AP Biology Summer Assignment
2020-2021 Mrs. Britt

This summer assignment is pretty extensive so it is important that you read through it as soon as possible and budget your work time to get it all done before school begins. The goals of this assignment are to learn some biology, to see connections to the personal lives of people through the lens of biology, and to get a jump-start on some AP Biology curriculum. I hope you are excited to take this course! Have a wonderful summer!!!
Mrs. Britt

I. Make sure you have joined the AP Biology google classroom (class code will be emailed to you) Please email me if you have any trouble joining the class.

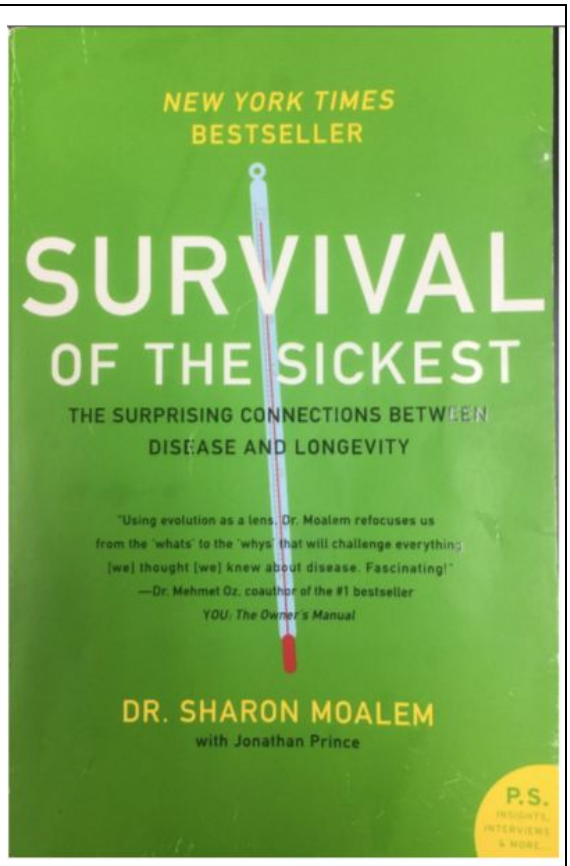
II. Read the book <u>Survival of the Sickest by Dr. Sharon Moalem</u>.

One of the four big ideas for AP Biology is Evolution. This is an interesting read about connections with disease and genetic codes.

"Every adaption is a compromise of sorts, an improvement in a some circumstances, a liability in others" - Dr. Sharon Moalem

As you read, consider the connections between each scenario raised in the book and connect it to the 4 big ideas:

1. The process of evolution drives the diversity and unity of life
2. Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis
3. Living systems store, retrieve, transmit, and respond to information essential to life processes.
4. Biological systems interact and these systems and their interactions possess complex properties.



Part 1: Reading Survival of the Sickest - As you read try to track how the science and ideas in the book relate to our 4 big ideas in AP Biology. Make notes in the margins where you see topics connected to the four themes. We will use our chapter card and your personal notes for a whole class activity. Be ready to put your thinking caps on and have some fun!

Part 2: Chapter Book Card
You must **email Mrs. Britt** to receive a chapter assignment and fill in the four sections on the book card. The book card format can be found in this document. The sections include:

1. Summary of the chapter
2. Scientific Vocabulary found in the chapter and a definition (you cannot leave this section blank)
3. Historical Connection of disease to modern day
4. Illustration that summarizes the chapter – your illustration must accurately portray the main theme/idea in the chapter.

III. From Biology by Campbell 8th Edition (9780805368444)

Read Chapters 4-5. These cover basic biochemistry, macromolecules, and organic chemistry. Make sure you take the time to engage with the charts, graphs, and pictures. Remember the new AP Bio exam is content WITH application, analysis, and interpretation. But we'll talk more about that later! Exciting, right? Alongside these textbook chapters there are reading guides for each chapter. Please complete these reading guides.

a. Complete the attached reading guide for chapters 5. This will count as a Homework grade. Please note I have included the reading guide for ch4 to help you see what is important in the chapter. However, you are ONLY required to complete the reading guide for chapter 5.
b. Pay particular attention to the functional groups in Ch4 (p64-65 chemical structure in the purple box). You will be asked to draw them for a **quiz** on the second day of class.

IV. Scientific Method

Read the attached article Temporary Remission in Acute Leukemia in Children Produced by Folic Acid Antagonist, 4-Aminopteroyl-Glutamic Acid (Aminopterin) – The New England Journal of Medicine.

i. Articles in scientific journals are titled so readers can decide quickly if the article is of interest. **PREDICT** from the title what the author's intended to share in this article.
ii. **DESCRIBE** the observations made by Dr. Farber that led to his experimental use of a folic acid antagonist.
iii. **EXPLAIN HOW** the data for Case 1 in Figure 1 support the claim that folic acid antagonists have an effect on leukemia patients.
iv. **IDENTIFY** the **independent** and **dependent** variables as well as the **control** in this experiment
v. **IDENTIFY** any ethical questions that pertain to this study.

Total points

ch5 Reading Guide for Campbell Biology– 100 points (homework)
Scientific Method – 100 points (lab)
Survival of the Sickest Reading Guides and Chapter Book Card – 200 points (homework)

Read and follow directions carefully. If you have any questions, you may email me at jbritt@stuartschool.org. All parts of this assignment will be collected on the first day of class for grading. You must submit hardcopies.

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Survival of the Sickest Book Card

Chapter # and Title: _____

Brief summary of the chapter you chose:	*Historical Connection of Disease to Modern Day*
Science Related Vocabulary and definition (you MUST have words here)	*Picture summary of selected chapter*

Temporary Remissions in Acute Leukemia in Children Produced by Folic Acid Antagonist . . . Aminopterin

Sidney Farber, M.D., et al.*

It is the purpose of this paper to record the results of clinical and hematologic studies on five children with acute leukemia treated by the intramuscular injection of a synthetic compound, 4-aminopteroylglutamic acid (aminopterin). This substance is an antagonist to folic acid regarding the growth of *Streptococcus faecalis R*.

The occurrence of what he interpreted as an "acceleration phenomenon" in the leukemic process as seen in the marrow and viscera of children with acute leukemia treated by the injection of folic acid conjugates[1]—pteroyltriglutamic acid (teropterin) and pteroyldiglutamic acid (diopterin)—and an experience gained from studies on folic acid deficiency suggested to Farber that folic acid antagonists might be of value in the treatment of patients with acute leukemia.[2] Postmortem studies of leukemic infiltrates of the bone marrow and viscera in patients treated with folic acid conjugates were regarded by Farber as evidences of an acceleration of the leukemic processes to a degree not encountered in his experience with some 200 postmortem examinations on children with acute leukemia not so treated. It appeared worthwhile, therefore, to ascertain if this acceleration phenomenon could be employed to advantage either by radiation or nitrogen mustard therapy after pretreatment with folic acid conjugates or by the administration of antagonists to folic acid.[2] A series of folic acid antagonists was made available by Dr. Y. Subbarow and his colleagues.[3–5]

The objective data sufficient to justify research in the direction of antagonists to folic acid in the treatment of leukemia were obtained from studies on a four-year-old girl with a rapidly progressing acute myelogenous leukemia.[2] Treatment from February 17 to March 24, 1947 with pteroyldiglutamic acid (diopterin), in a dosage of 100 to 300 mg. intramuscularly daily, had no effect upon the hematologic picture. The patient appeared to be moribund. A second bone-marrow biopsy on March 25 verified the diagnosis of myelogenous leukemia. Pteroylaspartic acid, the first antagonist to folic acid to be employed in our studies, was given intramuscularly from March 28 to April 4 in amounts of 40 mg. daily without altering the clinical course. Postmortem examination on

*Co-authors include: Louis K. Diamond, M.D., Robert D. Mercer, M.D., Robert F. Sylvester, Jr., M.D., and James A. Wolff, M.D.

Acknowledgment is made to Dr. Y. Subbarow and his colleagues in the Research Division of the Lederle Laboratories (American Cyanamid Company) and their associates of the Calco Chemical Division, who are responsible for the chemical research that made possible these studies on children.

