et PBTP |
| **THERMOSETTING:**<br>They can be heat moulded irreversibly and with chemical modification and contain tightly meshed reticulated structures.<br>They stay intact heated to the same temperatures used for thermoplastics. | |
| POLYOXYMETHYLENES | POM |
| POLYAMIDS | PA (Nylon, Kevlar®) |
| UNSATURATED POLYESTERS | UP |
| POLYCARBONATES | |
| AMINOPLASTS | UF (urea-formaldehyde)<br>MF (melamine formaldehyde) |
| PHENOPLASTS | PF (formophenolic) |
| EPOXIES | EP |
| POLYURATHANES (2 families) | PU |
| **ELASTOMERS:**<br>They can be moulded with techniques comparable to those used in the rubber industry and contain large meshed reticulated structures.<br>They take their shape again after having been compressed. | |
| SILICONES | SI (in the form of: oils, gums, liquids or pastes and resins) |
| RUBBERS | Natural et vulcanised |
| POLYCHLOROPRENE | Neoprene® |
| ELASTANE | Lycra® (Spandex) |

# METALS

Metals are obtained from minerals, which by fusion and purification processes, are transformed into metals. Metal in its pure form is rarely used. Different metals are combined to obtain what are called **alloys** in order to attain the desired properties.

Metallic materials are classed into two categories: **ferrous and non ferrous.**

**Ferrous metals:** Their principal element is iron. Cast iron and steel are alloys of iron and +/- 2 % carbon. Cast iron is fragile and hard, whereas steel is tough, ductile and elastic. They have the particularity of being attracted to magnets.

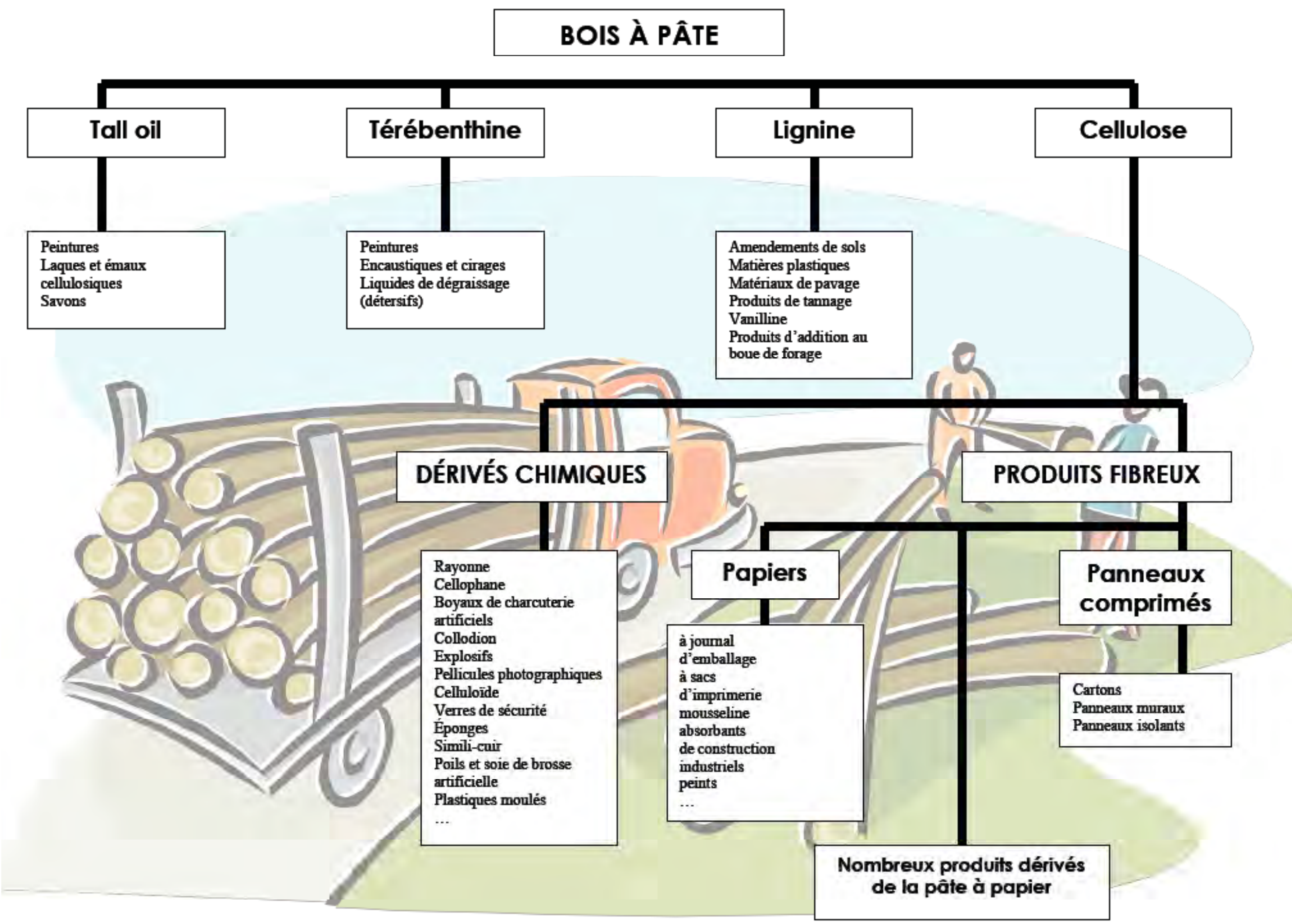
**Non ferrous metals** are those that do not contain any iron. There are several types: copper and its alloys (brass and bronze), lead, zinc and nickel are all non ferrous metals.

