

Lecture 9:

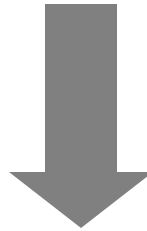
Surface Modification of Biomaterials

Supporting notes

3.051J/20.340J Materials for Biomedical Applications,
Spring 2006

Purpose:

Alter surface properties to enhance performance in biological environment while retaining bulk properties of device



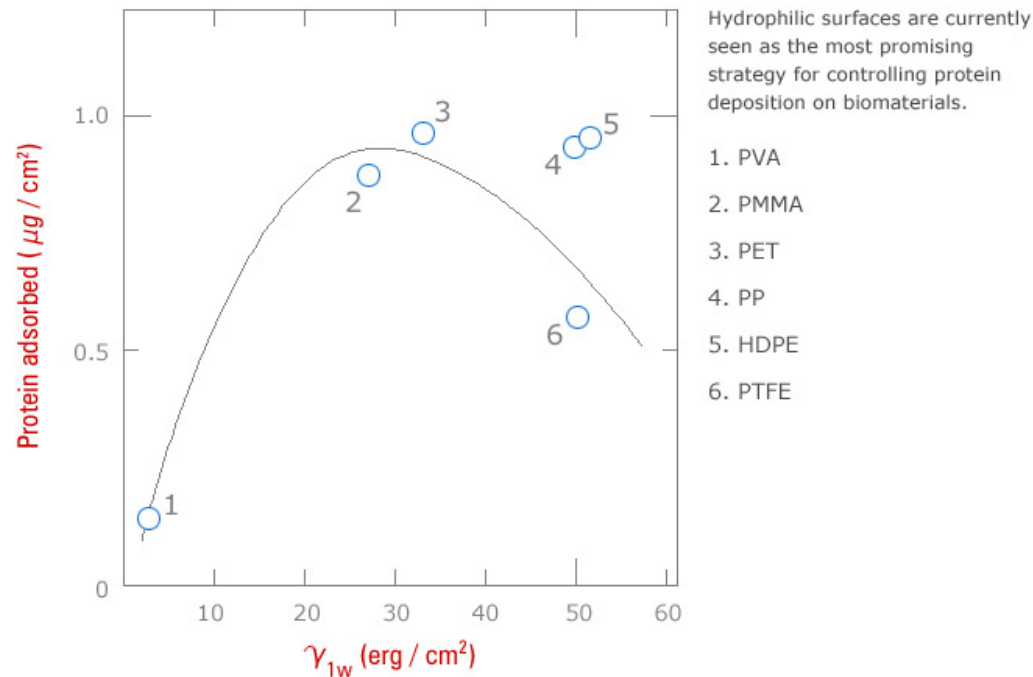
The modified zone at the surface of the device should be **as thin as possible**. Ideally < 1 nm

Specific objectives:

1. Clean a surface
- 2. Reduce/eliminate protein adsorption**
- 3. Reduce/eliminate cell adhesion**
- 4. Reduce bacterial adhesion**
- 5. Reduce thrombogenicity**
- 6. Promote cell attachment/adhesion**
7. Alter transport properties
8. Increase lubricity
9. Increase hardness
10. Enhance corrosion/degradation resistance

Preparation of non-fouling surfaces

to prevent non-specific protein/cell or bacterial adhesion
to reduce thrombogenicity



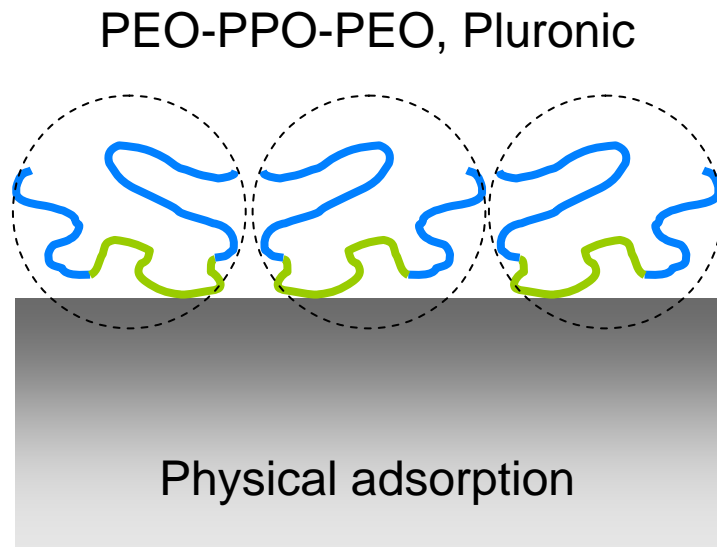
(after Y. Ikada et al., *Polymers as Biomaterials*, Plenum Press, NY 1984)

Figure by MIT OCW.

