



NTP

National Toxicology Program

U.S. Department of Health and Human Services

NTP TECHNICAL REPORT ON  
THE TOXICOLOGY AND  
CARCINOGENESIS STUDIES OF

*GINKGO BILOBA* EXTRACT  
(CAS No. 90045-36-6)  
IN F344/N RATS AND  
B6C3F1/N MICE  
(GAVAGE STUDIES)

NTP TR 578

MARCH 2013

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**(GAVAGE STUDIES)**



**NATIONAL TOXICOLOGY PROGRAM**  
**P.O. Box 12233**  
**Research Triangle Park, NC 27709**

**March 2013**

**NTP TR 578**

**NIH Publication No. 13-5920**

**National Institutes of Health**  
**Public Health Service**  
**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES**

## FOREWORD

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## CONTRIBUTORS

### National Toxicology Program

*Evaluated and interpreted results and reported findings*

P.C. Chan, Ph.D., Study Scientist  
 C.V. Rider, Ph.D., Study Scientist  
 A. Nyska, D.V.M., Study Pathologist  
 ILS, Inc.  
 J.B. Bishop, Ph.D.  
 R.S. Chhabra, Ph.D.  
 M.C. Cora, D.V.M.  
 P.M. Foster, Ph.D.  
 R.A. Herbert, D.V.M., Ph.D.  
 M.J. Hooth, Ph.D.  
 A.P. King-Herbert, D.V.M.  
 G.E. Kissling, Ph.D.  
 D.E. Malarkey, D.V.M., Ph.D.  
 J.H. Roycroft, Ph.D.  
 C.S. Smith, Ph.D.  
 M.D. Stout, Ph.D.  
 G.S. Travlos, D.V.M.  
 S. Waidyanatha, Ph.D.  
 N.J. Walker, Ph.D.  
 K.L. Witt, M.S.

### Battelle Columbus Operations

*Conducted studies and evaluated pathology findings*

M.R. Hejtmancik, Ph.D., Principal Investigator  
 C.A. Colleton, D.V.M.  
 M.J. Ryan, D.V.M., Ph.D.

### Experimental Pathology Laboratories, Inc.

*Provided pathology review*

M.H. Hamlin, II, D.V.M., Principal Investigator  
 A.E. Brix, D.V.M., Ph.D.  
 N. Allison, D.V.M.  
 R.R. Maronpot, D.V.M., Ph.D.  
 R.A. Miller, D.V.M., Ph.D.

### Gene Logic Laboratories, Inc.

*Provided SMVCE analysis*

G.W. Wolfe, Ph.D., Principal Investigator  
 B. Atkinson, M.Sc.  
 Y. Wang, M.S.

### NTP Pathology Working Group

*Evaluated slides and contributed to pathology report on 2-year rats (April 6 and June 16, 2010)*

J.P. Morrison, D.V.M., Ph.D., Coordinator  
 Pathology Associates International  
 A.E. Brix, D.V.M., Ph.D.  
 Experimental Pathology Laboratories, Inc.  
 S.A. Elmore, D.V.M., M.S.  
 National Toxicology Program  
 J.R. Harkema, D.V.M., Ph.D.  
 Michigan State University  
 R.A. Herbert, D.V.M., Ph.D.  
 National Toxicology Program  
 M.J. Hoenerhoff, D.V.M., Ph.D.  
 National Toxicology Program  
 L. Lanning, D.V.M., Ph.D.  
 National Institute of Allergy and Infectious Diseases  
 D.E. Malarkey, D.V.M., Ph.D.  
 National Toxicology Program  
 R.R. Maronpot, D.V.M., Ph.D.  
 Experimental Pathology Laboratories, Inc.  
 R.A. Miller, D.V.M., Ph.D.  
 Experimental Pathology Laboratories, Inc.  
 A. Nyska, D.V.M.  
 ILS, Inc.