Reprinted from: Farber, Sidney: Temporary Remissions in Acute Leukemia in Children Produced by Folic Acid Antagonist, 4-Aminopteroyl-Glutamic Acid (Aminopterin). The New England Journal of Medicine, 238:787-793, 1948.

April 4 revealed a markedly hypoplastic bone marrow, with a few immature cells. A change of this magnitude in such a short time has not been encountered in the marrow of leukemic children in our experience.

This observation was followed by clinical, laboratory, and postmortem studies** on a group of 14 children with acute leukemia treated with pteroylaspartic acid and on seven treated with methylpteroic acid. The details of these observations will be reported separately.

Sufficient encouragement was obtained from these observations to justify further studies on the effect of more powerful antagonists to folic acid on the course of acute leukemia in children. Since November 1947, when a sufficiently pure substance became available, to the time of this writing (April 15, 1948) we have made studies on 16 children with acute leukemia to whom the most powerful folic antagonist we have yet encountered, 4-aminopteroylglutamic acid (aminopterin) was administered by intramuscular injection. Many of these children were moribund at the onset of therapy. Of 16 infants and children with acute leukemia treated with aminopterin, 10 showed clinical, hematologic and pathological evidences of improvement of important nature of three months' duration at the time of this report. Six patients did not respond well; four of these are now dead, and two were unimproved. This paper presents detailed clinical, hematologic and bone-marrow studies in five children selected from these 10 who showed evidences of important improvement—the course in the other cases was essentially similar. The patients are selected for the purpose of illustrating some of the problems concerned with the use of aminopterin and because they demonstrate the best results that we have observed. The toxic effects are stressed in these histories, and the temporary nature of the remissions is emphasized.

**These studies were carried out by a group consisting of Sidney Farber, Gilbert G. Lenz, James W. Hawkins, Ernst Eichwald, Robert D. Mercer and E. Converse Peirce, II.

Case Reports

Case 1

W. G., a $7\frac{2}{12}$-year-old boy, entered the hospital for the first time on April 9, 1947 with complaints of joint pain and fever. He had been generally well until seven weeks before admission, when pain developed in the right knee. There were no associated physical abnormalities, and the pain promptly subsided. Five days later pain recurred in the right elbow, and a low-grade fever was noted. Migratory arthralgia and fever continued until admission.

Physical examination revealed only moderate pallor and slight enlargement of the liver and spleen. The boy appeared well developed and nourished and not particularly ill.

Examination of the blood disclosed a red-cell count of 3,670,000, with a hemoglobin of 10.6 gm. and a white-cell count of 56,000, with 73 percent blast forms. The platelet count was normal. A bone-marrow biopsy revealed leukemia.

The patient was treated with pteroylaspartic acid beginning on April 16 in doses of 20 to 60 mg. daily while in the hospital, in a convalescent home where he remained until May 20, and at home where the injections were given by the family physician. During that time he was active and fairly well, although the white-cell count remained high and the red-cell count and hemoglobin fell slowly.

On July 1 diopterin, in a dosage of 200 mg. by mouth daily, was begun. This therapy was continued for about one month, during which the patient steadily became more ill. The liver and spleen enlarged, and he became very anemic. The blast forms in the peripheral blood rose to 94 percent. Joint pain and fever recurred, and by August 13 he was critically ill, with a temperature

reaching 106°F. He was readmitted to the hospital and received several transfusions. Pteroylaspartic acid and methylpteroic acid, in doses of 40 mg. each, were given intramuscularly daily. The patient was discharged after about two weeks, and pteroylaspartic acid and methylpteroic acid in doses of 20 mg. each, were continued in the Tumor Therapy Office. A period of remission ensued, during which the red-cell count and platelets returned to normal levels, the liver and spleen receded in size and the nutrition improved remarkably. He returned to school part-time in October and was in quite good condition. The white-cell count had risen to high levels, however, and in November general deterioration began. The liver and spleen enlarged, and he became so anemic that transfusion was necessary by November 24. Only temporary benefit resulted and transfusions were required at about three-week intervals.

Aminopterin was started on December 16 and given daily, in doses of 0.5 mg. intramuscularly, for six doses. By December 30 the white-cell count had fallen from 60,000 to 19,000. There was moderate improvement in activity and appetite. Thereafter unfavorable weather made daily visits to the clinic impossible, and 1 mg. of aminopterin was given approximately three times weekly for about a month. During that time there was no striking clinical or hematologic improvement, although the patient was not seriously ill.

On February 3 daily injections of 1 mg. of aminopterin were begun. A bone-marrow biopsy and aspiration revealed 85 percent blast forms, no megakaryocytes and no erythropoiesis. After 10 days of regular therapy the white-cell count had fallen from 78,000 to 5,000 but severe stomatitis made cessation of therapy imperative. Within a week without therapy, the stomatitis had healed completely, and the patient had developed a ravenous appetite. The nutrition gradually improved. By February 21 the liver was no longer palpable, and only the tip of the spleen could be felt. Bone-marrow aspiration and biopsy revealed a slight decrease in blast forms and slight erythropoietic activity. The platelets reached normal levels about one month after this course of daily therapy. On March 1 the white-cell count began to rise in spite of daily administration of 0.25 mg. of aminopterin and by March 6 was 75,000. The spleen again enlarged. The dosage of aminopterin was raised to 1 mg. on March 8, and after about 10 days the white-cell count had fallen to 12,000. Slight stomatitis again appeared, and the dosage of aminopterin was reduced to 0.5 mg. daily, with one unit of crude liver extract weekly. The white-cell count has remained at a high-normal level, and the spleen is again slowly receding. The stomatitis is still present but is not progressing and does not interfere with ability to eat.

The leukemia in this case progressed slowly during treatment with pteroylaspartic acid and methylpteroic acid, but during a course of diopterin became rapidly worse. The liver and spleen enlarged, severe anemia developed, and the blast forms in the peripheral blood rose above 90 percent. The patient appeared critically ill, with a maximum temperature of 106°F. Transfusions and therapy with these two folic acid antagonists were followed by a marked but temporary remission. Irregular therapy with aminopterin has been of no benefit, but on two occasions daily injections have produced good clinical and hematologic remissions. On both occasions, stomatitis has interfered with optimal use of the drug. At the time of writing the patient is in excellent physical condition.

Case 2

R. P., a 6 $^{4}/_{12}$-year-old boy, was admitted to the hospital on March 4, 1948, with the chief complaint of increasing pallor. His growth, development and

Skip OR lightly skim the remaining case studies. Please read the discussion and conclusion at the end of this paper.

general health had been excellent until about three weeks before admission, when tonsillitis had developed. This had subsided promptly, but the patient had become lethargic, and increasing pallor was noted. About 10 days before admission his parents began to notice that he bruised easily.

Physical examination disclosed a well-developed and fairly well-nourished boy who was very pale and lethargic. Many small ecchymoses were noted over the extremities. The liver edge extended 4 cm. below the costal margin, and the tip of the spleen could be felt at the costal margin. There was slight generalized lymphadenopathy.

Examination of the blood revealed a red-cell count of 1,880,000, with a hemoglobin of 5.65 gm. and platelets of 46,000, and a white-cell count of 4200, with 20 percent immature or blast forms. A sternal-marrow aspiration revealed 75 percent blast forms. No megakaryocytes were seen.

Shortly after admission the patient developed a spiking temperature up to 104° or 105°F. daily, and rapidly became more lethargic. Blood cultures revealed no growth. Frequent transfusions raised the red-cell count and hemoglobin to normal levels, but there was no favorable clinical response. The white-cell count fell to 1500. He appeared critically ill. On the seventh hospital day penicillin was started, and the temperature decreased although it continued to reach 101 to 102°F. daily.