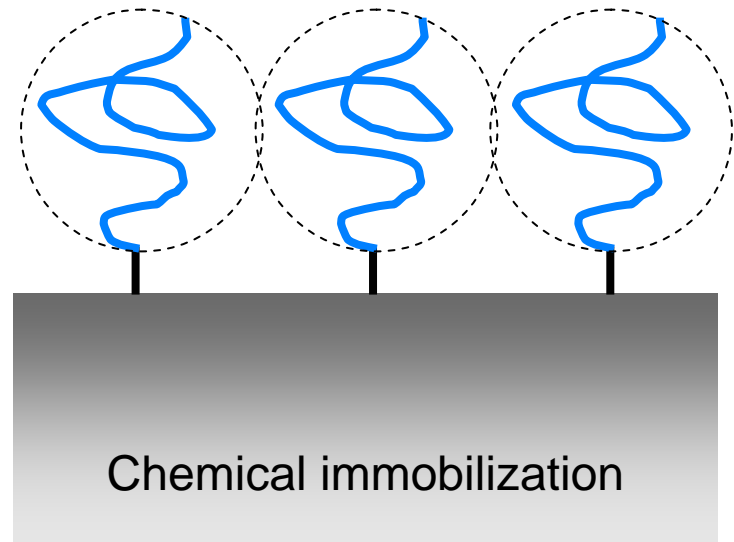
Surfaces should be hydrophilic or very hydrophobic.

Example of “gold standard”

Surface modification with PEO derivative.