*Evaluated slides and contributed to pathology report on 2-year mice (May 13, July 29, and August 31, 2010)*

L. Kooistra, D.V.M., Ph.D., Coordinator  
 Pathology Associates International  
 N. Allison, D.V.M.  
 Experimental Pathology Laboratories, Inc.  
 A.E. Brix, D.V.M., Ph.D.  
 Experimental Pathology Laboratories, Inc.  
 S. Chandra, D.V.M., Ph.D.  
 GlaxoSmithKline  
 S.A. Elmore, D.V.M., M.S.  
 National Toxicology Program  
 M.J. Hoenerhoff, D.V.M., Ph.D.  
 National Toxicology Program  
 R.A. Herbert, D.V.M., Ph.D.  
 National Toxicology Program  
 L. Lanning, D.V.M., Ph.D.  
 National Institute of Allergy and Infectious Diseases  
 D.E. Malarkey, D.V.M., Ph.D.  
 National Toxicology Program  
 R.A. Miller, D.V.M., Ph.D.  
 Experimental Pathology Laboratories, Inc.  
 A. Nyska, D.V.M.  
 ILS, Inc.  
 D.B. Rao, BVSc., Ph.D.  
 ILS, Inc.

**Dynamac Corporation**

*Prepared quality assessment audits*

S. Brecher, Ph.D., Principal Investigator  
S. Iyer, B.S.  
V.S. Tharakan, D.V.M.

**SRA International, Inc.**

*Provided statistical analyses*

R.W. Morris, Ph.D., Principal Investigator  
L.J. Betz, M.S.  
S.F. Harris, B.S.

**Biotechnical Services, Inc.**

*Prepared Technical Report*

S.R. Gunnels, M.A., Principal Investigator  
L.M. Harper, B.S.  
T.S. Kumpe, M.A.  
J.I. Powers, M.A.P.  
D.C. Serbus, Ph.D.

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## SUMMARY

### **Background**

Extracts from leaves of the *Ginkgo biloba* tree are used as an herbal remedy and dietary supplement purported to improve memory and brain function. We studied the effects of ginkgo biloba extract on rats and mice to identify potential toxic or cancer-related hazards.

### **Methods**

We deposited solutions containing *Ginkgo biloba* extract in corn oil through a tube directly into the stomach of male and female rats and mice five times a week for two years. Groups of 50 male and female rats received 100, 300, or 1,000 milligrams of *Ginkgo biloba* extract per kilogram of body weight, and groups of male or female mice received 200, 600, or 2,000 mg/kg each day. Similar groups of animals were given solutions of corn oil with no chemical added and served as the control groups. At the end of the studies, tissues from more than 40 sites were examined for every animal.

### **Results**

Every group of animals exposed to *Ginkgo biloba* extract experienced increased rates of a variety of lesions in the liver, thyroid gland, and nose, and male and female mice also experienced several different lesions in the forestomach. These lesions included hypertrophy in the liver and thyroid gland in rats and mice, liver hyperplasia in male and female rats, hyperplasia and atrophy of the epithelium within the nose of male and female rats, and inflammation, hyperplasia, hyperkeratosis, and ulcer in the forestomach of male and female mice. In addition, increased incidences of cancers of the thyroid gland were seen in male and female rats and male mice and liver cancers in male and female mice.

### **Conclusions**

We conclude that *Ginkgo biloba* extract caused cancers of the thyroid gland in male and female rats and male mice and cancers of the liver in male and female mice.



## ABSTRACT



### **GINKGO BILOBA EXTRACT**

CAS No. 90045-36-6

**Synonyms:** Ginkgo, Ginkgo biloba, fossil tree, maidenhair tree, Japanese silver apricot, baiguo, bai guo ye, kew tree, yinhsing (yin-hsing)  
**Botanical name:** *Ginkgo biloba*

*Ginkgo biloba* extract has been used primarily as a medicinal agent in the treatment or prevention of cardiovascular and cerebrovascular dysfunction. *Ginkgo biloba* extract was nominated for study by the National Cancer Institute because of its widespread use as an herbal supplement to promote mental function and the limited availability of toxicity and carcinogenicity data. Furthermore, one of the major ingredients in *Ginkgo biloba* extract, quercetin, is a known mutagen. The *Ginkgo biloba* extract used in the current studies was procured from a supplier known to provide material to United States companies and contained 31.2% flavonol glycosides, 15.4% terpene lactones (6.94% bilobalide, 3.74% ginkgolide A, 1.62% ginkgolide B, 3.06% ginkgolide C), and 10.45 ppm ginkgolic acid. Male and female F344/N rats and B6C3F1/N mice were administered *Ginkgo biloba* extract in corn oil by gavage for 3 months or 2 years. Genetic toxicology studies were conducted in *Salmonella typhimurium*, *Escherichia coli*, and mouse peripheral blood erythrocytes.