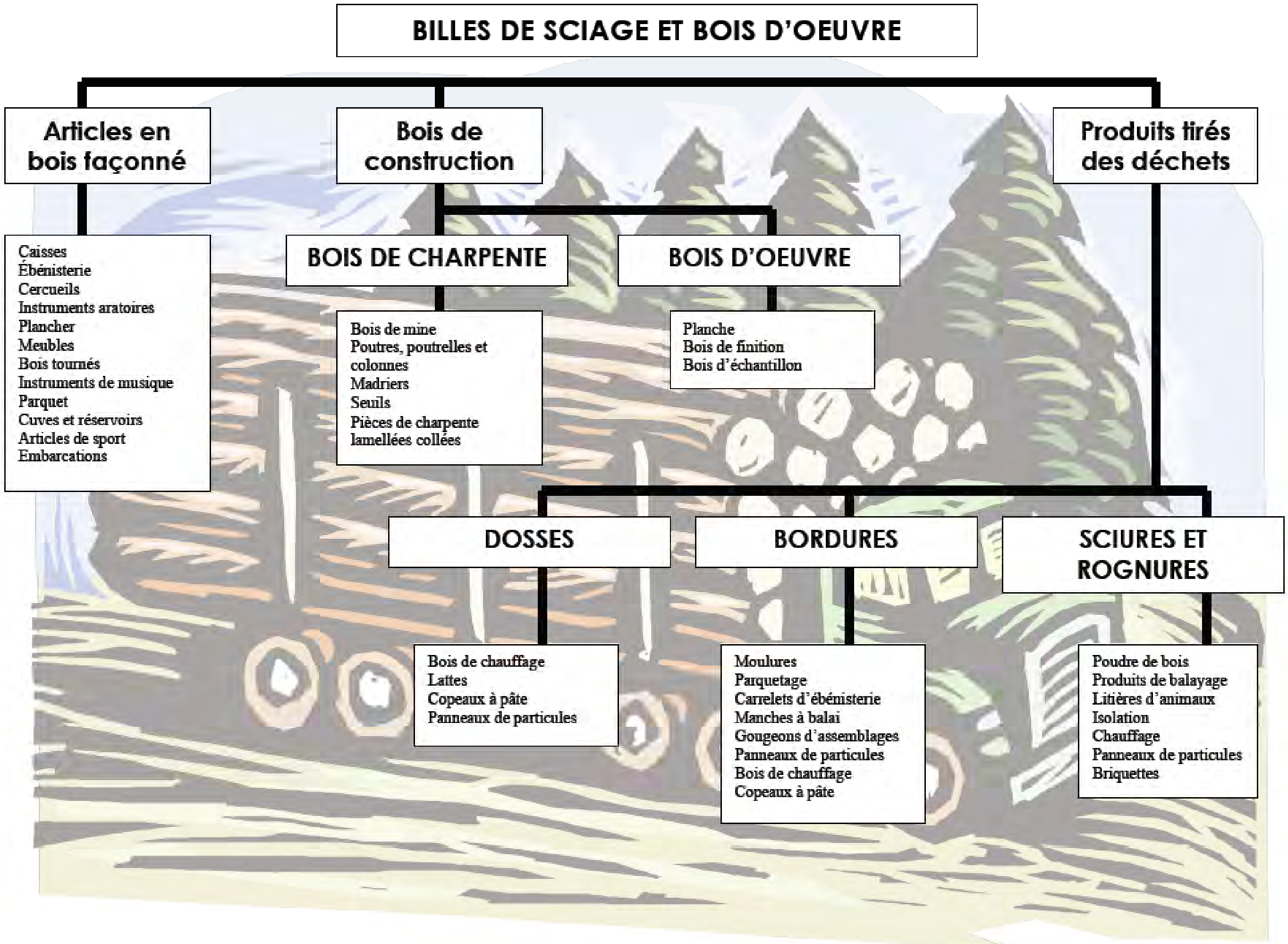
**THE MOST COMMON METALS**

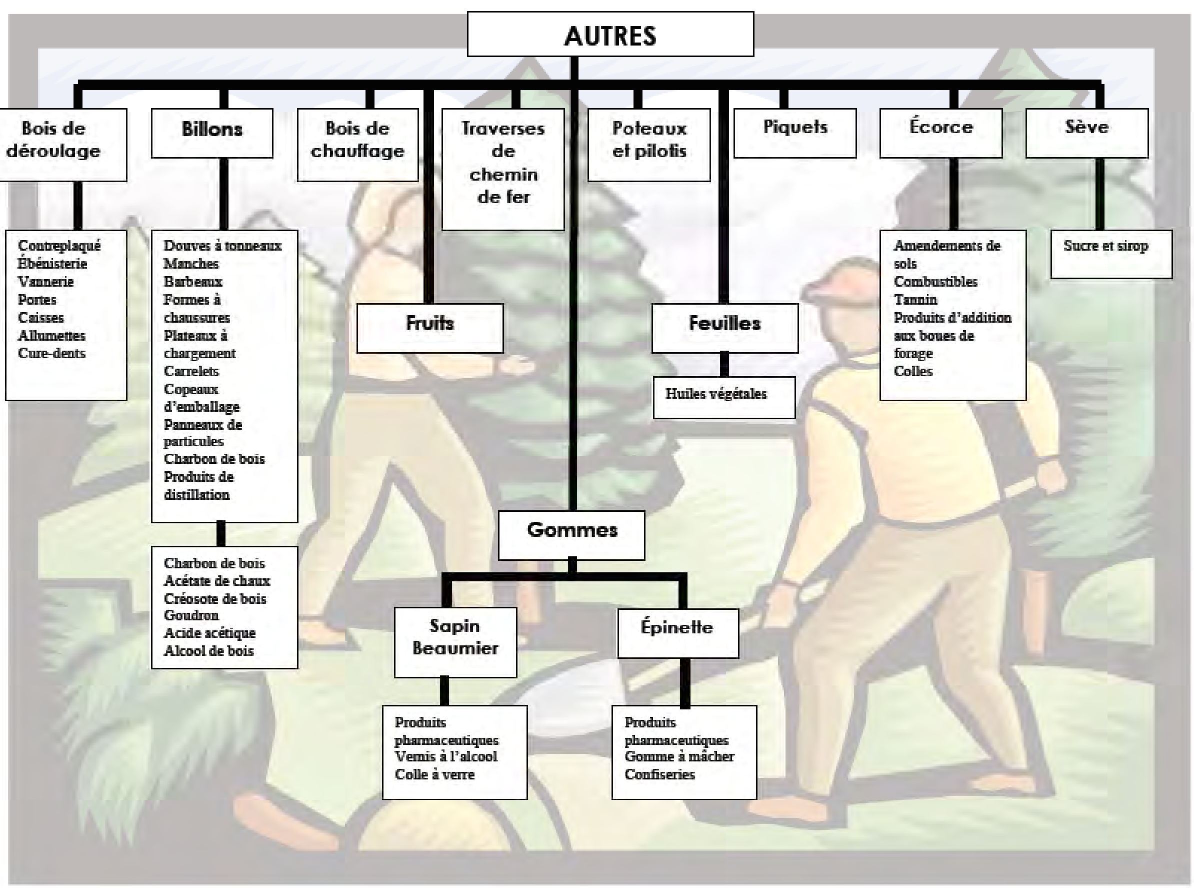
| METAL | COLOUR | HEAT OF FUSION (approximate) | COMPOSITION |
|---|---|---|---|
| Steel | Grey | Around 1535° | Iron and carbon (0.5% to 1.5%) |
| Stainless steel | Shiny grey | Around 1535° | Iron–Carbon with at least 10% chrome. (sometimes nickel, molybdenum or vanadium) |
| Aluminium | Metallic white | 666° | |
| Bronze | Golden yellow | 280° to 950° | Copper - Pewter |
| Copper | Red | 1080° | |
| Pewter | Pure white | 230° | |
| Iron | Greyish white | 1500° | Carbon (0.1 to 0.5%) |
| Cast iron | White or grey | 1100° | Iron and carbon (1.5 to 5%) |
| Brass | Reddish yellow | 870° à 1000° | Copper<br>Zinc |
| Lead | Blue white | 330° | |
| Titanium | Shiny dark grey | 1660° | Titanium, Aluminium, Vanadium |
| Zinc | Blue white | 420° | |

# WOOD AND ITS DERIVATIVES

| **Some species** | | |
|---|---|---|
| Eastern cedar | Red pine | Bitternut hickory |
| White spruce | Hemlock | Black cherry |
| Black spruce | Balsam fir | White oak |
| Red spruce | White birch | Red oak |
| Larch | Yellow birch | Silver maple |
| White pine | Pecan | Sugar maple |
| Grey pine | | Linden |