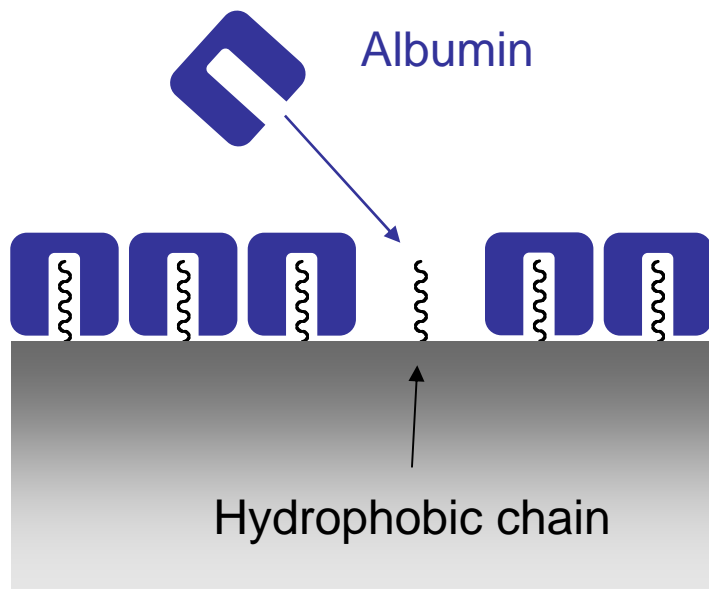
Short-time use
Ex. Drug delivery



Long-time use

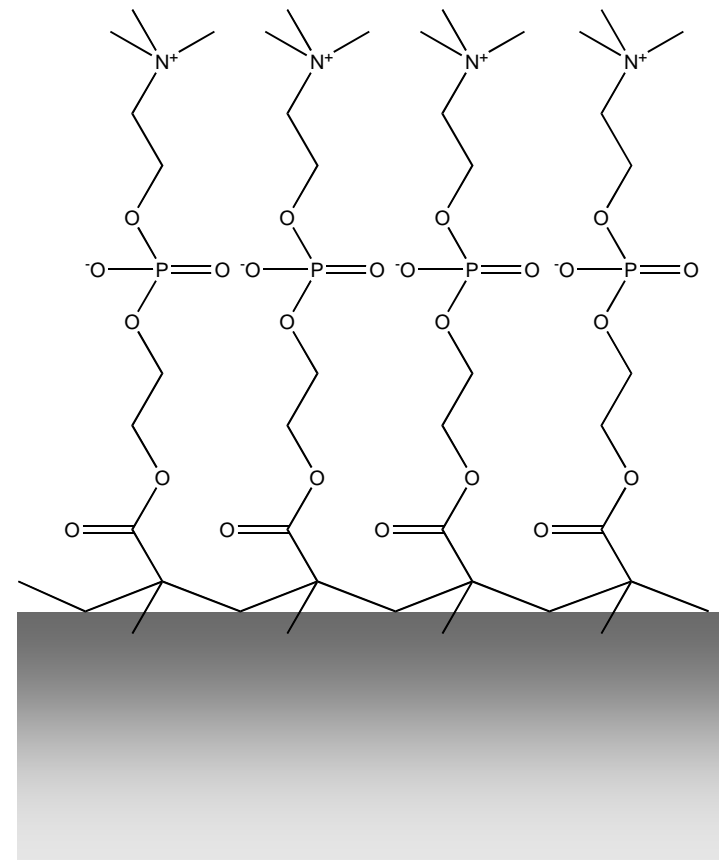
Other strategies for hydrophilic surfaces 1

Albumin coating surface



Serum albumin:
High water solubility and stability
No affinity to proteins and platelets

Phospholipid-mimicking surface

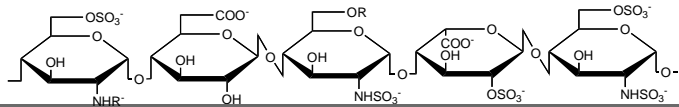


Hydrophilic phosphocholine head

Hydrophobic acylchain

Other strategies for hydrophilic surfaces 2

Heparinized surface



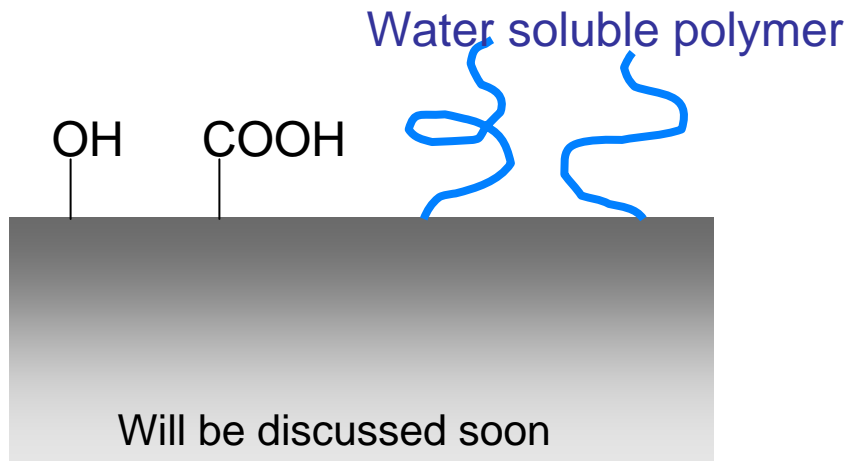
Heparin:
Immobilized covalently and ionically
Inhibitor for thrombin or platelet adhesion

Endothelial cell attachment



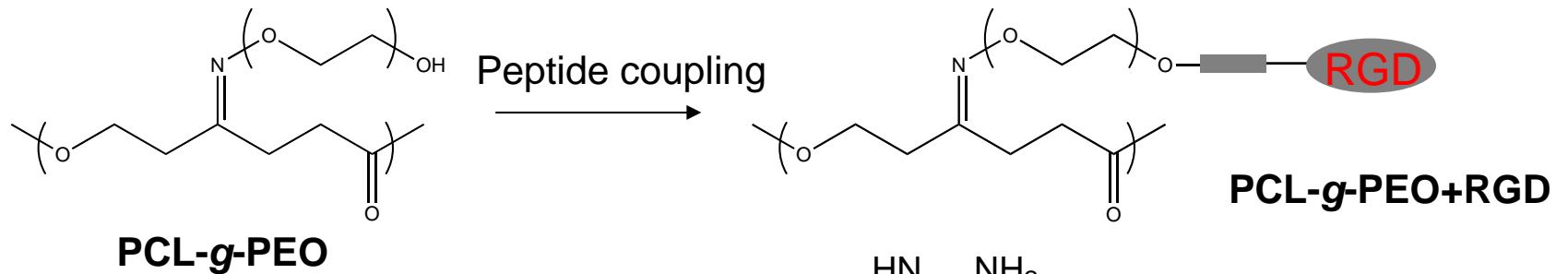
Natural blood vessel lining:
Fibrinolytic activity (hydrolysis of fibrin)