### **3-MONTH STUDY IN RATS**

Groups of 10 male and 10 female rats were administered 0, 62.5, 125, 250, 500, or 1,000 mg *Ginkgo biloba* extract/kg body weight in corn oil by gavage, 5 days per week for 14 weeks. Additional groups of 10 male and 10 female rats (clinical pathology study) were administered the same doses, 5 days per week for 23 days. All rats survived to the end of the study. Mean body weights of all dosed groups were similar to those of the vehicle control groups. Liver weights of all dosed groups of males and females were significantly greater than those of the vehicle control groups.

The incidences of hepatocyte hypertrophy in all dosed groups of males and in 500 and 1,000 mg/kg females were significantly greater than those in the vehicle control groups; there was a dose-related increase in severity of this lesion in males. Hepatocyte fatty change occurred in all dosed males. The incidences of thyroid gland follicular cell hypertrophy were significantly

increased in 500 and 1,000 mg/kg males and in 1,000 mg/kg females. The incidences of pigmentation in the olfactory epithelium of the nose were significantly increased in 500 and 1,000 mg/kg males and in females administered 125 mg/kg or greater.

### 3-MONTH STUDY IN MICE

Groups of 10 male and 10 female mice were administered 0, 125, 250, 500, 1,000, or 2,000 mg *Ginkgo biloba* extract/kg body weight in corn oil by gavage, 5 days per week for 14 weeks. One female mouse in the 1,000 mg/kg group died of a dosing accident during week 11. Mean body weights of 2,000 mg/kg females were significantly less than those of the vehicle control group. Ruffled fur was observed in two 1,000 mg/kg males between weeks 7 and 8 and all 2,000 mg/kg males between weeks 5 and 9. Liver weights of 250 mg/kg or greater males and all dosed groups of females were significantly greater than those of the vehicle control groups. Kidney weights of 2,000 mg/kg males were significantly less than those of the vehicle control group. The Markov transition matrix analyses indicate female mice in the 2,000 mg/kg group had a significantly higher probability of extended estrus than did the vehicle control females.

The incidences of hepatocytic hypertrophy were significantly increased in males and females in the 250 mg/kg or greater groups. Significantly increased incidences of focal hepatocytic necrosis occurred in 1,000 and 2,000 mg/kg males. The incidences of hyaline droplet accumulation in the respiratory epithelium of the nose were significantly increased in 500 mg/kg males and 1,000 and 2,000 mg/kg females. In the olfactory epithelium of the nose, the incidences of hyaline droplet accumulation were significantly increased in the 125 (female only), 500, and 1,000 mg/kg groups. Incidences of atrophy of the olfactory epithelium were significantly increased in the 1,000 mg/kg groups. The incidences of pigment accumulation in macrophages in the olfactory epithelium were significantly increased in males in the 500 mg/kg or greater groups and in 1,000 and 2,000 mg/kg females.

### 2-YEAR STUDY IN RATS

Groups of 50 male and 50 female rats were administered 0, 100, 300, or 1,000 mg *Ginkgo biloba* extract/kg body weight in corn oil by gavage, 5 days per week for 104 or 105 (females) weeks. Additional

groups of 10 male and 10 female rats (special study) were administered the same doses, 5 days per week for 14 weeks. Survival of 1,000 mg/kg males was significantly less than that of the vehicle controls. At week 14, all dosed groups of males and 1,000 mg/kg females had increased levels of thyroid stimulating hormone compared to those of the vehicle control groups. There were no significant decreases in the levels of triiodothyronine or total thyroxine. Mean body weights of 300 mg/kg males and females were less (10% or more) than those of the vehicle controls after week 93, and those of 1,000 mg/kg males and females were less after week 89. Clinical findings included ruffled fur in seven, eight, and 10 males in the 100, 300, and 1,000 mg/kg groups, respectively, beginning at week 89; four vehicle control males also had ruffled fur.

Liver weights were significantly increased in all dosed groups of special study rats at 14 weeks. In the liver at 2 years, incidences of hepatocellular adenoma were slightly increased in 100 and 300 mg/kg males. Significantly increased incidences of nonneoplastic lesions at 2 years included hepatocyte hypertrophy and bile duct hyperplasia in all dosed groups of males and females, focal fatty change in all dosed groups of females, cystic degeneration in 100 and 1,000 mg/kg males, and oval cell hyperplasia and necrosis in 1,000 mg/kg males.

