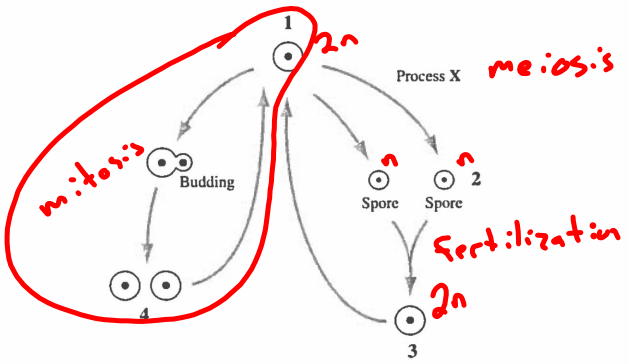
Use the following information to answer the next two questions.

A yeast called *Saccharomyces cerevisiae* has the ability to reproduce both asexually and sexually. When conditions are favourable, the yeast cells reproduce through a process known as budding, which produces cells that are identical to the mother cell. When conditions become unfavourable, yeast cells produce spores that function much like gametes.

Life Cycle of *Saccharomyces cerevisiae*



24. In the life cycle shown above, Process X is

A. mitosis
B. meiosis
C. cloning
D. fertilization

25. Which of the following rows describes the chromosome content of the cells numbered 2 and the chromosome content of the cells numbered 4 in the life cycle shown above?

Row	Cells 2	Cells 4
A.	Diploid	Diploid
B.	Haploid	Haploid
C.	Haploid	Diploid
D.	Diploid	Haploid

haploid - n
diploid - 2n

Use the following information to answer the next two questions.

Mitosis must be carefully regulated to ensure the normal distribution of chromosomes to the daughter cells. A ring-shaped protein molecule known as cohesin attaches to the centromere of a chromosome and holds sister chromatids together to prevent their premature separation. Enzymes detach cohesin molecules from the centromere immediately before the sister chromatids segregate. anaphase

—based on *Nature*, 2006

Megee, Paul. 2006. Chromosome guardians on duty. *Nature* 441, no. 7089 (May 4): 35–36.

26. The phase of mitosis during which enzymes detach cohesin molecules from the centromere is

A. late prophase
B. late anaphase
C. early anaphase
D. early metaphase

27. The failure of enzymes to detach cohesin molecules from the centromere could result in

A. recombination - meiosis, crossing over
B. nondisjunction - failure to seperate/segregate
C. reduction division - meiosis
D. unequal cytokinesis
↳ splitting of cell

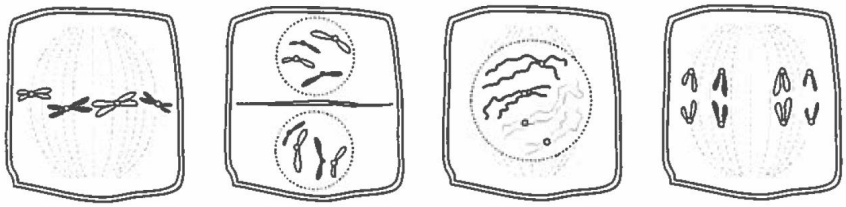
28. In organisms that reproduce sexually, the **primary** purpose of meiosis is the

A. replication of genetic material
B. independent assortment of genes
C. reduction of chromosome number
D. production of identical daughter cells

creation of gametes
reduction division
2n → n
halving chromosome number

Use the following information to answer the next question.

Some Phases of Mitosis in Plant Cells



1 2 3 4

Numerical Response

4. Match each phase of mitosis numbered above with its name given below.

Phase:	4	1	3	2
Name:	**Anaphase**	**Metaphase**	**Prophase**	**Telophase**

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Some Statements About Cell Division

1 Diploid cells are produced.
2 Haploid cells are produced.
3 Four gametes are produced.
4 Two somatic cells are produced.
5 Cell division occurs only in the gonads.
6 Cell division occurs in most body tissues.
7 The products are genetically identical to the parent cells.
8 The products are genetically different from the parent cells.

Numerical Response

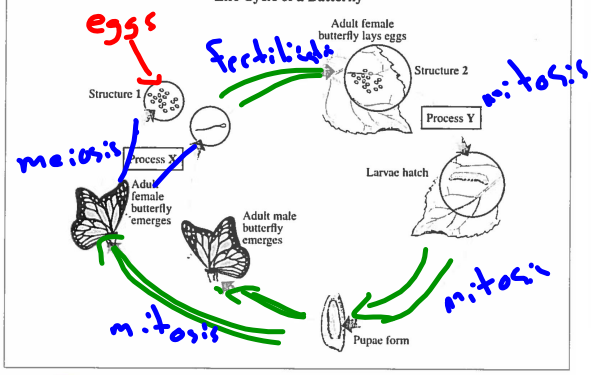
5. The statements about cell division numbered above that describe meiosis are 2, 3, 5, and 8.