Plasma treatment



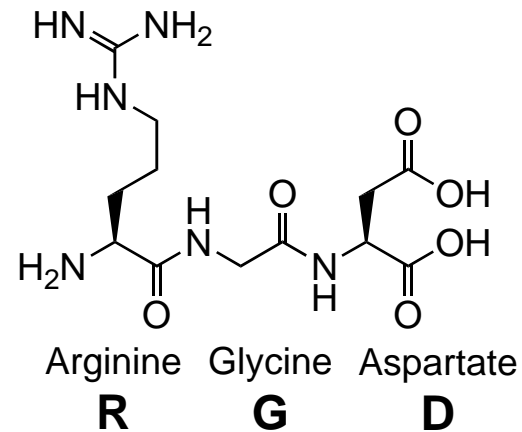
NR6 WT fibroblast adhesion triggered by RGD recognition

Photos removed for copyright reasons.



NR6 WT:
mice fibroblast bearing human integrin

Taniguchi, *Polym Int.* submitted



Biomolecule immobilization method for specific surfaces

Physical adsorption

van der Waals

Electrostatic

Affinity

Adsorbed and cross-linked

Physical “entrapment”

Barrier system

Hydrogel

Dispersed system

Covalent attachment

Soluble polymer conjugate

Solid surface

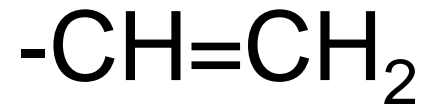
Hydrogel

Biomolecules: proteins/peptides, saccharides, lipids, drugs,
ligands, nucleic acids/nucleotides, (cells,) etc.

Chemical modification of materials

ref. Ratner, *Biomaterials Science*, p. 229

For covalent binding to an inert solid polymer surface, the surface **must first be chemically modified** to provide reactive groups for the subsequent immobilization step.

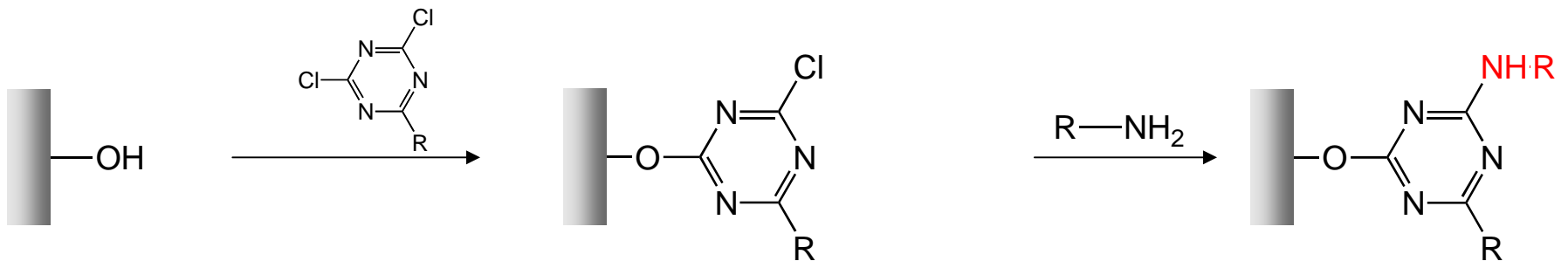
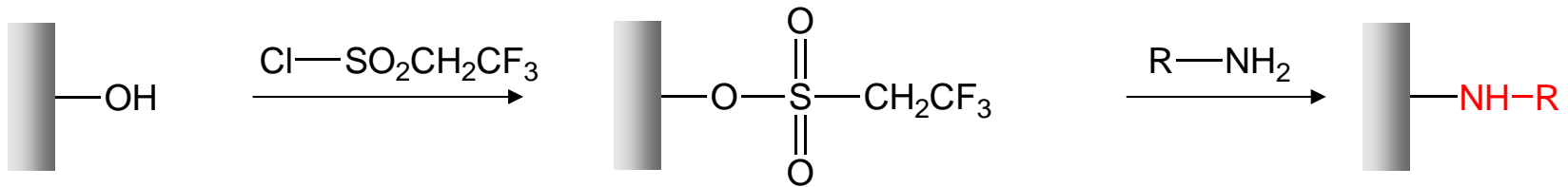
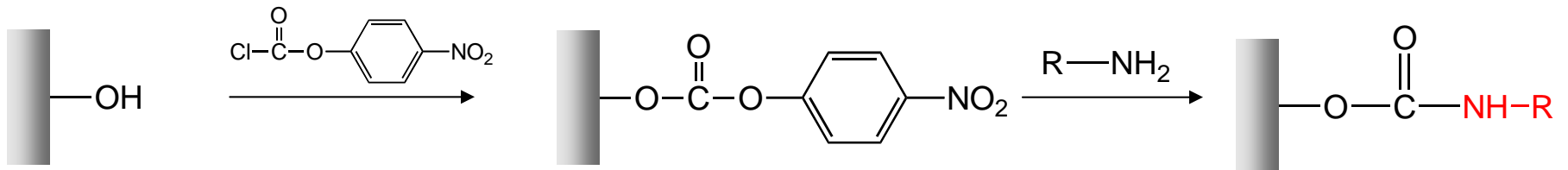