In the thyroid gland, incidences of follicular cell adenoma were slightly increased in 300 and 1,000 mg/kg males and 300 mg/kg females. Single incidences of follicular cell carcinoma occurred in the 300 and 1,000 mg/kg female groups. There were significantly increased incidences of follicular cell hypertrophy in all dosed groups of males and females and follicle hyperplasia in all dosed groups of males.

In the nose, adenoma of the respiratory epithelium occurred in two females receiving 300 mg/kg. Except for respiratory epithelium hyperplasia in 100 mg/kg females, the incidences of transitional epithelium and respiratory epithelium hyperplasia were significantly increased in all dosed groups of males and females. Except for olfactory epithelium respiratory metaplasia in 100 mg/kg females, the incidences of atrophy, respiratory metaplasia, nerve atrophy, and pigmentation were significantly increased in the olfactory epithelium of all dosed groups of males and females. Incidences of goblet cell hyperplasia in the respiratory epithelium were significantly increased in 300 and 1,000 mg/kg males and females, and incidences of chronic active inflammation were significantly increased in

1,000 mg/kg males and females. The incidence of submucosa fibrosis was significantly increased in 1,000 mg/kg males.

The incidences of mononuclear cell leukemia in 300 and 1,000 mg/kg males were significantly greater than that in the vehicle controls.

Dose-related increased severity of kidney nephropathy was noted in all dosed groups of males.

## 2-YEAR STUDY IN MICE

Groups of 50 male and 50 female mice were administered 0, 200, 600, or 2,000 mg *Ginkgo biloba* extract/kg body weight in corn oil by gavage, 5 days per week for 104 weeks. Survival of 600 and 2,000 mg/kg males was significantly less than that of the vehicle controls; survival of 600 mg/kg females was significantly greater than that of the vehicle controls. Mean body weights of 600 and 2,000 mg/kg males were less (10% or more) than those of the vehicle controls after weeks 85 and 77, respectively; mean body weights of 2,000 mg/kg females were generally less than those of the vehicle controls between weeks 17 and 69 and after week 93.

In the liver, there were significantly increased incidences of hepatocellular adenoma in all dosed groups of females, hepatocellular carcinoma in all dosed groups of males and 2,000 mg/kg females, and hepatoblastoma in all dosed groups of males and 600 and 2,000 mg/kg females. The increased incidences of these neoplasms were primarily due to increased incidences of multiple adenoma, carcinoma, and hepatoblastoma. Except for the incidences of hepatocellular carcinoma or hepatoblastoma (combined) in 200 and 600 mg/kg females, the incidences of hepatocellular adenoma or carcinoma (combined), hepatocellular carcinoma or hepatoblastoma (combined), and hepatocellular adenoma, hepatocellular carcinoma, or hepatoblastoma (combined) were significantly increased in all dosed groups of males and females. Significantly increased incidences of nonneoplastic liver lesions included hypertrophy in all dosed groups of males and females, erythrophagocytosis in all dosed groups of males and in 600 and 2,000 mg/kg females, hematopoietic cell proliferation, inflammation, and necrosis in 600 and 2,000 mg/kg males, and cytoplasmic vacuolization, eosinophilic focus, and mixed cell focus in all dosed groups of females.

In the thyroid gland, two incidences each of follicular cell adenoma occurred in the 600 and 2,000 mg/kg male groups. The incidence of follicle hyperplasia was

significantly increased in 2,000 mg/kg males, and the incidences of follicular cell hypertrophy were significantly increased in 2,000 mg/kg males and 600 and 2,000 mg/kg females.

In the forestomach, the incidences of inflammation, epithelium hyperplasia, and epithelium hyperkeratosis were significantly increased in all dosed groups of males and in 2,000 mg/kg females; the incidences of epithelium ulcer were significantly increased in 2,000 mg/kg males and females.

In the nose, the incidences of hyaline droplet accumulation in the olfactory epithelium were significantly increased in 2,000 mg/kg males and females; the incidences of pigmentation in the olfactory epithelium were significantly increased in 2,000 mg/kg males and 600 and 2,000 mg/kg females.