On the eighth hospital day, aminopterin (1 mg.) and crude liver extract (1 unit) were given intramuscularly. The white-cell count was 1500. This medication was continued daily, and the patient rapidly became more alert and active. The white-cell count remained near 2000. He was discharged moderately improved on March 15. After discharge he was seen six times weekly in the Tumor Therapy Clinic and 1 mg. of aminopterin and one unit of crude liver extract were given at each visit. Rapid improvement in appetite and activity continued. A second sternal-marrow biopsy and aspiration after one week of therapy revealed a 25 percent decrease in blast forms and an increase in more mature leukocytes and megakaryocytes. By March 25 the white-cell count had reached 500, with 34 percent neutrophils, 63 percent lymphocytes and two percent blast forms. His activity and appetite were normal, and easy bruising was no longer a complaint. At about that time he developed minor lesions of the oral mucosa. The dosage of aminopterin was reduced to 0.5 mg., and the liver extract was given once weekly. Steady improvement has continued. The liver and spleen are no longer palpable. The patient is active in outdoor games, and his endurance is good. On March 31 he returned to school, where his teacher noted marked improvement in his appearance and interest. Sternal-marrow aspiration on April 1 revealed a slight further reduction in blast forms, a moderate increase in megakaryocytes and a marked increase in erythropoiesis. He continues on daily injections of 0.5 mg. of aminopterin with liver extract once weekly.

This patient had rapid progression of leukemia until one month after the onset, when he appeared critically ill. After three weeks of daily aminopterin therapy his activity and appearance have returned to normal and he is in school part-time. The red-cell count and hemoglobin are still high, and the white-cell count is within normal limits. Immature cells or blast forms have disappeared from the peripheral blood, and the bone marrow shows a moderate shift toward maturity of leukocytes, with an increase of erythrocyte precursors and megakaryocytes.

Case 3

G. J., a 3 $^{8}/_{12}$-year-old boy, was admitted to the hospital on November 2, 1947—five days after the onset of an

acute illness with sore throat and fever.

The past history, birth and developmental history were not remarkable.

Physical examination disclosed a critically ill patient with an acute follicular tonsillitis and enlarged tender cervical lymph nodes. There was no generalized adenopathy and no hepatomegaly or splenomegaly. A blood culture was positive for beta-hemolytic streptococcus.

Examination of the peripheral blood showed a red-cell count of 1,900,000, a white-cell count of 480 and a platelet count of 123,000. Bone-marrow aspiration showed 16.4 percent blast forms, 3.2 percent mature polymorphonuclear leukocytes, 76.2 percent lymphocytes and 1.6 percent erythroid elements. On the basis of the bone-marrow aspiration a diagnosis of leukemia was made. The bacteremia was treated with penicillin and streptomycin.

After recovery from the infection the patient went into a complete clinical and hematologic remission for about two months. At that time bilateral acute otitis media developed. Two weeks later the total nucleated count of the sternal bone marrow was 910,000 (normal 200,000 to 250,000), with 96 percent blast forms. By February 26, 1948, the white-cell count was 17,250, with 80 percent blast forms, the spleen extended to the umbilicus, petechiae began to appear, and it was obvious that the child was entering a rapidly progressive phase of the leukemia.

He was readmitted to the hospital on March 6. He appeared chronically ill, with pallor, petechiae, moderate generalized lymphadenopathy and marked hepatomegaly and splenomegaly. The white-cell count, which was 30,400 with 86 percent blast forms, on admission, fell rapidly to 900 by March 12, and the patient appeared moribund. Blood cultures were negative.

Aminopterin was started on March 13 in doses of 0.5 mg. and given for five consecutive days. Crude liver extract, in a dosage of one unit daily, was given in the same syringe. At the end of that time there was no noticeable clinical improvement, but the white-cell count, which was still 900, contained only five percent blast forms. A sternal-marrow smear made at the end of this short period of therapy and compared to one just before therapy was started showed a shift to the right, with some reduction in blast forms and an increase in more mature forms of granulocytes, as well as a slight increase in erythroid elements. Aminopterin was discontinued until it became apparent that the leukopenia was not increasing.

After four days without treatment, 0.5 mg. of aminopterin daily with one unit of crude liver extract was given once more. The white-cell count increased gradually, and blast forms disappeared from the peripheral blood. The child began to show clinical improvement, his appetite became better, and the liver and spleen became scarcely palpable. The petechiae and generalized adenopathy disappeared.

At the present writing there is a partial contracture of the left leg, probably resulting from leukemic infiltrations about the knee joint and in the gastrocnemius muscle. The tip of the spleen is still palpable. Otherwise the child is normal on physical examination. The white-cell count is 6700, with a normal differential. The platelet count is 152,000. Aspiration of the sternal marrow on March 29 revealed eight percent blast forms, with an increase in more mature granulocytes, erythrocyte precursors and megakaryocytes.

This child with acute leukemia had a remission of about two months' duration after a bacteremia. At the time aminopterin was started he was in a rapidly progressive phase of the leukemia and appeared moribund. After five days of therapy there was marked improvement in the peripheral blood and sternal-mar-

row picture. He has continued to demonstrate rapid and remarkable clinical improvement. Eighteen days after therapy was started the sternal-marrow aspiration showed only a slight shift toward immaturity of the myeloid elements and a moderate reduction of lymphocytes and erythroid elements. The peripheral blood at present shows slight thrombocytopenia, with a white-cell count of 8000 and a differential count that is essentially normal except for a large number of band forms.

Case 4

C. C., a $2^{1}/_{12}$-year-old girl, was admitted to the hospital on August 22, 1947. Six weeks previously her father had noticed lumps about the head and neck. Two weeks previously her family physician had made a diagnosis of leukemia on the basis of a peripheral blood smear.

Physical examination revealed a pale girl, with ecchymotic areas over the lower extremities. There was marked generalized adenopathy, particularly about the parotid region, and the liver edge and tip of the spleen extended down to the iliac crests.

Examination of the blood disclosed a white-cell count of 75,000, with 80 percent blast forms. The platelet count was 54,000. The patient was discharged and given X-ray therapy to the parotid region in the outpatient department. A total of 600 rads was given from September 4 to September 8. The white-cell count, which was 94,000 on September 4, had dropped to 5000 by September 11.

The patient was readmitted on September 27. She was much worse, with a poor appetite, marked pallor and massive adenopathy. The white-cell count was 1000, with 30 percent blast forms. Several transfusions before discharge produced only slight improvement.

The third admission, on November 6, followed a generalized convulsion. The patient was comatose, with a temperature of 103.6°F.

Physical examination was essentially unchanged except that the kidneys were definitely enlarged and easily palpable. There was no positive evidence of infection. A transfusion and penicillin were given, and the patient was discharged in fair condition.

The fourth and last admission was on December 2, when there was a temperature of 105°F. There was a severe stomatitis and pharyngitis, with extensive exudation. The left ear was inflamed but not suppurating. Bronchopneumonia was present on the left. A lumbar puncture showed evidence of subarachnoid hemorrhage. A blood culture was positive for *Staphylococcus aureus*, coagulase positive.

For the first six hospital days the patient ran a septic temperature ranging between 105° and 103°F. She was given penicillin and sulfadiazine, as well as repeated blood transfusions, throughout the hospital stay. At this admission she was seen for the first time by the Tumor Clinic and received 20 mg. of teropterin per day for 18 doses, from December 3 through December 20.

On several occasions the patient appeared moribund but on about the seventh hospital day she began to improve and continued to improve until the time of her discharge. The white-cell count, which had dropped to 650 on the fourth hospital day, rose to 6400 on the day before discharge. The differential count included 68 percent neutrophils, 24 percent lymphocytes and eight percent monocytes. There were no blast forms.