etc.

Protein/peptide immobilization strategies 1

Major reacting groups: **-NH₂**

Activation of -OH

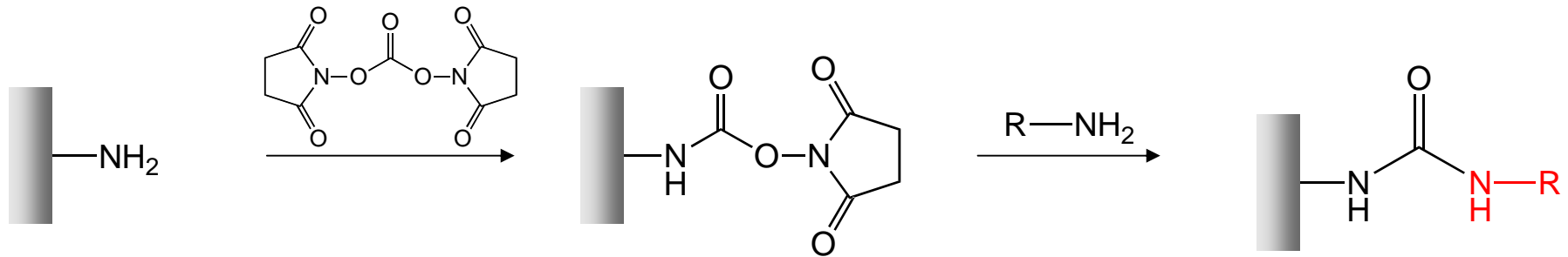


All the procedures must be carried out under anhydrous condition

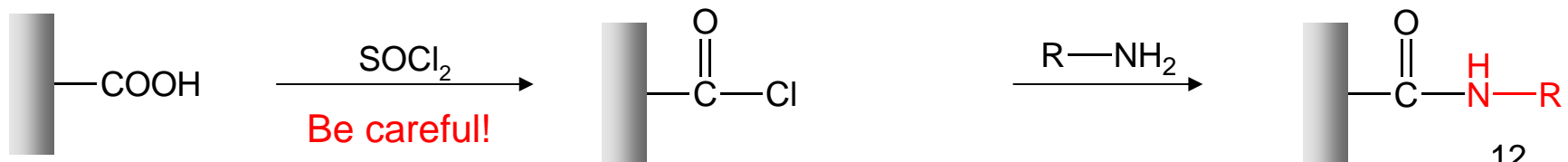
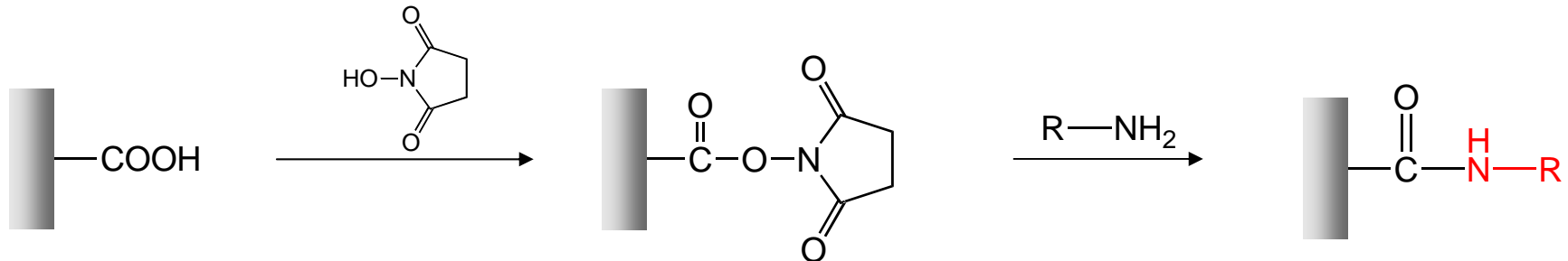
Protein/peptide immobilization strategies 2

