Object-oriented design

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Grady Booch
“Object-oriented analysis and design”
2nd edition
Addison-Wesley, 1994

MCnet

Main goal: manage complexity

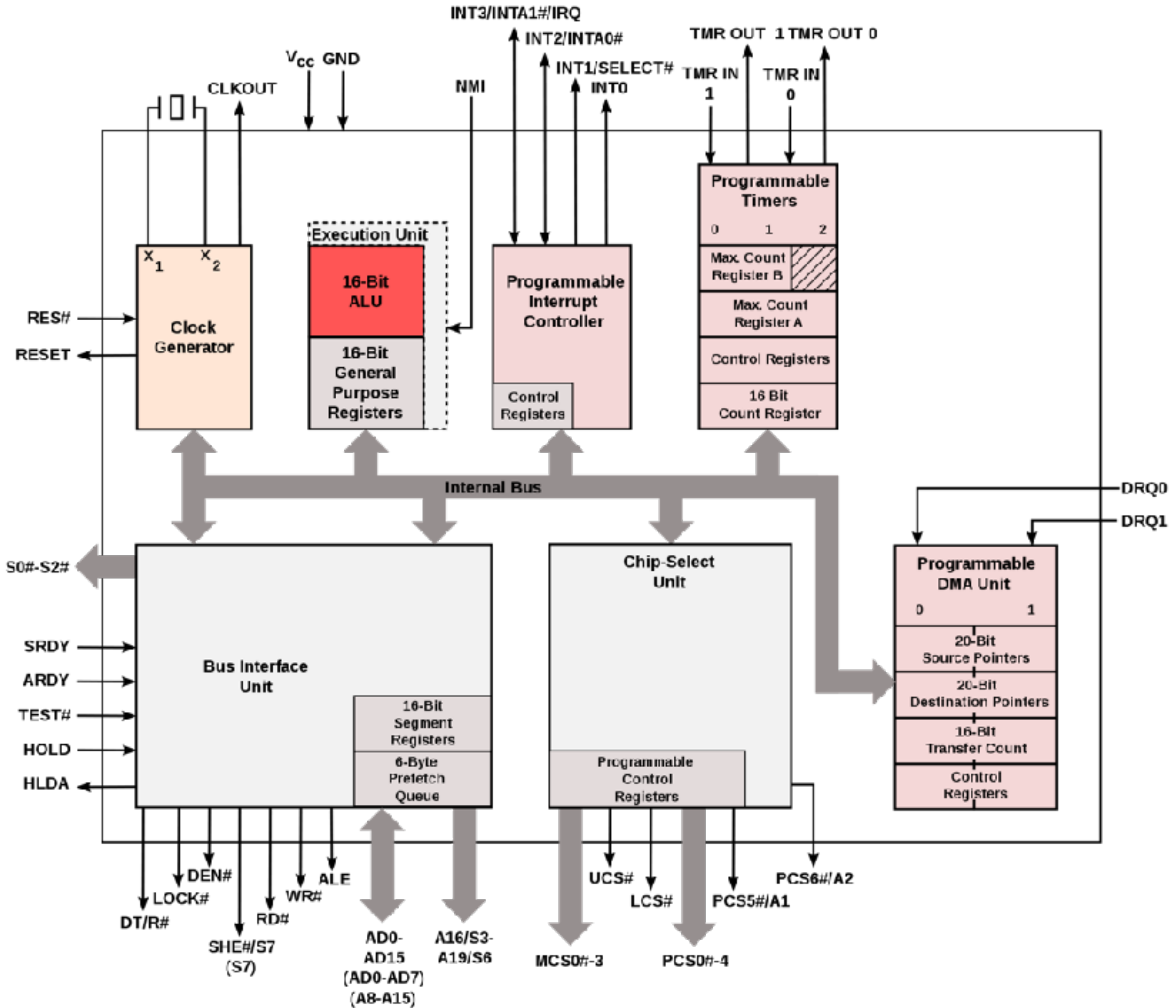
Different approaches, OO is just one of them!