BILLES DE SCIAGE ET BOIS D'OEUVRE
Articles en bois façonné
Caisses
Ébénisterie
Cercueils
Instruments aratoires
Plancher
Meubles
Bois tournés
Instruments de musique
Parquet
Cuves et réservoirs
Articles de sport
Embarcations
Bois de construction
BOIS DE CHARPENTE
Bois de mine
Poutres, poutrelles et colonnes
Madriers
Seuils
Pièces de charpente lamellées collées
BOIS D'OEUVRE
Planche
Bois de finition
Bois d'échantillon
Produits tirés des déchets
DOSSES
Bois de chauffage
Lattes
Copeaux à pâte
Panneaux de particules
BORDURES
Moulures
Parquetage
Carrelets d'ébénisterie
Manches à balai
Gougeons d'assemblages
Panneaux de particules
Bois de chauffage
Copeaux à pâte
SCIURES ET ROGNURES
Poudre de bois
Produits de balayage
Litières d'animaux
Isolation
Chauffage
Panneaux de particules
Briquettes


AUTRES
Bois de déroulage
Contreplaqué
Ébénisterie
Vannerie
Portes
Caisses
Allumettes
Cure-dents
Billons
Douves à tonneaux
Manches
Barbeaux
Formes à chaussures
Plateaux à chargement
Carrelets
Copeaux d'emballage
Panneaux de particules
Charbon de bois
Produits de distillation
Charbon de bois
Acétate de chaux
Créosote de bois
Goudron
Acide acétique
Alcool de bois
Bois de chauffage
Fruits
Traverses de chemin de fer
Gommes
Sapin Beaumier
Produits pharmaceutiques
Vernis à l'alcool
Colle à verre
Épinette
Produits pharmaceutiques
Gomme à mâcher
Confiseries
Poteaux et pilotis
Feuilles
Huiles végétales
Piquets
Écorce
Amendements de sols
Combustibles
Tannin
Produits d'addition aux boues de forage
Colles
Sève
Sucre et sirop

# COMPOSITE MATERIALS

A composite material is an assemblage of at least two non miscible (that can not be mixed) materials but that together, has a good adhesive capacity.

| **Some composite materials** | |
|---|---|
| Fibreglass | Very fine glass filaments that are generally associated with polymers (plastic resins). |
| Carbon fibres | This material is used in high performance recreational equipment (cycling, sailing…) because it allows for reduced weight. |
| Plywood | Superposed layers of wood. |
| Particle board | Glued, compressed particles |
| Plaster board | Plaster contained between two layers of cardboard. |
| Concrete, reinforced concrete | Mixture of granulates (sand, gravel) usually bound by cement |
| Aramid fibres (Kevlar™) | Polyamide family in plastics |

# CERAMICS

EVERYTHING YOU NEED TO KNOW ABOUT CERAMICS
http://www.cerampilot.com/

http://www.ceramic-center.com

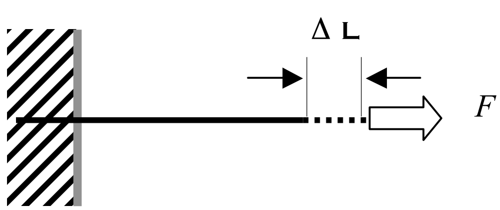
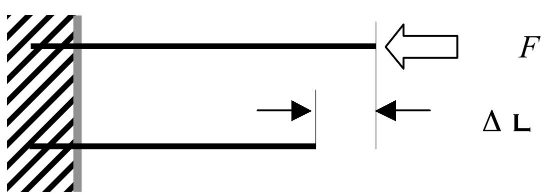
## Some PROPERTIES OF MATERIALS

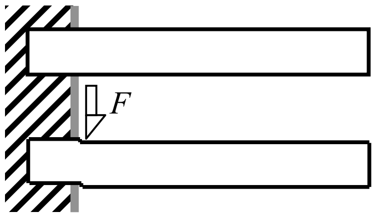
| **Physical properties** | |
|---|---|
| | |
| Colour | Gas permeability |
| Transparency | Fusion point |
| Refraction index | Boiling point |
| Dilatation | Thermal conductibility |
| Water absorption | Electrical conductibility |
| | |
| **Chemical properties** | |
| Oxidation | Combustion |
| Degradation | Photo degradation |

# RESISTANCE OF MATERIALS

When a material is submitted to the force of an action, certain constraints are established within the material. This action brings about deformities. Parts of an object must resist the forces that they will have to bear. Their shape and dimensions must allow them to resist these forces.