Major reacting groups: **-NH₂**

Activation of -NH₂



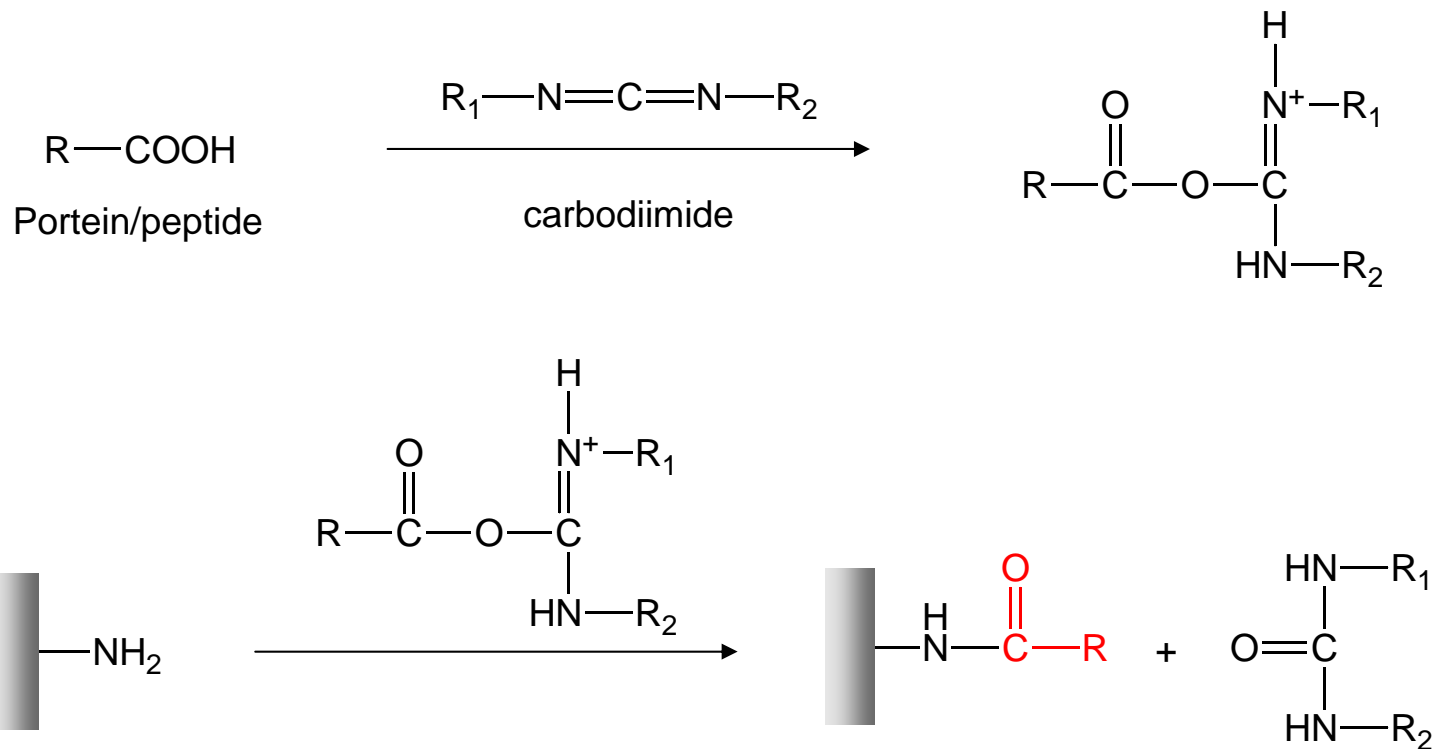
Activation of -COOH



Protein/peptide immobilization strategies 3

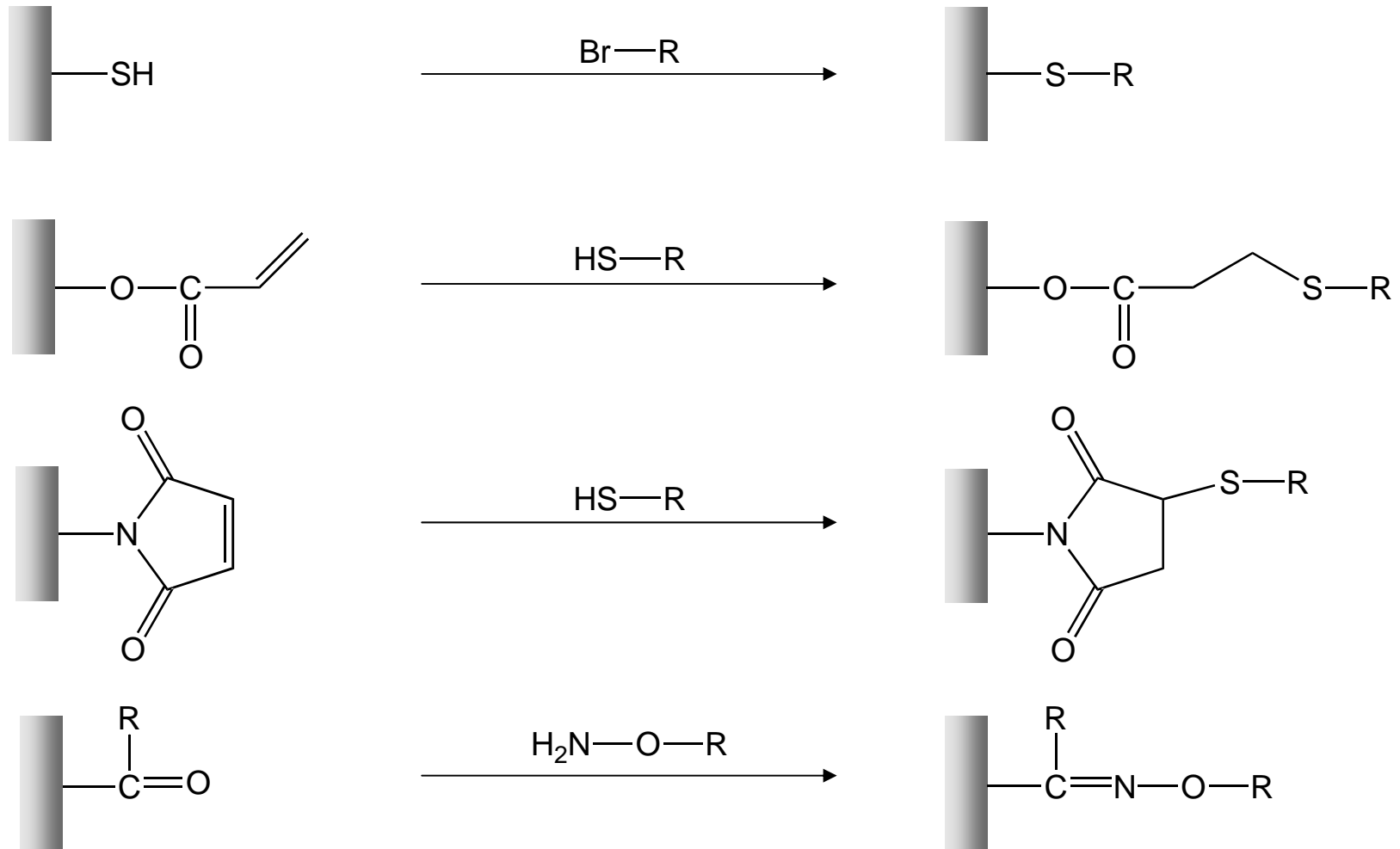
Major reacting groups: **-COOH**

Activation of $-NH_2$



Protein/peptide immobilization strategies 4