After this severe infection there was a remission in the clinical and hematologic condition. During that time the patient was given an occasional dose of teropterin to a total of 140 mg. By January 13 small lymph nodes over the scalp, parotid and cervical regions had begun to develop. These rapidly increased, and by January 19 there was massive generalized adenopathy. The peripheral blood and bone marrow continued at values

approaching normal. There were only occasional to five percent blast forms in the peripheral blood, with a normal total white-cell count, and 8.4 percent blast forms in the bone marrow, with a slight depression of mature forms and a moderate depression of erythroid forms. On January 20 aminopterin was started in doses of 1 mg. daily with 20 mg. of teropterin daily. This was given on 26 clinic visits from January 20 to February 21. Four days after treatment had been started there was a marked decrease in the size of all the lymph nodes. In two weeks the patient was normal on physical examination. Her appetite became very good, her disposition happy, and she began to play and run about like a normal child. Her parents stated that she was better than she had been before she became sick for the first time. Since treatment was stopped, she has continued to do well. She has been without treatment since February 21 and at present is completely normal on physical examination. The total white-cell count is 9000, with an occasional blast form. The platelet count is 256,000, the red-cell count 4,600,000 and the hemoglobin 14.8 gm.

This child is known to have had acute leukemia since early August, 1947. Her course was rapidly and progressively downhill until December, when she had a fulminating generalized infection with bacteremia. After this she had clinical and hematologic evidence of remission. In the middle of January a relapse was taking place, as evidenced by massive generalized adenopathy although the blood and bone-marrow picture remained the same. After aminopterin therapy the adenopathy disappeared. The patient has remained clinically well for 43 days without treatment and shows an essentially normal hematologic picture at the time of writing. At the end of 47 days without treatment a few nodules appeared beneath the scalp and in the subcutaneous tissue over the face. It is probable that these represented leukemic deposits, although at the time of their appearance the peripheral blood was still essentially normal. Because of this finding the treatment has been reinstituted.

Case 5

R. S., a $2\,{}^{2}/_{12}$-year-old boy, was admitted to the hospital on August 26, 1947 with the chief complaint of increasing pallor. He was one of identical twins, and his birth, growth and development, and general health had been unremarkable. About 10 days before admission he had developed a low-grade fever, soon followed by increasing pallor, lethargy, anorexia and intermittent vomiting.

Physical examination showed a fairly well-developed and well-nourished and only moderately ill boy. He was very pale. There was generalized enlargement of the lymph nodes and moderate hepatomegaly and splenomegaly. X-ray study showed marked infiltration of the long bones. The hemoglobin was 5.5 gm., and the white-cell count 12,400, with 41 percent immature or blast forms.

During two weeks in the hospital the patient received transfusions, which restored the hemoglobin to normal levels. After discharge he was seen in the Tumor Therapy Clinic daily except Sunday and on each visit received 20 mg. of pteroylaspartic acid intramuscularly. He continued on this regime for about two months, during which the disease progressed slowly but steadily. He became less alert and less active. He developed a limp. There was gradual weight loss, and the liver and spleen continued to enlarge. The leukocytes remained at normal levels but the percentage of blast forms increased. The red-cell count and hemoglobin slowly fell, until on November 6 it was necessary to admit him to the hospital for transfusion. At that time a small pathologic fracture was noted in the left tibia. After discharge he was seen in the Tumor Therapy Office

three times weekly and on each visit received 40 mg. of pteroylaspartic acid intramuscularly. Late in November there was a definite acceleration in the progress of the disease. The white-cell count began to rise, and the platelets fell. The patient began to bruise easily and had occasional slight oozing from the gums. He developed moderate exophthalmos. He refused to walk. Hospitalization was necessary twice in the early weeks of December for treatment of arthritis and upper respiratory infection. Sternal-marrow aspiration at that time revealed 40 percent blast forms and little erythropoiesis. By the end of December the patient appeared moribund. He had marked generalized adenopathy, marked hepatomegaly and a spleen whose tip extended into the pelvis. There was moderate dyspnea and stridor, pallor, marked wasting and exophthalmos. There were many ecchymoses, and oozing occurred at the gingival margins.

Aminopterin therapy was begun on December 28. On each of three successive days the patient received 1.0 mg. of the drug intramuscularly. During that time the white-cell count began to fall rapidly from the pretreatment level of 60,000. By December 31 the count was 9000, and respiratory difficulty was even more marked. He was admitted to the hospital, aminopterin was discontinued, and a transfusion was given. He was discharged on January 3, 1948, slightly improved, but with the white-cell count only 2700. After discharge he was again followed in the Tumor Therapy Clinic. By January 13 marked clinical improvement had become apparent. The patient was walking for the first time in two months, and respiratory difficulty had disappeared. His appetite was ravenous. There was no more bleeding. "His clothes became loose about the abdomen." On January 27 the white-cell count reached 5000, and 0.5 mg. of aminopterin was started and given three times weekly. Gradual improvement continued, but a white-cell count of about 3000 persisted. In the middle of February, teropterin in 10 mg. amounts was given with each dose of aminopterin for five doses. Early in March a rise in the hemoglobin and red-cell count began. Since then folic acid for a time and lately crude liver extract have been used in conjunction with aminopterin. There had been steady clinical and hematologic improvement so that at the time of writing, activity, alertness and nutrition are equal to or better than those of the well twin. The liver and spleen have decreased in size, so that they are barely palpable beneath the costal margins. Exophthalmos has disappeared. The red-cell and white-cell count, differential counts and platelets are within normal limits, The sternal marrow, examined by biopsy, is normally cellular, and the differential count is normal. Erythropoiesis is active, and megakaryocytes are present in normal numbers.

This boy exhibited slow but regular progression of leukemia from the time of diagnosis in August, 1947 until December, when he became rapidly worse. By January 1948, he appeared moribund. After three daily doses of 1 mg. each of aminopterin there was a rapid fall in the white-cell count, followed in about 10 days by remarkable clinical improvement. On maintenance therapy there has been continued improvement until at present the patient is clinically well, and all the laboratory data are within normal limits.

Discussion

Clinical, hematologic and histologic details are given concerning five children with acute undifferentiated leukemia treated with aminopterin. These patients were selected from a group of 10 who responded favorably to the use of this substance. The 10 were members of a group of 16 children with acute leukemia—six did not respond well, and of these, four are now dead. The observa-

tions on these patients show that the aminopterin has a marked effect upon the leukemic bone marrow, and upon the immature cells in the peripheral blood, and judging from the disappearance of enlargement of the spleen, liver and lymph nodes, when those organs were enlarged, very probably on leukemic deposits in the viscera as well.

Under treatment with aminopterin the white-cell count tended to return to a normal level. This occurred in patients in whom the count was initially high and also in those in whom there was marked leukopenia at the onset of the therapy. The percentage of immature cells fell, and the blast forms decreased markedly and in some cases disappeared from the peripheral blood. The relative percentages of mature leukocytes tended to approach normal values in the peripheral blood. The peripheral-blood changes included improvement approaching the normal in the value of hemoglobin, red-cell count and platelets. Studies of the bone marrow showed changes that varied from a decrease in number to a disappearance of the leukemic cells and variation from hypoplasia to almost normal pattern. Toxic effects included stomatitis, with early ulceration. In an attempt to prevent this complication crude liver extract was employed, as were folic acid and folic acid conjugates.

This report describes only temporary remissions produced by the injection of aminopterin in children with acute leukemia. It is impossible to state whether the substance will be of value for a longer period than that covered by these studies. The toxic effects may make continued use of the drug impossible. One patient (Case 4) had been without treatment for 43 days after having had a satisfactory remission. During this time the peripheral blood and the sternal bone marrow became essentially normal. At the end of 47 days without treatment a few nodules appeared beneath the scalp and in the subcutaneous tissue over the face. It is probable that these represent leukemic deposits, although at the time of their appearance the peripheral blood was still essentially normal. Because of this finding the treatment has been reinstituted. After 10 days of aminopterin treatment, the nodules have disappeared once more.

These studies justify a search for other antagonists to folic acid that are less toxic than aminopterin and may be even more powerful.

Summary

Clinical, hematologic and histologic details of five patients with acute leukemia treated with aminopterin, selected from a group of 16 patients so treated, form the basis of this paper. It is again emphasized that these remissions are temporary in character and that the substance is toxic and may be productive of even greater disturbances than have been encountered so far in our studies. No evidence has been mentioned in this report that would justify the suggestion of the term "cure" of acute leukemia in children. A promising direction for further research concerning the nature and treatment of acute leukemia in children appears to have been established by the observations reported.

