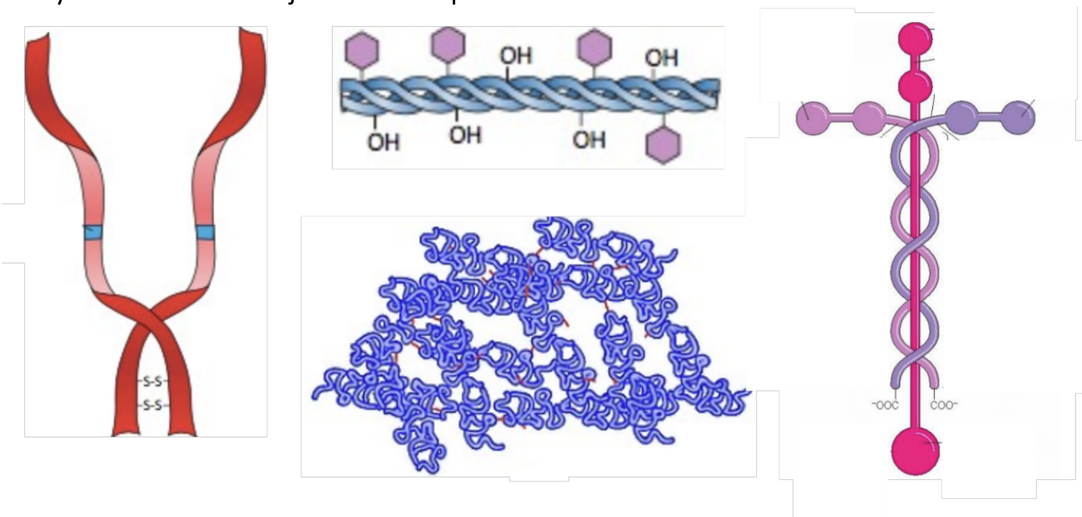
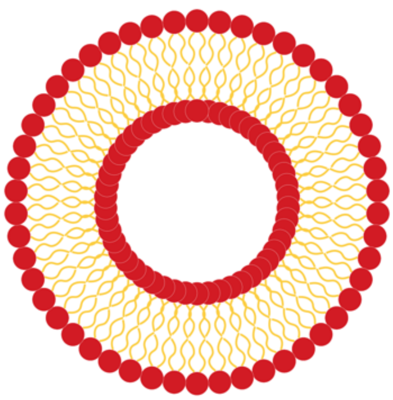
1. During the lecture you heard about the extracellular matrix (ECM), that is surrounding cells.
   a) Why is it so important?
   b) Can you name these major structural proteins of the ECM?



   c) Please draw the structure of the RGD motif and name the structural ECM protein it is present in? You can use the codon-table from last time, that is attached at the bottom.
   d) How would you engineer an ECM-mimicking biomaterial to take over the function of the ECM?

2. Could you think of an artificial cellular system, that would allow for the screening of different drug candidates and their effect on physiology?
   a) What features would such a system require to be relevant for biomolecular research?
   b) What environment would such a system require to thrive in?
   c) Could you tell the major drawback of the currently available natural product used for the culturing of these systems?
   d) Name two major advantages of synthetic alternatives to the currently used natural product used for culturing such systems.

3. During the lecture you got a small introduction to the immune system.
   a) What are the main two branches of the immune system and what are their differences?
   b) Can you name 2 major cell types of each of the immune system classes.
   c) Please draw the main product of a specific subset of B-cells, that is very important for an immunological response and indicate the different critical functional sites.
   d) You are trying to engineer a vaccine and below you can see a nanoparticle, that you would start with. Please draw other important components and explain how they contribute to the establishment of an immunological memory against the disease of interest.



4. I would like to select a strong binding ligand with phage display for a specific receptor expressed in a cancer cell line.
   a) How would I go about selecting this ligand, starting from a large library of potential ligands. You can use a cartoon to explain the method.
   b) How do we determine the sequence of the selected ligand?

   These short, high affinity peptides are often used as "tags" to couple to other proteins or nanoparticles, or even surfaces.

   c) What important tag corresponds to this sequence and draw the chemical structure: CAT-CAC-CAT-CAT-CAC-CAC
   d) How can we include a "tag" in an engineered protein? Can you schematically draw the plasmid?
   e) Why could it be interesting for scientists to find a strong binding ligand for a specific cancer cell line?

5. Viruses and bacteria both are very common microorganisms on Earth. While the great majority are harmless to humans, pathogenic virus and bacteria can cause infectious diseases and even endanger our lives and health.
   a) Name 3 positive functions of bacteria for humans?
   b) Name 2 similarities and 2 differences between bacteria and viruses (think about their biological structures)?
   c) If you would like to engineer a living material using bacteria, what components need to be introduced into the bacteria and how would you do this? Please draw a schematic.
   d) If you want to functionalize your living biomaterial with other proteins like the GFP to visualize the material, what would you need to add to the plasmid of these GFP proteins?