## Mechanical constraints that may be inflicted on a material

| | |
|---|---|
| Traction<br><br> | This force acts on the axis of the part and tends to lengthen it.<br>In material resistance, we must verify the longitudinal lengthening by applying a force of traction to each side of the material. In this way, among other things, we can obtain the maximal length which corresponds to the rupture point. |
| Compression<br><br> | This force acts on the axis of the part and tends to shorten it.<br>We verify how much it can be shortened by applying a compression force to each side of the material. |

| | |
|---|---|
| Shearing   | Under the force of this action, one part tends to slide in relation to the other. The force is contained in the slide plane. |
| Flexion | Under the force of this action, the axis of the part that was straight becomes curved. |

The material used for manufacturing a part must allow it to resist the forces mentioned in the above table.

All materials do not resist the same way to forces of rupture and wear.

In order to know how it will act, we have to make the part, submit it to the appropriate forces, note the deformities caused by the force and finally, determine the conditions under which it will rupture. This method, used in aviation, has the major inconvenience of being very expensive.

In the study of materials resistance, we only deform until rupture the simple test parts made with the materials used to make the parts.

## OTHER PROPERTIES OF MATERIALS

| | |
|---|---|
| **Hardness** | The capacity to resist penetration and deformation. |
| **Stretch** | The capacity to be stretched without breaking. |
| **Elasticity** | The capacity to take its initial form back when the force acting on the material is removed. |
| **Resiliency** | The capacity to resist assaults and to keep its shape after such assaults. |
| **Malleability** | The capacity to be shaped by tooling or to be made into sheets without tearing. |
| **Resistance to corrosion** | The capacity to resist salts and chemicals. |
| **Toughness** | The capacity to resist a force of traction. |

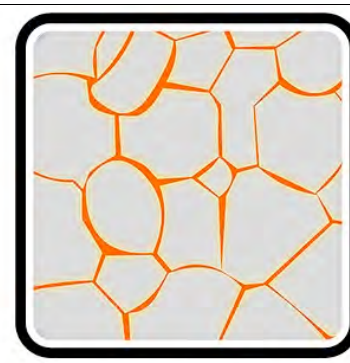
## INDUSTRIALS PROCESSES

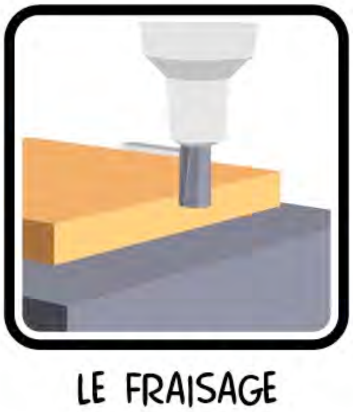
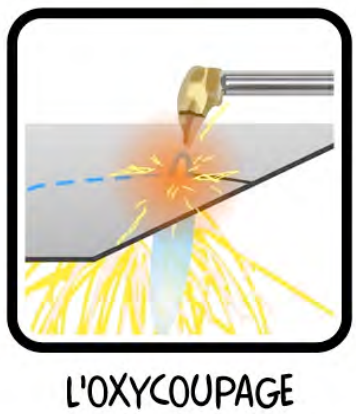
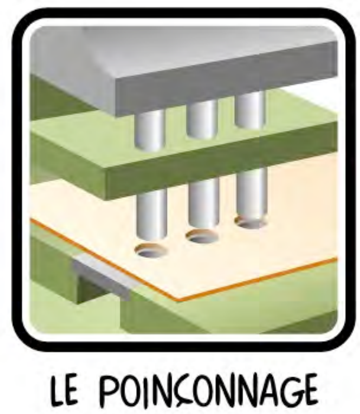
How to use the labels

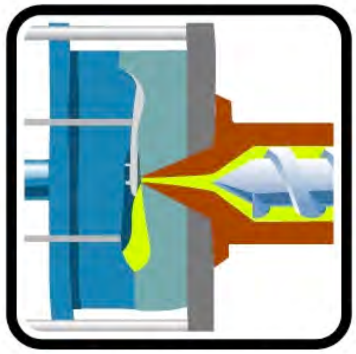
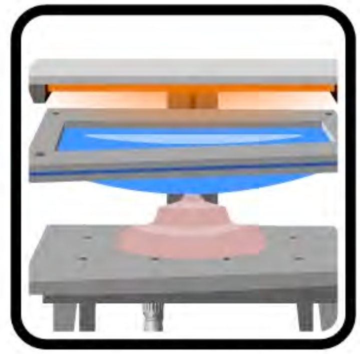
These labels were designed to be used in conjunction with the **« Industrials Processes »** animation. We want to warn teachers against the idea that the names of these processes are to be learned by rote – this practice is in fact, not at all recommended. Rather, we suggest that they be integrated into learning situations. They may be used in a number of ways.