References

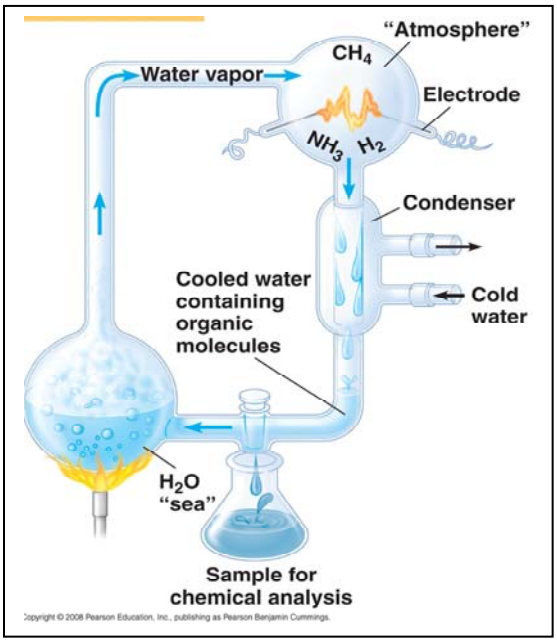
1. Farber, S., et al.: Action of pteroylglutamic conjugates on man. Science 106:619-621, 1947.
2. Farber, S.: Action of folic acid conjugates and antagonists on malignant tumors, including leukemia. Am. J. Dis. Child. (in press).
3. Hutchings, B. L., et al.: Pteroylaspartic acid, antagonist for pteroylglutamic acid. J. Biol. Chem. 170:323-328, 1947.
4. Seeger, D. R.; Smith, J. M., Jr., and Hultquist, M. E.: Antagonist for pteroylglutamic acid. J. Am. Chem. Soc. 69:2567, 1947.
5. Smith, J. M., Jr.; Cosulich, D. B.; Hultquist, M. E., and Seeger, D. R.: Chemistry of certain pteroylglutamic acid antagonists. Tr. New York Acad. Sc. Special Number, Series II, 10: 99-102, 1948.

Name_____**Period**_____

Chapter 4: Carbon and the Molecular Diversity of Life

Concept 4.1 Organic chemistry is the study of carbon compounds

1. Study this figure of Stanley Miller's experiment to simulate conditions thought to have existed on the early Earth. Explain the elements of this experiment, using arrows to indicate what occurs in various parts of the apparatus.



2. What was collected in the sample for chemical analysis? What was concluded from the results of this experiment?

Concept 4.2 Carbon atoms can form diverse molecules by bonding to four other atoms

3. Make an electron distribution diagram of carbon. It is essential that you know the answers to these questions:

   a. How many valence electrons does carbon have?

   b. How many bonds can carbon form?

   b. What type of bonds does it form with other elements?

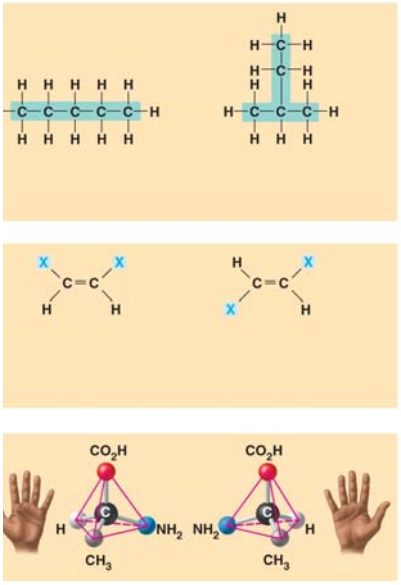
4. Carbon chains form skeletons. List here the types of skeletons that can be formed.

5. What is a *hydrocarbon*? Name two. Are hydrocarbons hydrophobic or hydrophilic?

6. In Chapter 2 you learned what an *isotope* is. Since students often confuse this word with *isomer*, please define each term here and give an example.

	Definition	Example
isotope		
isomer		

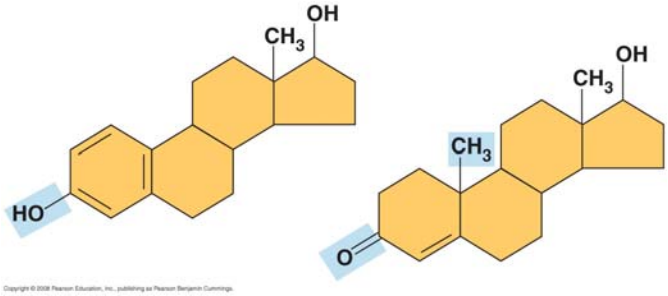
7. Use this figure to identify the three types of isomers. For each type, give a key character and an example.



8. Give one example of enantiomers that vary in their pharmacological effect.

Concept 4.3 A small number of chemical groups are key to the functioning of biological molecules

9. Here is an idea that will recur throughout your study of the function of molecules: Change the structure, change the function. You see this in enantiomers, you will see it in proteins and enzymes, and now we are going to look at testosterone and estradiol. Notice how similar these two molecules are, and yet you know what a vastly different effect each has. Label each molecule in the sketch below, and circle the differences.



10. Define *functional group*.

11. There are seven functional groups. Complete the following chart.

	Hydroxyl	**Carbonyl**	**Carboxyl**	**Amino**	**Sulfhydryl**	**Phosphate**	**Methyl**
Structure							
Example							
Functional Properties							

12. You will need to master the chart and the information in it. Using the functional groups above, see if you can answer the following prompts:

a. $–NH_2$

b. Can form cross-links that stabilize protein structure

c. Key component of ATP

d. Can affect gene expression

e. CH_3

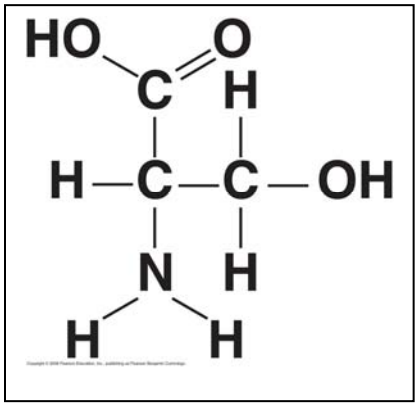
f. Is always polar

g. Determines the two groups of sugars

h. Has acidic properties

i. –COOH

j. Acts as a base



k. Circle and identify three functional groups in the molecule shown above.

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1._____ 2._____ 3._____ 4._____ 5._____ 6._____ 7._____

Name_____Period_____

Chapter 5: The Structure and Function of Large Biological Molecules

Concept 5.1 Macromolecules are polymers, built from monomers

1. The large molecules of all living things fall into just four main classes. Name them.

2. Circle the three classes that are called *macromolecules*. Define *macromolecule*.

3. What is a *polymer*?

   a *monomer*?

4. Monomers are connected in what type of reaction? What occurs in this reaction?

5. Large molecules (polymers) are converted to monomers in what type of reaction?

6. The root words of *hydrolysis* will be used many times to form other words you will learn this year. What does each root word mean?

   hydro–

   lysis

7. Consider the following reaction:

   $$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11}$$

   a. The equation is not balanced; it is missing a molecule of water. Write it in on the correct side of the equation.

   b. So, what kind of reaction is this?

   c. Is $C_6H_{12}O_6$ (glucose) a monomer, or a polymer?

   d. To summarize, when two monomers are joined, a molecule of _____ is always removed.

Concept 5.2 Carbohydrates serve as fuel and building material

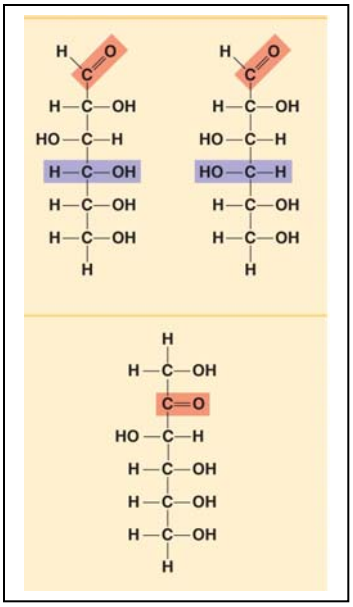
8. Let's look at carbohydrates, which include sugars and starches. First, what are the monomers of all carbohydrates?