<table>
<tr><th rowspan="2">First Position</th><th colspan="8">Second Position</th><th rowspan="2">Third Position</th></tr>
<tr><th colspan="2">T</th><th colspan="2">C</th><th colspan="2">A</th><th colspan="2">G</th></tr>
<tr><td rowspan="4">T</td><td>TTT</td><td rowspan="2">Phe</td><td>TCT</td><td rowspan="4">Ser</td><td>TAT</td><td rowspan="2">Tyr</td><td>TGT</td><td rowspan="2">Cys</td><td>T</td></tr>
<tr><td>TTC</td><td>TCC</td><td>TAC</td><td>TGC</td><td>C</td></tr>
<tr><td>TTA</td><td rowspan="2">Leu</td><td>TCA</td><td>TAA</td><td>STOP</td><td>TGA</td><td>STOP</td><td>A</td></tr>
<tr><td>TTG</td><td>TCG</td><td>TAG</td><td>STOP</td><td>TGG</td><td>Trp</td><td>G</td></tr>
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<tr><td rowspan="4">A</td><td>ATT</td><td rowspan="3">Ile</td><td>ACT</td><td rowspan="4">Thr</td><td>AAT</td><td rowspan="2">Asn</td><td>AGT</td><td rowspan="2">Ser</td><td>T</td></tr>
<tr><td>ATC</td><td>ACC</td><td>AAC</td><td>AGC</td><td>C</td></tr>
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<tr><td rowspan="4">G</td><td>GTT</td><td rowspan="4">Val</td><td>GCT</td><td rowspan="4">Ala</td><td>GAT</td><td rowspan="2">Asp</td><td>GGT</td><td rowspan="4">Gly</td><td>T</td></tr>
<tr><td>GTC</td><td>GCC</td><td>GAC</td><td>GGC</td><td>C</td></tr>
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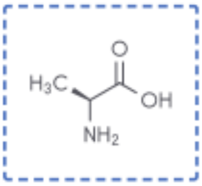
<tr><td>GTG</td><td>GCG</td><td>GAG</td><td>GGG</td><td>G</td></tr>
</table>

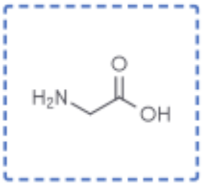
Chart Key

Alkyl · Aromatic · Neutral · Acidic · Basic · Essential · Non-Essential

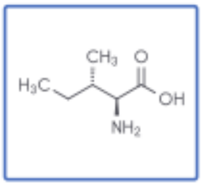
Note: The NH_2 and COOH values listed below are pK_a values.



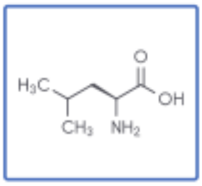
Alanine
Ala A
NH_2: 9.87 COOH: 2.35



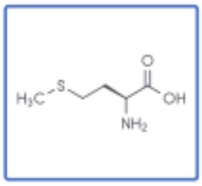
Glycine
Gly G
NH_2: 9.60 COOH: 2.34



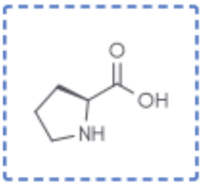
Isoleucine
Ile I
NH_2: 9.76 COOH: 2.32



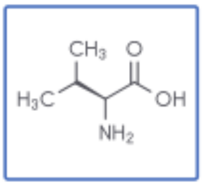
Leucine
Leu L
NH_2: 9.60 COOH: 2.36



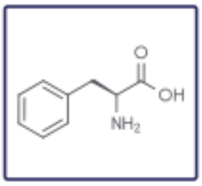
Methionine
Met M
NH_2: 9.21 COOH: 2.28



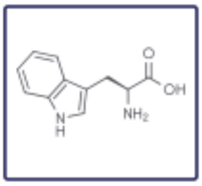
Proline
Pro P
NH_2: 10.60 COOH: 1.99



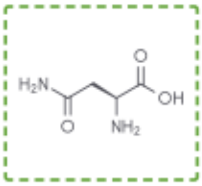
Valine
Val V
NH_2: 9.72 COOH: 2.29



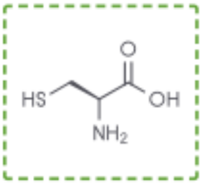
Phenylalanine
Phe F
NH_2: 9.24 COOH: 2.58



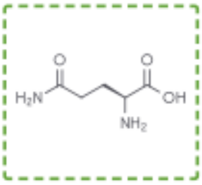
Tryptophan
Trp W
NH_2: 9.39 COOH: 2.38



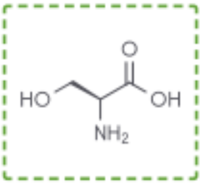
Asparagine
Asn N
NH_2: 8.80 COOH: 2.02



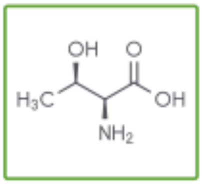
Cysteine
Cys C
NH_2: 10.78 COOH: 1.71



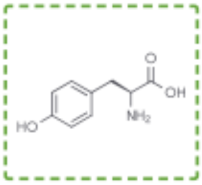
Glutamine
Gln Q
NH_2: 9.13 COOH: 2.17



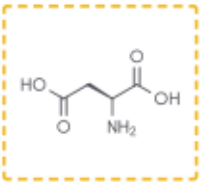
Serine
Ser S
NH_2: 9.15 COOH: 2.21



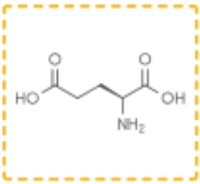
Threonine
Thr T
NH_2: 9.12 COOH: 2.15



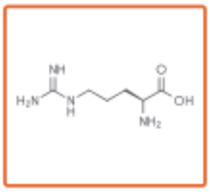
Tyrosine
Tyr Y
NH_2: 9.11 COOH: 2.20



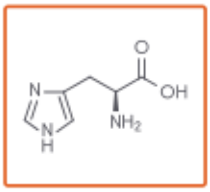
Aspartic Acid
Asp D
NH_2: 9.60 COOH: 1.88



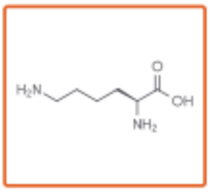
Glutamic Acid
Glu E
NH_2: 9.67 COOH: 2.19



Arginine
Arg R
NH_2: 9.09 COOH: 2.18



Histidine
His H
NH_2: 8.97 COOH: 1.78



Lysine
Lys K
NH_2: 10.28 COOH: 8.90