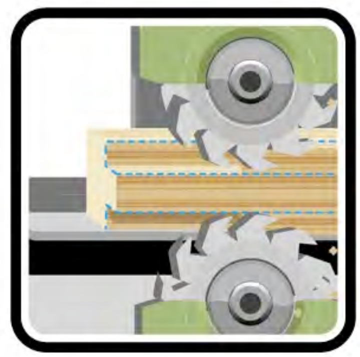
When going through the analysis stages of a technical object, we may have to specify the process used during the fabrication of each part of the object. Rather than describe in words each process used, it could be useful to adjoin the labels to an illustration or photograph of the object connecting the label to the appropriate component, for example.

The labels may also be printed in large format and placed on the classroom or workshop walls during a manufacturing study. This would create an attractive visual for the students. Even better, find examples of applications of these processes in real objects that can be demonstrated to the students. They may also be used in a slide presentation or be printed and given to the students as a reference.

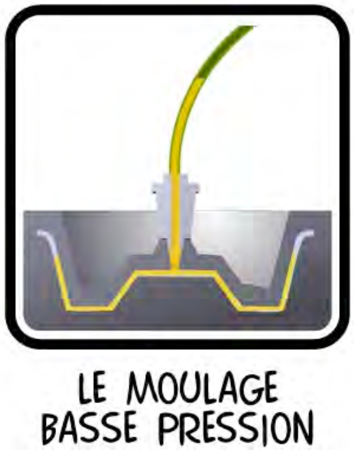
| METAL FORMING | | |
|---|---|---|
|  LE FLUOTOURNAGE<br>Hydro spinning is used to produce different circular mechanical objects. |  LE CINTRAGE<br>Bending is used to curve long metallic pieces (plates, tubes, formed objects) |  LE PLIAGE<br>Folding is used to fold plates or sheet metal to obtain, among other things, formed objects. |
|  LE FORGEAGE<br>Forging is used to produce parts that must offer high resistance, in large quantity. |  L'EMBOUTISSAGE<br>Stamping (or dieing) allows for rapid volume starting from thin plates. |  L'EXTRUSION<br>Extrusion allows for the production of formed parts of great length. |
|  LE MOULAGE À LA CIRE PERDUE<br>Wax moulding is used to quickly, precisely and inexpensively produce complex parts in small quantity. |  LE MOULAGE AU SABLE<br>Sand moulding is used to produce precise mechanical parts of all sizes, inexpensively and in small quantity. |  LE FRITTAGE<br>Sintering allows for the production of very diverse formed parts, to make up alloys and to control the porosity and strength of the parts.<br>. |

| MACHINING METALS | | |
|---|---|---|
|  Milling allows a block of solid material to be transformed by removing material from it. |  Turning allows a part to be transformed by rotation, by withdrawing matter from it. |  Rectifying is used to precisely remove small parts or to finish the part. |
|  Shearing is used to quickly cut sheet metal. |  Oxy-fuel cutting is used to freely and easily cut metal plates. |  Die-cutting is used to perforate, cut or shape thin metal plates. |
|  Electro-erosion allows precise machining of conductive metals, no matter how hard they are. | | |

| FORMING PLASTICS | | |
|---|---|---|
| <br>LE THERMOPLIAGE<br>Thermo-folding is mainly used for tailor made, small quantity production of objects that are of uniform thickness. | <br>L'INJECTION<br>Injection is mainly used in the mass production of objects with complex shapes or containing precise details. | <br>LE THERMOFORMAGE<br>Thermo-forming is mainly used for disposable objects or objects for which the quality of the finish is not an essential criterion. |
| <br>L'EXTRUSION<br>Extrusion is used for the continuous production of differently shaped formed objects. | <br>LE ROTOMOULAGE<br>Rotary moulding allows for the production of large hollow parts. | |

| MACHINING LINEAR MATERIALS | | |
|---|---|---|
|  LE DÉGAUCHISSAGE<br>Straightening allows the first face of a board to be evened out. |  LE RABOTAGE<br>Planing allows for the second face to be prepared after the first face has been straightened. |  LE TOUPILLAGE<br>Shaping results in profiled pieces of wood, also known as “mouldings”. |
|  LE TOURNAGE SUR BOIS<br>Spindling allows cylindrical pieces of wood to be shaped. |  LE MORTAISAGE<br>Mortising allows for the production of complex pieces of wood. |  LE TENONNAGE<br>Tenoning allows for the production of complex pieces of wood. |
|  LE GOUJONNAGE<br>Doweling allows the production of dowels. | | |

## FORMING COMPOSITE MATERIALS



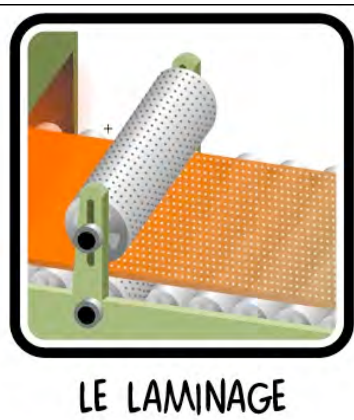

Moulding of composite materials allows the production of objects that must resist to considerable constraints.