9. Most monosaccharides are some multiple of (CH_2O). For example, ribose is a 5-carbon sugar with the formula $C_5H_{10}O_5$. It is a pentose sugar. (From the root *penta–,* meaning 5.) What is the formula of a hexose sugar?

10. Here are the three hexose sugars. Label each of them. Notice that all sugars have the same two functional groups. Name them:

    C=O _____

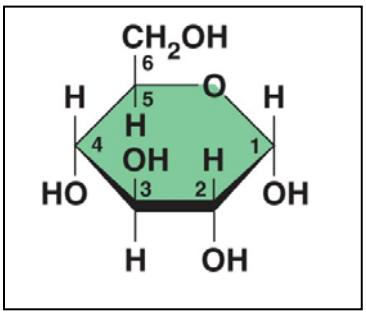
    —OH _____



11. What is the difference between an *aldehyde sugar* and a *ketone sugar*?

12. So, as a quick review, all of these sugars have the same chemical formula: $C_6H_{12}O_6$. What term did you learn in Chapter 3 for compounds that have the same molecular formulas but different structural formulas?

13. Here is the abbreviated ring structure of glucose. Where are all the carbons?



Pay attention to the numbering system. This will be important as we progress in our study. Circle the number 3 carbon. Put a square around the number 5 carbon.

14. Let's look at our reaction in question 7 again: $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$

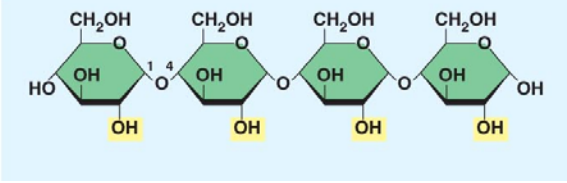
    Notice that two monomers are joined to make a polymer. Since the monomers are monosaccharides, the polymer is a *disaccharide*. Three disaccharides are important to us with the formula $C_{12}H_{22}O_{11}$. Name them below and fill out the chart.

Disaccharide	Formed from which two monosaccharides?	Found where?

15. Have you noticed that all the sugars end in *–ose*? This root word means _____.

16. What is a *glycosidic linkage*?

17. Here is a molecule of starch, which shows 1–4 glycosidic linkages. Translate and explain this terminology in terms of carbon numbering.



18. There are two categories of *polysaccharides*. Name them and give examples.

Type of Polysaccharide	Examples

19. Why can you not digest cellulose? What organisms can?

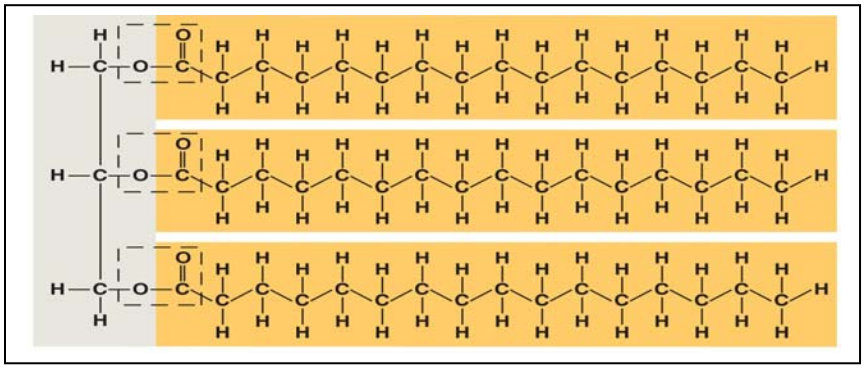
20. Let's review some key points about the carbohydrates. Each prompt below describes a unique carbohydrate. Name the correct carbohydrate for each.

    a. Has 1–4 B glucose linkages
    b. Is a storage polysaccharide produced by vertebrates; stored in your liver
    c. Two monomers of this form maltose
    d. Glucose +_____ form sucrose
    e. Monosaccharide commonly called "fruit sugar"
    f. "Milk sugar"
    g. Structural polysaccharide that gives cockroaches their crunch
    h. Malt sugar; used to brew beer
    i. Structural polysaccharide that comprises plant cell walls

Concept 5.3 Lipids are a diverse group of hydrophobic molecules

21. Lipids include fats, waxes, oils, phospholipids, and steroids. What characteristic do all lipids share?

22. What are the building blocks of *fats*? Label them on this figure.



23. If a fat is composed of 3 fatty acids and 1 glycerol molecule, how many water molecules will be removed to form it? Again, what is this process called?

24. On the figure with question 22, label the ester linkages.

25. Draw a fatty acid chain that is 8 carbons long and is *unsaturated*. Circle the element in your chain that makes it unsaturated, and explain what this means.

26. Name two saturated fats.

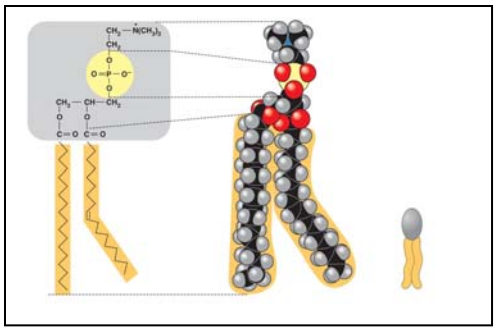
27. Name two unsaturated fats.

28. Why are many unsaturated fats liquid at room temperature?

29. What is a *trans fat*? Why should you limit them in your diet?

30. List four important functions of fats.

31. Here is a figure that shows the structure of a phospholipid. Label the sketch to show the phosphate *group*, the *glycerol*, and the *fatty acid chains*. Also indicate the region that is *hydrophobic* and the region that is *hydrophilic*.



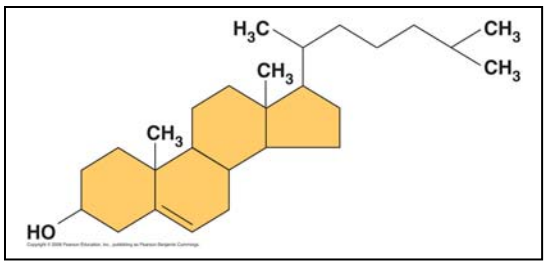
32. Why is the "tail" hydrophobic?

33. Which of the two fatty acid chains in the figure with question 31 is unsaturated? Label it. How do you know it is unsaturated?

34. To summarize, a phospholipid has a glycerol attached to a phosphate group and two fatty acid chains. The head is hydrophilic, and the tail is hydrophobic. Now, sketch the phospholipid bilayer structure of a plasma membrane. Label the hydrophilc heads, hydrophobic tails, and location of water.

35. Study your sketch. Why are the tails all located in the interior?

36. Some people refer to this structure as three hexagons and a doghouse. What is it?



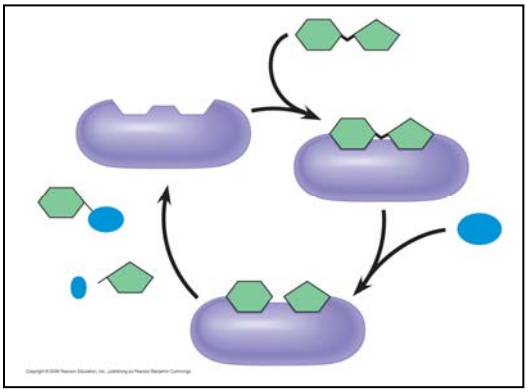
37. What are other examples of steroids?

Concept 5.4 Proteins have many structures, resulting in a wide range of functions

38. Table 5.1 is loaded with important information. Select any five types of proteins and summarize each type here.

Type of Protein	Function	Example

39. *Enzymes* are an important type of protein. They will be studied in Chapter 8. For now, use this sketch to review what you know about enzymes. Label the *active site*, the *substrate*, and the *products*. Show what happens to water.