(Record all **four digits** of your answer **in any order** in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

Adult butterflies are diploid. The sex chromosomes in adult female butterflies are W and Z chromosomes, whereas the sex chromosomes in adult male butterflies are two Z chromosomes.

Life Cycle of a Butterfly



autosome - non-sex chromosome

29. A karyotype of Structure 1 in the diagram above would have

A. ~~two copies~~ of each autosome and two Z chromosomes
B. one copy of each autosome and either a W or a Z chromosome
C. one copy of each autosome, a W chromosome, and a Z chromosome
D. ~~two copies~~ of each autosome, a W chromosome, and a Z chromosome

30. Which of the following rows identifies Process X and Process Y as shown in the diagram above?

Row	Process X	Process Y
A.	Meiosis	Fertilization
B.	Meiosis	Mitosis
C.	Fertilization	Mitosis
D.	Fertilization	Differentiation

Female WZ
male ZZ

Use the following information to answer the next question.

The Kermode bear, also called "spirit bear" by the Tsimshian people, is a subspecies of the black bear and is found on Princess Royal Island, British Columbia. Most Kermode bears have a black coat, but a small number have a white coat, which is caused by the presence of two autosomal recessive alleles. aa

31. Two heterozygous Kermode bears mate and produce a cub. What is the probability that their cub is female and has a white coat?

A. 0.13
B. 0.25
C. 0.50
D. 0.75

parents Aa × Aa

	A	a
A	AA	Aa
a	Aa	aa

prob of white coat: 0.25 × prob of female: 0.5

autosomal - not to do with sex chromosomes

Use the following information to answer the next question.

In rare cases, single gene mutations can cause obesity in humans. The mode of inheritance of these mutated genes can be autosomal recessive, autosomal dominant, X-linked recessive, or X-linked dominant.

—based on Centers for Disease Control and Prevention, 2005

Office of Genomics and Disease Prevention. 2005. Obesity: Single gene disorders that have obesity as primary feature. *Public Health Perspectives*. Centers for Disease Control and Prevention. http://www.cdc.gov/genomics/info/perspectives/files/obesdisord.htm (accessed March 11, 2005).

Descriptions of Some Forms of Hereditary Obesity

1. All daughters of a man who has this form of hereditary obesity are affected and none of his sons are affected.
2. Two unaffected parents cannot produce an affected child with this form of hereditary obesity.
3. To be affected with this form of hereditary obesity, a person must be homozygous for the mutated gene.
4. In this form of hereditary obesity, a female requires two mutated alleles to be affected, whereas a male requires only one.

$X^A Y$

$aa \times aa$

aa

Numerical Response

6. Match each description of hereditary obesity given above with its mode of inheritance given below. (Use each number only once.)

Description:	3	2	4	1
Mode of Inheritance:	**Autosomal recessive**	**Autosomal dominant**	**X-linked recessive**	**X-linked dominant**

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

$X^A Y$ mommy

$X^A X^a$ $X^a X^A$

aa Aa AA $X^a X^a$ $X^a Y$

↳ more males than females affected

Use the following information to answer the next two questions.

The eumelanin gene determines coat colour in dogs. The dominant allele (*E*) produces a black coat, and the recessive allele (*e*) produces a red coat. The merle gene controls the expression of colour. The merle alleles are incompletely dominant, as shown below.

Genotype	Phenotype
mm	Full colour (either black or dark red)
Mm	Dilute colour (either grey or light red)
MM	White

The eumelanin and merle genes are located on two different autosomes.

EEMm ee mm

32. A grey dog that is homozygous dominant for eumelanin mates with a dark red dog. The phenotypes that are possible in their offspring are

A. grey and black
B. black and white
C. grey and dark red
D. dark red and black

EEMm

EM Em

eemm	EM	Em
em	EeMm	Eemm

Use the following information to answer the next two questions.

The eumelanin gene determines coat colour in dogs. The dominant allele (*E*) produces a black coat, and the recessive allele (*e*) produces a red coat. The merle gene controls the expression of colour. The merle alleles are incompletely dominant, as shown below.