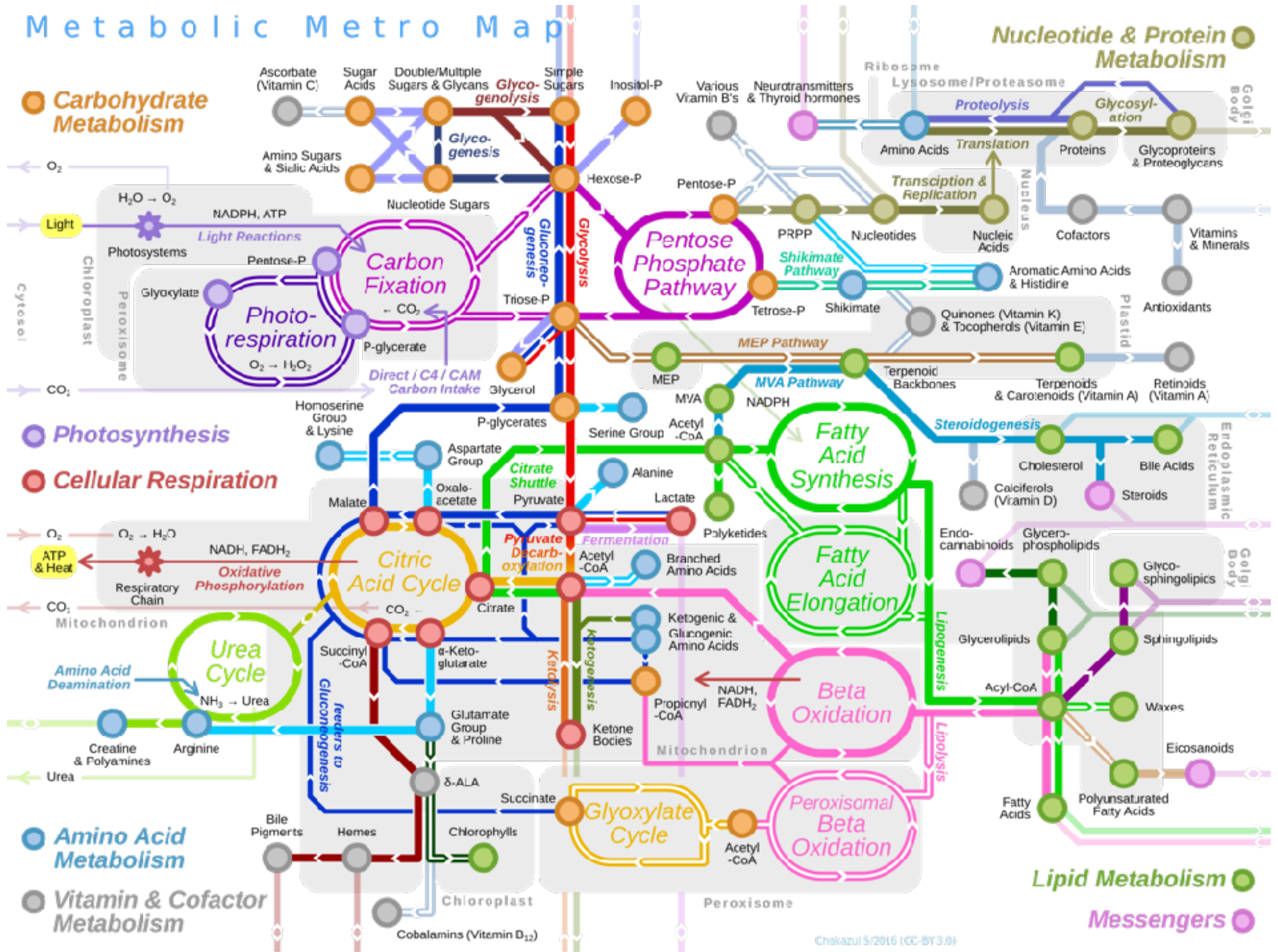
see e.g. Haskell for a completely different approach to complexity handling: functional programming

MCnet

- Complexity of the problem domain
  external; requires software maintenance, evolution, preservation
- Development process
  impossible for one developer to understand large projects completely
- Software is boundlessly flexible
  able to work at any level of abstraction; no fixed quality standards
- Behaviour of discrete system
  natural world physics is local and continuous
  program state is not: combinatoric, small change -> large effect