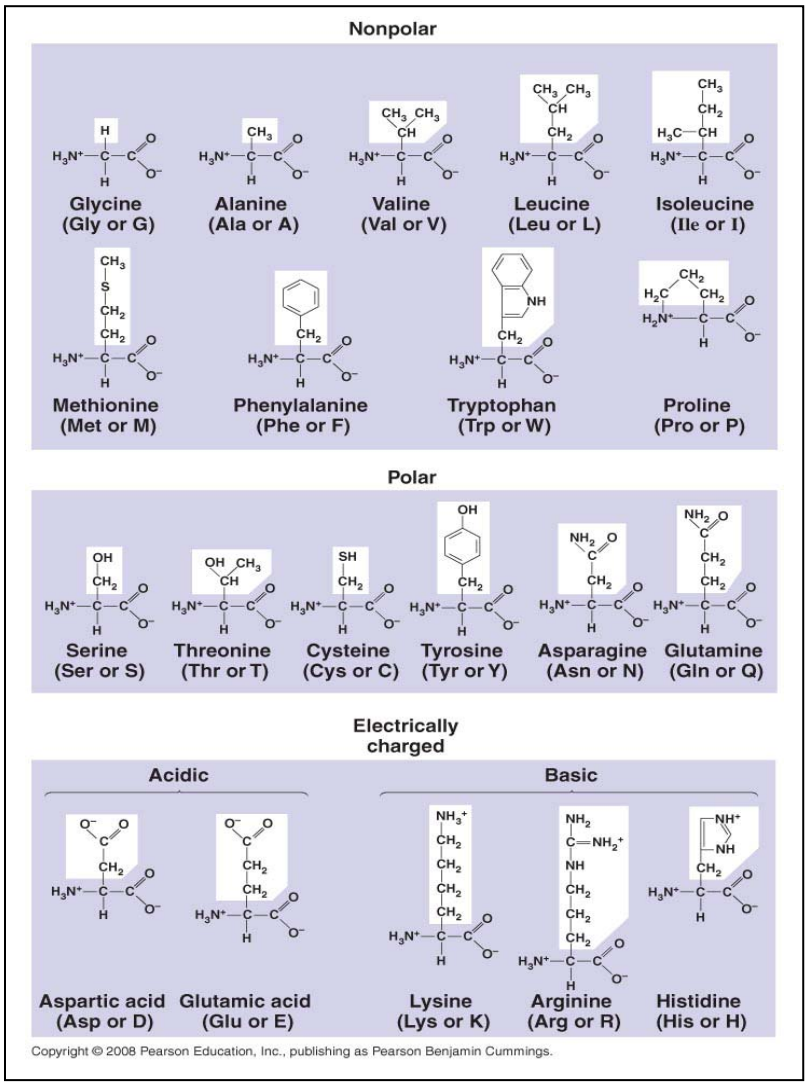


40. Is this reaction dehydration synthesis or hydrolysis?

41. The monomers of proteins are *amino acids*. Sketch an amino acid here. Label the *alpha* or *central carbon*, *amino group*, *carboxyl group*, and *R group*.

42. What is represented by *R*? How many are there?

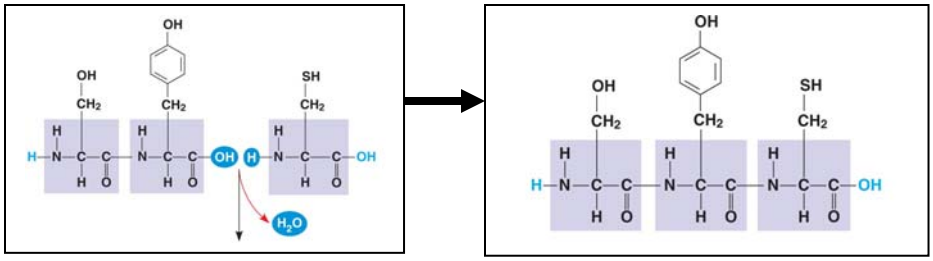
43. Study the figure. See if you can understand why some R groups are nonpolar, some polar, and others electrically charged (acidic or basic). If you were given an R group, could you place it in the correct group? Work on the R groups until you can see common elements in each category.



44. Define these terms:

dipeptide

polypeptide



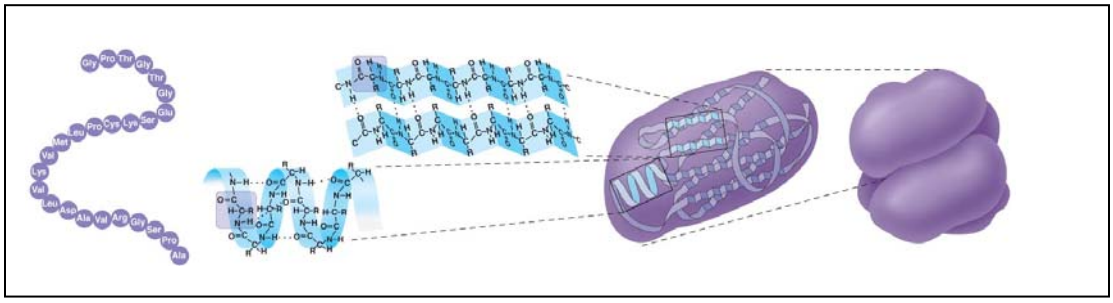
peptide bond

Label each of these terms on the diagrams.

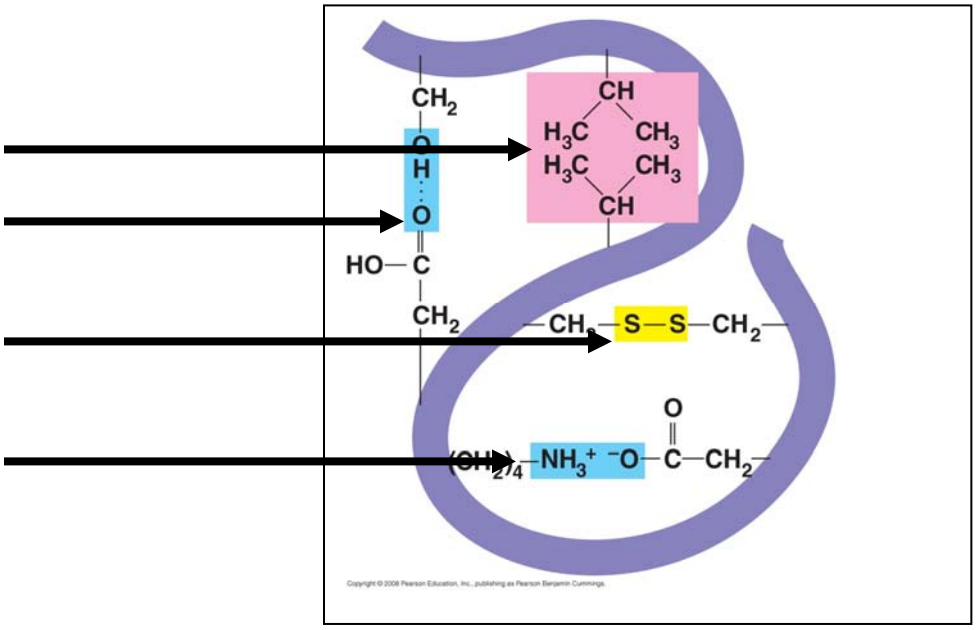
45. There are four levels of protein structure. Refer to Figure 5.21, and summarize each level in the following table.

Level of Protein Structure	**Explanation**	**Example**
Primary (I^o)		
Secondary (II^o) *Alpha helix* *Beta pleated sheet*		
Tertiary (III^o)		
Quaternary (IV^o)		

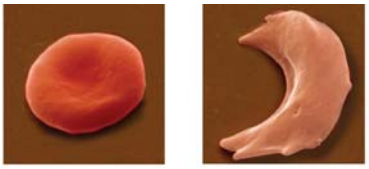
46. Label each of the levels of protein structure on this figure.



47. Enzymes are globular proteins that exhibit at least tertiary structure. On this figure, identify and explain each interaction that folds this portion.