Chemoselective ligation

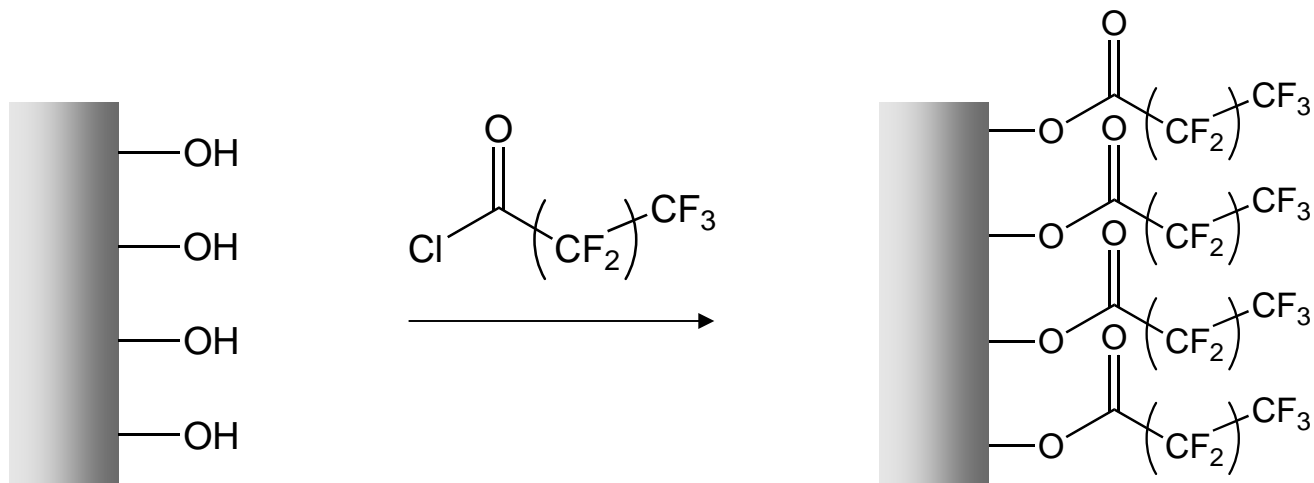


Reactions take place between selected pairs of functional groups 14

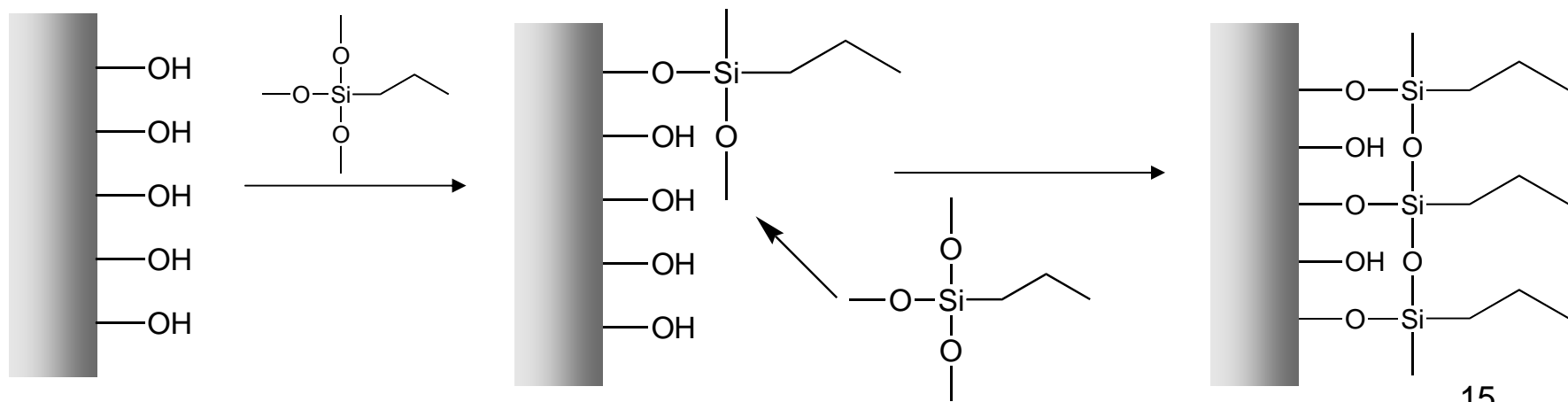
Other chemical surface modifications

Preparation of hydrophobic and inert surfaces

Fluorination



Silanization



Summary:

- Clean a surface
- Reduce/eliminate protein/cell/bacteria adsorption, reduce thrombogenicity

Non-fouling and bioinert surfaces

- Promote biological response

Immobilization of biomolecules

Short time - Physical adsorption

Long time - Covalent bonding