Intel 80186 / 80188 architecture





Metabolic Metro Map
Carbohydrate Metabolism
Photosynthesis
Cellular Respiration
Amino Acid Metabolism
Vitamin & Cofactor Metabolism
Nucleotide & Protein Metabolism
Lipid Metabolism
Messengers
Ascorbate (Vitamin C)
Sugar Acids
Double/Multiple Sugars & Glycans
Glyco-genolysis
Simple Sugars
Inositol-P
Amino Sugars & Sialic Acids
Glyco-genesis
Hexose-P
Nucleotide Sugars
Gluconeo-genesis
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Glycerol
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Light
$H_2O \to O_2$
NADPH, ATP
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Carbon Fixation
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$O_2 \to H_2O_2$
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Direct / C4 / CAM Carbon Intake
CO_2
O_2
Cytosol
Chloroplast
Peroxisome
Pentose Phosphate Pathway
Tetrose-P
PRPP
Nucleotides
Nucleic Acids
Transcription & Replication
Translation
Amino Acids
Proteins
Glycoproteins & Proteoglycans
Proteolysis
Glycosyl-ation
Ribosome
Lysosome/Proteasome
Golgi Body
Nucleus
Various Vitamin B's
Neurotransmitters & Thyroid hormones
Cofactors
Vitamins & Minerals
Antioxidants
Shikimate Pathway
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Aromatic Amino Acids & Histidine
Quinones (Vitamin K) & Tocopherols (Vitamin E)
MEP Pathway
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Terpenoid Backbones
Terpenoids & Carotenoids (Vitamin A)
Retinoids (Vitamin A)
Plastid
MVA Pathway
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NADPH
Acetyl -CoA
Fatty Acid Synthesis
Steroidogenesis
Cholesterol
Bile Acids
Calciferols (Vitamin D)
Steroids
Endoplasmic Reticulum
Homoserine Group & Lysine
Aspartate Group
Serine Group
Alanine
Oxalo-acetate
Citrate Shuttle
Pyruvate
Lactate
Malate
Polyketides
Pyruvate Decarb-oxylation
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Acetyl -CoA
Branched Amino Acids
Fatty Acid Elongation
$O_2 \to H_2O$
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Oxidative Phosphorylation
Respiratory Chain
Citric Acid Cycle
Citrate
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Mitochondrion
Ketogenic & Glucogenic Amino Acids
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Urea Cycle
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$NH_3 \to$ Urea
Creatine & Polyamines
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Ketone Bodies
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Glyoxylate Cycle
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Peroxisomal Beta Oxidation
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Bile Pigments
Hemes
Chlorophylls
Chloroplast
Cobalamins (Vitamin B_{12})
Endo-cannabinoids
Glycero-phospholipids
Glyco-sphingolipids
Glycerolipids
Sphingolipids
Acyl-CoA
Waxes
Eicosanoids
Fatty Acids
Polyunsaturated Fatty Acids
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* Complexity is hierarchical grouping of subsystems, down to elementary components
* Choice of elementary blocks is mostly arbitrary
* Links and interactions within a component are much stronger than between components
* Hierarchy uses only a few different subsystems in different combinations
* Working complex systems evolve from working simple systems

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* Deal with complexity by decomposition
* Algorithmic decomposition:
  which steps in which order?
* OO decomposition:
  which entities are involved?
  how do they relate to each other?

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Core features of OO design

* Abstraction
* Encapsulation
* Modularity
* Hierarchy

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Abstraction

* Outside view of the object
* Focus on relevant details, ignore others
* Define distinction to other objects
* No surprises, no unexpected side behaviour

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Abstraction

* Identify object invariants, properties that must be true at any time
* Operations have pre- and post-conditions, they must be satisfied
* Objects should never enter inconsistent state

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Abstraction

* Implementation details do not matter here
* Define public member functions
* Private section doesn't matter yet

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Encapsulation

* separates object's tasks from each other
* actual implementation of the abstraction is hidden
* allows isolated implementation changes
* internal design changes in the objects do not impact the users of the objects

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Encapsulation

* Abstractions only work well if implementation is encapsulated!