Genotype	Phenotype
mm	Full colour (either black or dark red)
Mm	Dilute colour (either grey or light red)
MM	White

The eumelanin and merle genes are located on two different autosomes.

ee mm × E_ eMM

ee Mm E_ Mm
grey

Use the following additional information to answer the next question.

A dog breeder wants to determine the genotype of her white dog. To do so, she mates her dog with another dog in a test cross. Some of the puppies produced have grey coats, and the remainder of the puppies have light red coats.

always cross unknown genotype with homozygous recessive

33. Which of the following rows identifies the genotype of the breeder's white dog and the phenotype of the other dog in the test cross?

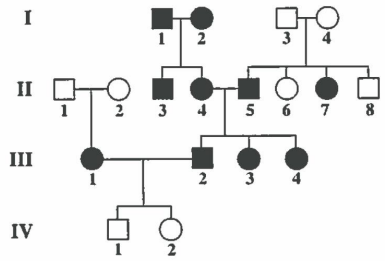
Row	Genotype of the White Dog	Phenotype of the Other Dog
A.	*EeMM*	Dark red
B.	*Eemm*	Dark red
C.	*eeMM*	White
D.	*eemm*	White

Use the following information to answer the next question.

A form of congenital deafness is inherited as a result of the interaction between two genes, *D* and *E*, which assort independently.

Genotype	Phenotype
*D_E_*	Normal hearing
dd _ _	Deaf
_ _ *ee*	Deaf

Pedigree Illustrating the Inheritance of Congenital Deafness



34. The evidence in the pedigree that two different genes interact in the inheritance of congenital deafness is that

A. more female than male offspring are affected
B. individuals I-3 and I-4 produced affected offspring
C. individuals II-4 and II-5 produced affected offspring
D. individuals III-1 and III-2 produced unaffected offspring

Use the following information to answer the next question.

Researchers at Memorial University in Newfoundland recently discovered the mutated gene that causes a disorder known as ARVC5. The disorder, which is characterized by the replacement of healthy heart tissue with fatty, fibrous tissue, results from the inheritance of one copy of the mutated gene. The researchers found the mutation on chromosome 3.

—based on Merner et al., 2008

Merner, Nancy D., Kathy A. Hodgkinson, Annika F. M. Haywood et al. 2008. Arrhythmogenic right ventricular cardiomyopathy type 5 is a fully penetrant, lethal arrhythmic disorder caused by a missense mutation in the *TMEM43* gene. *The American Journal of Human Genetics* 82 (April 11): 809–21.

35. The discovery of the gene for ARVC5 on chromosome 3 indicates that the disorder

A. is transmitted primarily from fathers to sons
B. is transmitted primarily from mothers to sons
C. occurs more frequently in females than in males
D. occurs with equal frequency in males and females

Use the following information to answer the next question.

Researchers have constructed a genetic map of the chromosomes of *Schistosoma mansoni*, a parasitic blood fluke that causes chronic illness in humans. Some of the genes on chromosome 5 and the distances between them are shown in the table below.

Genes	Distance
1 and 3	13.0
2 and 3	24.3
2 and 4	8.2
3 and 4	16.1

—based on Criscione et al., 2009

Criscione, Charles D., Claudia L. L. Valentim, Hirohisa Hirai, Philip T. LoVerde, and Timothy J. C. Anderson. 2009. Genomic linkage map of the human blood fluke *Schistosoma mansoni*. *Genome Biology* 10, no. 6 (June 30), http://genomebiology.com/2009/10/6/R71.

Numerical Response

7. What is the distance between gene 1 and gene 4?

Answer: 29.1 or 3.1

(Record your answer **as a value rounded to one decimal place** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

An enzyme called RNase L breaks down RNA molecules in cells, which results in the inhibition of protein synthesis. RNase L is found in the nucleus of cells.

36. Which of the following steps in protein synthesis is affected **first** by the presence of RNase L?

A. Movement of mRNA from the nucleus to the cytoplasm
B. Production of mRNA from a DNA template
C. Attachment of tRNA to an amino acid
D. Attachment of tRNA to the ribosome

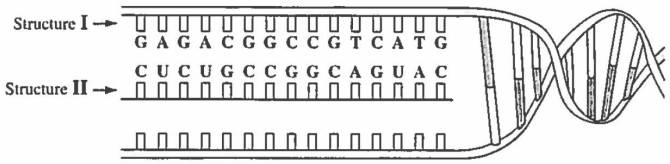
↳ not in nucleus, only cytoplasm

37. One role of tRNA in protein synthesis is to attach to

A. an amino acid in the nucleus
B. an amino acid in the cytoplasm
C. a DNA molecule in the cytoplasm
D. an mRNA molecule in the nucleus

Use the following information to answer the next question.

