International Master's Programs of Chemical Engineering in the Graduate School of Engineering, Kyushu University (Academic Year from October, 2026)

Subject： Fundamentals of Bioengineering（1 sheet）
Sample answers:

1. (20 points)
(1.1)
DNA usually forms a double-stranded double helix structure, whereas RNA is generally single-stranded. In addition, RNA can form secondary structures such as stem-loop structures through intramolecular base pairing.

(1.2)
C ＞ B ＞ A ＞ D

(1.3)
The melting temperature (Tm) of double-stranded DNA mainly depends on GC content and fragment length. GC base pairs form three hydrogen bonds, whereas AT base pairs form only two, making GC-rich DNA more thermally stable. In addition, longer DNA fragments have more base-stacking interactions, which further stabilize the double helix. Fragment C has the highest Tm because it is the longest fragment and contains a high proportion of GC pairs. Fragment B also has a very high Tm because it is composed entirely of GC-rich sequences. Fragment A has intermediate GC content and therefore moderate stability. Fragment D is AT-rich and has the lowest thermal stability and Tm.

2. (20 points)
(2.1)
The mitochondrion, specifically across the inner mitochondrial membrane.

(2.2)
ATP stores energy in its chemical bonds. It acts as the primary carrier of energy, storing it when not needed and releasing it when required for cellular work.

(2.3)
ATP is synthesized through the electron transport chain by oxidative phosphorylation, in which electrons from NADH and $FADH_2$ pass through a series of protein complexes, releasing energy that pumps protons across the inner mitochondrial membrane, creating a gradient that drives ATP synthase to produce ATP from ADP and inorganic phosphate.

(2.4)
The citric acid cycle, also known as the Krebs cycle.

3. (10 points)

Embryonic stem cells are most commonly isolated from the inner cell mass of a blastocyst, often obtained from surplus embryos donated following in vitro fertilization procedures. Alternatively, somatic cell nuclear transfer involves fusing a somatic cell nucleus with an enucleated oocyte to generate an embryo.

The primary ethical concern centers on the destruction of human embryos, which some individuals regard as the termination of potential human life. This issue generates significant debate concerning the moral status of the embryo in comparison to the justification of advancing life-saving medical therapies.