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Modularity

* Grouping of classes into functionally related units. Modules should be loosely coupled externally.
* "Physical" collection of units in files, rather than abstract connections
* Difficult to get right first time, may need several redesigns during development

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Hierarchy

* Abstractions form hierarchies
* Helps to think about the useful levels

Two main kinds:

* “is-a”: cat is an animal; oak is a plant
* “has-a”: car has an engine; house has a door

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Hierarchy: “is-a”

* Modelled by inheritance
* Common functionality moves to the top; applies to all classes down the hierarchy

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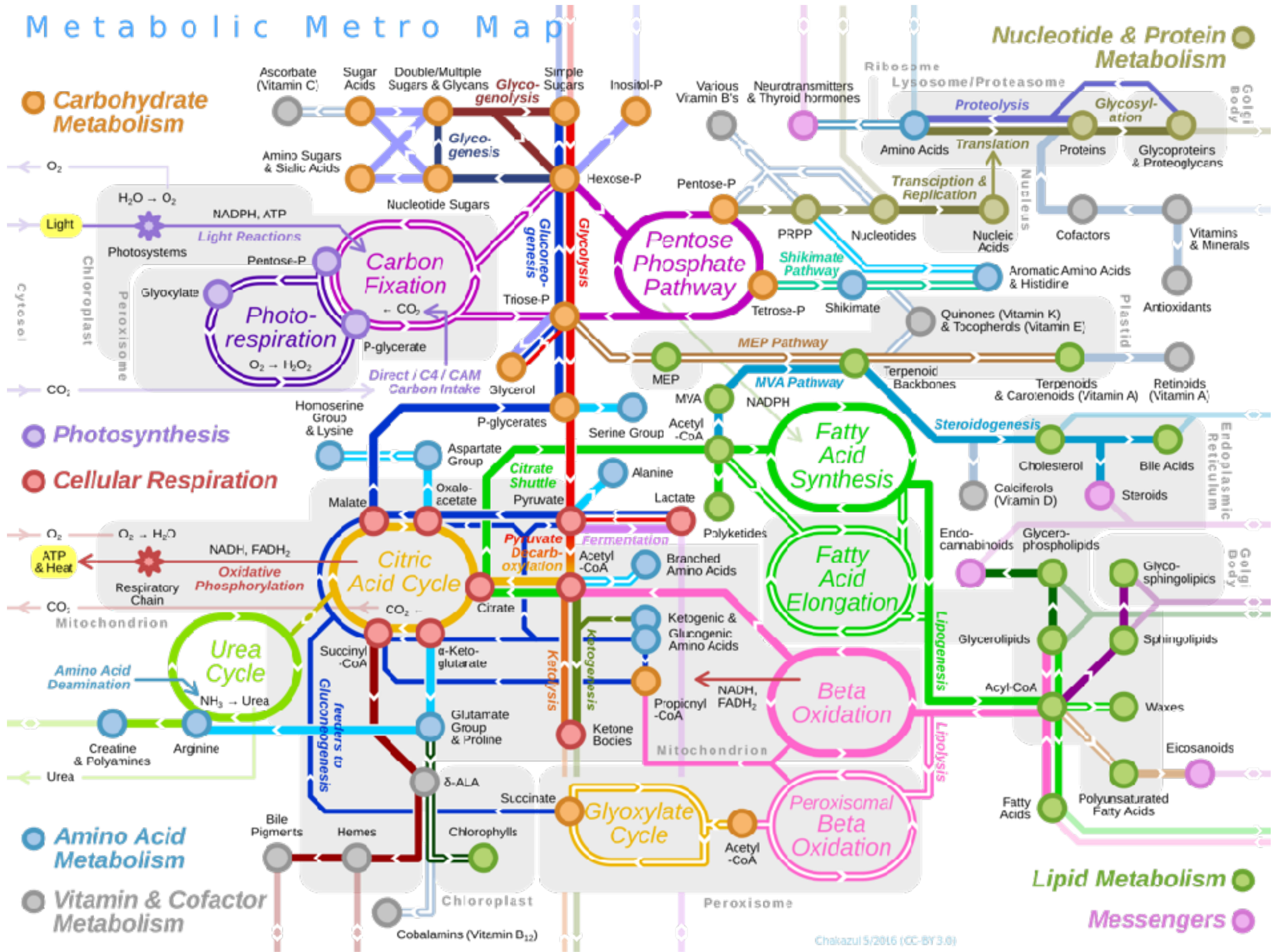
Hierarchy: “has-a”

* Modelled by aggregation
* Objects have other objects as member variables



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Cobalamins (Vitamin B_{12})
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Object

* **State**: inner structure with current values
* **Behaviour**: external interaction and state changes (construct / destruct // modify / select / iterate)
* **Identity:** distinct to all other objects
  It's not the name, one object can have many names!
  Identity considerations are relevant when looking at copying, lifetime and ownership behaviour.

Class

Objects with common structure and behaviour belong to a **class**. The class defines both.

An object is an **instance** of a class.

… main message …

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