Some Events in a Cell



Structure I	Structure II	Process	Location
1 DNA	1 DNA	1 Replication	1 Nucleus
2 mRNA	2 mRNA	2 Transcription	2 Cytoplasm
3 Amino acid	3 Amino acid	3 Translation	

Numerical Response

8. Using the numbers given above, identify Structure I, Structure II, the process illustrated in the diagram above, and the location in the cell where the process takes place.

Answer: 1 (Structure I) 2 (Structure II) 2 (Process) 1 (Location)

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

Some forms of deafness are caused by mutations in the connexin 26 gene. One mutation results from the deletion of 9 base pairs.

—based on *Human Gene Mutation Database*, 2010

Institute of Medical Genetics. 2010. Gene symbol: *GJB2*. *Human Gene Mutation Database*. Cardiff University. www.hgmd.cf.ac.uk/ac/index.php.

9 base pairs = 3 codons in mRNA ⇓ 3 a.a.

38. Compared with the protein coded by the normal connexin 26 gene, the protein coded by the mutated form of the gene described above is expected to have

A. 3 fewer amino acids
B. 9 fewer amino acids
C. 18 fewer amino acids
D. 27 fewer amino acids

Use the following additional information to answer the next question.

Another mutation in the connexin 26 gene involves the deletion of two bases and their replacement by two new bases. The deletion is shown below.

A<u>TC</u>
Deleted bases

The two deleted bases are replaced by two adenine bases.

—based on *Human Gene Mutation Database*, 2010

Institute of Medical Genetics. 2010. Gene symbol: *GJB2*. *Human Gene Mutation Database*. Cardiff University. www.hgmd.cf.ac.uk/ac/index.php.

DNA : A<u>TC</u> ⇒ AAA
mRNA : UAG UUU
a.a. stop phenylalanine

39. The transcription of the mutated connexin 26 gene described above results in the replacement of a

A. stop codon with a lysine codon
B. methionine codon with a lysine codon
C. stop codon with a phenylalanine codon
D. methionine codon with a phenylalanine codon

Use the following information to answer the next question.

A Section of a Gene

CTT TGA CAC TCC – DNA

GAA|ACU|GUG|AGG mRNA

Some Amino Acids

1 Valine
2 Serine
3 Arginine
4 Histidine
5 Threonine
6 Glutamate
7 Glutamine
8 Tryptophan

Numerical Response

9. The amino acid sequence coded by the nucleotide sequence of the section of the gene shown above is 6, 5, 1, and 3.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

Some researchers are developing a technology to test for the presence of different flu viruses in a person's blood. One step in the process involves using RNA as a template to produce DNA. The DNA that is produced is then cut into fragments.

40. Which of the following rows identifies the technology used to cut DNA into fragments and describes a property of the DNA fragments?

Row	Technology	Property of DNA Fragments
A.	~~Ligase~~ enzymes	A sequence of nucleotides that contains thymine
B.	~~Ligase~~ enzymes	A sequence of codons that contains uracil
C.	Restriction enzymes	A sequence of nucleotides that contains thymine
D.	Restriction enzymes	A sequence of ~~codons~~ that contains uracil

ligase - glue DNA together

restriction - cuts DNA at specific sites

Use the following additional information to answer the next question.

Other researchers are testing for the presence of different flu viruses by using a technology known as a microarray. A glass chip is covered with tiny fragments of DNA that match sections of the genetic material of many different flu viruses. A blood sample from a patient with the flu is applied to the chip. Viral fragments in the patient's blood will stick to matching fragments on the chip, thus identifying the specific flu virus that has infected the patient.

—based on Townsend et al., 2006

Townsend, Michael B., Erica D. Dawson, Martin Mehlmann et al. 2006. Experimental evaluation of the FluChip diagnostic microarray for influenza virus surveillance. *Journal of Clinical Microbiology* 44, no. 8 (August): 2863–71.

41. Viral fragments from a patient stick to viral fragments on the chip when a

A. purine base in a viral fragment comes in contact with a purine base on the chip

B. base in a viral fragment comes in contact with an identical base on the chip

C. pyrimidine base in a viral fragment comes in contact with a pyrimidine base on the chip

D. base in a viral fragment comes in contact with a complementary base on the chip