## FORMING GLASS AND CERAMIC

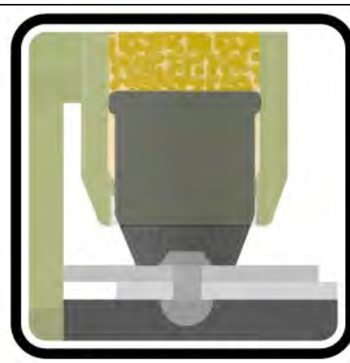
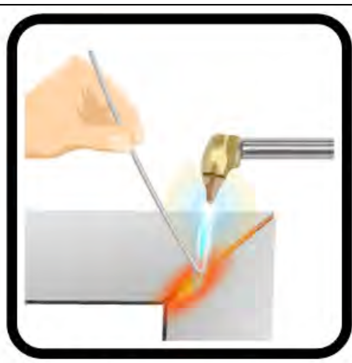
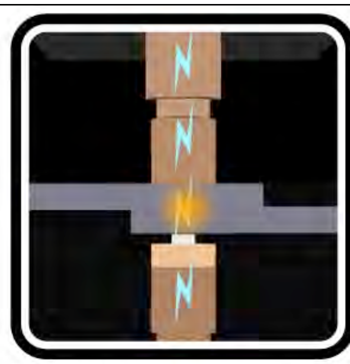

Blowing allows the production of hollow glass containers and other hollow objects

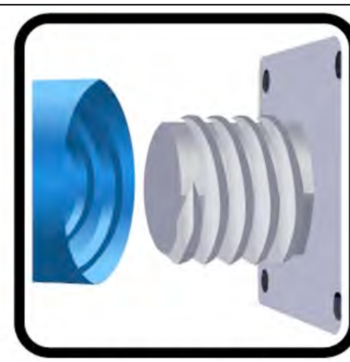

Pressure allows the production of hollow glass containers and other hollow objects


The float process is used in the production of flat glass and mirrors, more efficiently than the lamination-stretching process.




Lamination is used to produce textured glass.

| INDIRECT ASSEMBLIES | | |
|---|---|---|
| <br>LE CLOUAGE<br><br>Industrial nailing allows wooden parts to be quickly assembled to one another (frames, cases, palettes). | <br>LE VISSAGE DU BOIS<br><br>Screwing allows for an indirect assembly between two parts. | <br>LE VISSAGE DU MÉTAL<br><br>Screwing allows for an indirect assembly between two parts. |
| <br>LE BOULONNAGE<br><br>Bolting allows the assembled parts to be disassembled. | <br>LE RIVETAGE<br><br>Riveting allows two thin parts to be permanently and quickly assembled. | <br>LE SOUDAGE À L'ARC<br><br>Arc welding allows, by means of molten metal (welding), the production of links that can not be disassembled. |
| <br>LE SOUDAGE AU GAZ<br><br>Gas welding allows, by the means of a joint of molten alloy (solder) for the production of links that can not be disassembled. | <br>LE SOUDAGE PAR POINT<br><br>Point welding allows almost undetectable welds between two parts. | |

| DIRECT ASSEMBLIES | | |
|---|---|---|
|  LE COINCAGE<br>Jamming allows for resistant assembly while retaining the ability to be disassembled as needed (interchangeableness). |  LE FORCAGE PAR COMPRESSION<br>Compression forcing allows parts with complementary shapes to be assembled using their elasticity |  LE FRETTAGE<br>Hooping allows parts with complementary shapes to be assembled using thermal dilation or contraction. |
|  LE SERTISSAGE<br>Crimping allows for quick, inexpensive assembly of parts to one another. |  L'AGRAFAGE<br>Stapling allows parts with complementary shapes to be assembled using claws. |  LE FILETAGE<br>Threading allows parts with complementary shapes to be assembled using threads. |