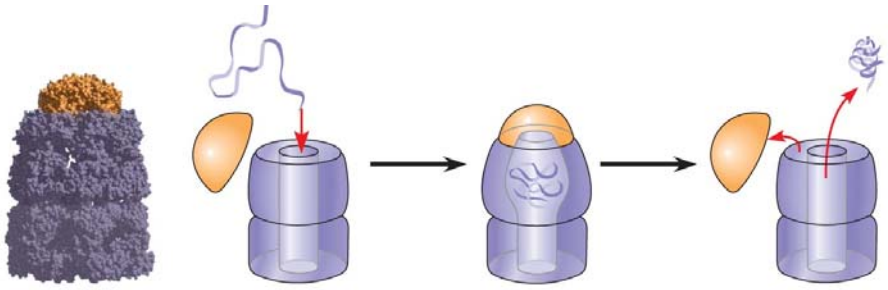


48. Do you remember when, in Chapter 4, we said, "Change the structure, change the function"? Explain how that principle applies to sickle-cell disease. Why is the structure changed?



49. Besides mutation, which changes the primary structure of a protein, protein structure can be changed by denaturation. Define *denaturation*, and give at least three ways a protein may become denatured.

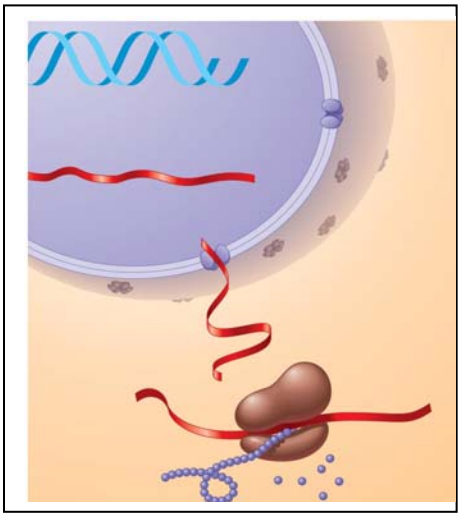
50. *Chaperone proteins* or *chaperonins* assist in the proper folding of proteins. Annotate this figure to explain the process.



Concept 5.5 Nucleic acids store and transmit hereditary information

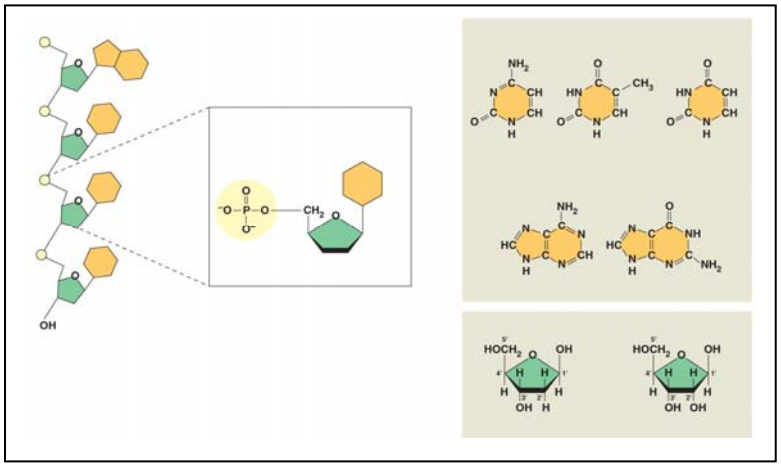
DNA and RNA will be the core topics of Chapter 17. For now, you should just review the general functions and know the components.

51. The flow of genetic information is from DNA → RNA→ protein. Use this figure to explain the process. Label the *nucleus*, *DNA*, *mRNA*, *ribosome*, and *amino acids*.



52. The components of a nucleic acid are a *sugar*, a *nitrogenous base*, and a *phosphate group*. Label each on the figure below.

53. You may recall that early in this chapter we looked at the numbering system for the carbons of a sugar. Label the end of the strand on the left side of the figure below that has the number 5 sugar **5'** and the other end of the chain **3'**.



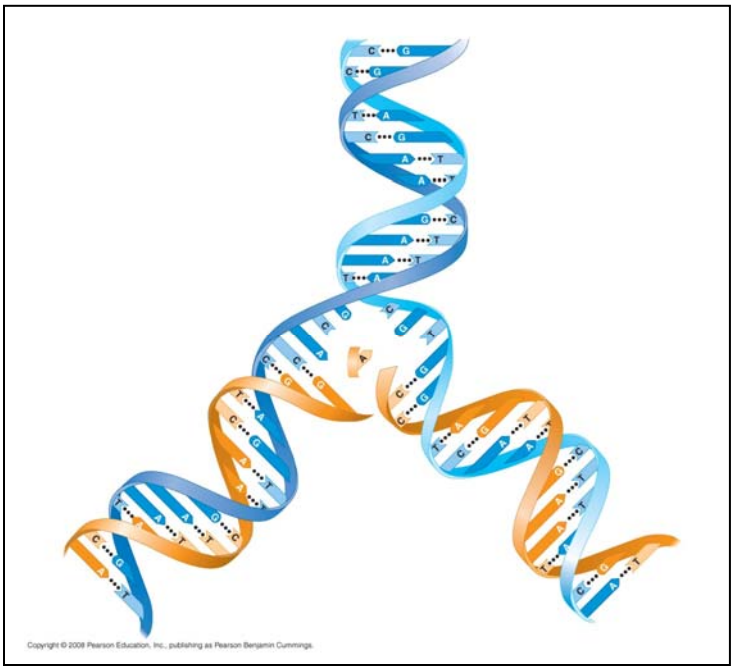
54. Notice that there are five nitrogen bases. Which four are found in DNA?

55. Which four are found in RNA?

56. How do ribose and deoxyribose sugars differ?

57. To summarize, what are the three components of a nucleotide?

58. Here is a model of DNA, which was proposed by James Watson and Francis Crick. What is this shape called?



59. Why are the strands said to be *antiparallel*?

60. What two molecules make up the "uprights"?

61. What molecules make up the rungs?

62. For the two nucleotides of DNA below, provide the complementary base.
    A —
    C —

63. In a DNA double helix, a region along one DNA strand has this sequence of nitrogenous bases:

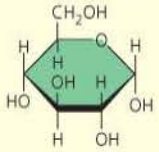
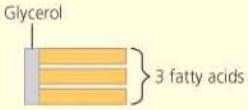
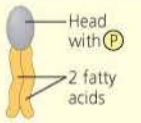
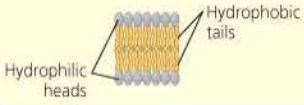
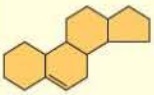
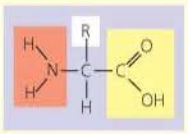
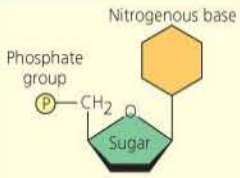
    5'-T A G G C C T-3'

Write the complementary strand. Indicate the 5' and 3' ends of the new strand.

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1._____ 2._____ 3._____ 4._____ 5._____ 6._____ 7._____

This summary table from the Chapter 5 Review is an excellent study tool. Use it to organize material from this chapter in your mind.

Large Biological Molecules	Components	Examples	Functions
Concept 5.2 **Carbohydrates** serve as fuel and building material	 Monosaccharide monomer	Monosaccharides: glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
		Disaccharides: lactose, sucrose	
		Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	• Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls
Concept 5.3 **Lipids** are a diverse group of hydrophobic molecules and are not macromolecules		Triacylglycerols (fats or oils): glycerol + 3 fatty acids	Important energy source 
		Phospholipids: phosphate group + 2 fatty acids	Lipid bilayers of membranes 
	 Steroid backbone	Steroids: four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signals that travel through the body (hormones)
Concept 5.4 **Proteins** have many structures, resulting in a wide range of functions	 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease
Concept 5.5 Nucleic acids store and transmit hereditary information	 Nucleotide monomer	DNA: • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores all hereditary information
		RNA: • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Carries protein-coding instructions from DNA to protein-synthesizing machinery