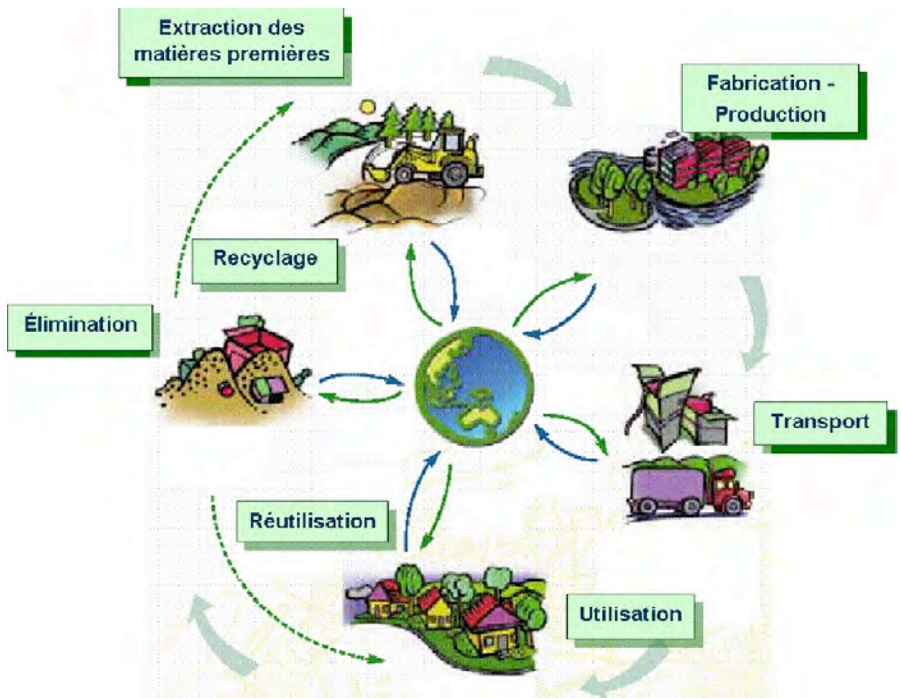
**Drawn from the website below:**
**http://sunensa.uqac.ca/empreinte/acv.htm#Analyse_de_cycle_de_vie_**

## Analysis of the cycle of life

The products we consume increase our ecological footprint far more than we can imagine.

Beginning with the extraction of raw materials and all the way to the elimination of residual materials, a product implies numerous stages throughout its lifecycle (manufacturing, transportation, conservation, etc.).

Yet each of these stages consumes energy and resources - in other words, each of them increases the ecological footprint of the product.




When we consume a product, the ecological footprint of its **lifecycle** becomes our own. Certain actions that we consider commonplace in everyday life actually sharply increase the footprint that we leave on the planet.

Have you ever thought about the implications of drinking a simple **glass of milk**? This implies:

- an arable surface to cultivate the food consumed by the cows;
- the water used to grow the food and to water the cows;
- human and/or machine labour consuming energy for sowing;
- space for the elimination of waste produced by the cows;
- human and/or machine labour consuming energy for milking;
- more energy for the machines that treat the milk (pasteurisation, homogenisation, etc.);
- raw materials and again energy to package the milk in bags or

cartons;

- combustibles and again and always energy to transport the milk while keeping it cool;
- the energetic needs of the refrigerators at the supermarket;
- the energy you will use to get to the supermarket;
- the energy used by your refrigerator;
- the natural resources required to eliminate the carton or bag that will be thrown in the garbage.

Think about it!

# BIBLIOGRAPHY


**Books**

Société des Industries du Plastique du Canada. Les plastiques aujourd'hui et demain, mars 1990, 96 p.

GUILLEMETTE, André. Éléments de physique du bois, éditions FM, Laval, 1982, 153 p.

**Web sites**

TECHNOLOGICAL ANALYSIS
http://technoargia.free.fr/cms2/?Techno:6%E8me

BIOMEDICAL MATERIALS
http://www.infoscience.fr/dossier/biomateriaux/biomateriaux_som.html

EVERYTHING YOU NEED TO KNOW ABOUT CERAMICS
http://www.ceramic-center.com

FRENCH SITE ABOUT WOOD
http://www.site-en-bois.net/fr/accueil.phtml

PLASTICS IN OUR LIFE
http://plastics.ca/?lang=EN

DIFFERENT TYPES OF PLASTIC MATERIALS
http://www.cap-sciences.net/upload/sites/dossierspedago/Fiche6-différents-plastiques.pdf
http://www.cap-sciences.net/upload/differents_plastiques.pdf

http://www.lesplastiques.com

http://www.plastics.ca/

http://www.recyc-quebec.gouv.qc.ca/Upload/Publications/Fiche-plastiques.pdf

Ministry of natural resources and fauna Quebec
http://www.mrn.gouv.qc.ca

ECOLOGICAL FOOTPRINT
http://www.agir21.org/flash/empreinteecoweb/loadcheckplugin.html

http://en.wikipedia.org/wiki/Ecological_footprint

http://www.mddep.gouv.qc.ca/jeunesse/jeux/questionnaires/Empreinte/Questionnaire.htm

TECHNOLOGICAL RESOURCES (ACADÉMIE DE REIMS)
http://www.ac-reims.fr/datice/techno/ressources/6eme/ressources.htm

http://phares.ac-rennes.fr/techno/techno6/exi6.ppt