## GENETIC TOXICOLOGY

*Ginkgo biloba* extract was mutagenic in *S. typhimurium* strains TA98 and TA100, and in *E. coli* strain WP2 *uvrA*/pKM101, with and without exogenous metabolic activation. Results of a peripheral blood micronucleus test in male and female B6C3F1/N mice administered *Ginkgo biloba* extract for 3 months by gavage were negative in males but judged to be equivocal in females based on a significant trend test.

## CONCLUSIONS

Under the conditions of these 2-year gavage studies, there was *some evidence of carcinogenic activity\** of *Ginkgo biloba* extract in male F344/N rats based on increased incidences of thyroid gland follicular cell adenoma. The increased incidences of mononuclear cell leukemia and hepatocellular adenoma may have been related to *Ginkgo biloba* extract administration. There was *some evidence of carcinogenic activity* of *Ginkgo biloba* extract in female F344/N rats based on increased incidences of thyroid gland follicular cell neoplasms. Increased occurrence of respiratory epithelium adenomas in the nose may have been related to *Ginkgo biloba* extract administration. There was *clear evidence of carcinogenic activity* of *Ginkgo biloba* extract in male B6C3F1/N mice based on increased incidences of hepatocellular carcinoma and hepatoblastoma. The increased incidences of thyroid gland follicular cell adenoma were also related to *Ginkgo biloba* extract administration. There was *clear evidence of carcinogenic activity* of *Ginkgo biloba* extract in female B6C3F1/N mice based on increased incidences of hepatocellular adenoma, hepatocellular carcinoma, and hepatoblastoma.

Administration of *Ginkgo biloba* extract resulted in increased incidences of nonneoplastic lesions in the liver, thyroid gland, and nose of male and female rats and mice and the forestomach of male and female mice. Increased severity of nephropathy in male rats was also due to administration of *Ginkgo biloba* extract.

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\* Explanation of Levels of Evidence of Carcinogenic Activity is on page 13. A summary of the Peer Review Panel comments and the public discussion on this Technical Report appears on page 15.

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**Summary of the 2-Year Carcinogenesis and Genetic Toxicology Studies of Ginkgo biloba Extract**


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	Male F344/N Rats	Female F344/N Rats	Male B6C3F1/N Mice	Female B6C3F1/N Mice
<b>Doses in corn oil by gavage</b>	0, 100, 300, or 1,000 mg/kg	0, 100, 300, or 1,000 mg/kg	0, 200, 600, or 2,000 mg/kg	0, 200, 600, or 2,000 mg/kg
<b>Body weights</b>	300 mg/kg group $\geq$ 10% less than the vehicle control group after week 93; 1,000 mg/kg group $\geq$ 10% less than the vehicle control group after week 89	300 mg/kg group $\geq$ 10% less than the vehicle control group after week 93; 1,000 mg/kg group $\geq$ 10% less than the vehicle control group after week 89	600 and 2,000 mg/kg groups $\geq$ 10% less than the vehicle control group after week 85 and 77, respectively	2,000 mg/kg group $\geq$ 10% less than the vehicle control group between weeks 17 and 69 and after week 93
<b>Survival rates</b>	38/50, 37/50, 31/50, 16/50	37/50, 27/50, 37/50, 32/50	34/50, 27/50, 21/50, 23/50	31/50, 36/50, 43/50, 36/50
<b>Nonneoplastic effects</b>	<u>Liver</u> : hepatocyte, hypertrophy (1/50, 17/50, 26/50, 27/50); bile duct, hyperplasia (32/50, 43/50, 46/50, 46/50); oval cell, hyperplasia (0/50, 1/50, 1/50, 10/50); degeneration, cystic (4/50, 14/50, 10/50, 14/50); necrosis (1/50, 4/50, 6/50, 7/50) <u>Thyroid gland</u> : follicular cell hypertrophy (13/50, 37/50, 41/49, 41/45); follicle, hyperplasia (0/50, 7/50, 9/49, 5/45) <u>Kidney</u> : severity of nephropathy (1.7, 2.0, 2.4, 2.9) <u>Nose</u> : transitional epithelium, hyperplasia (2/50, 18/49, 43/49, 31/50); respiratory epithelium, hyperplasia (14/50, 28/49, 45/49, 35/50); olfactory epithelium, atrophy (1/50, 26/49, 37/49, 31/50); olfactory epithelium, respiratory metaplasia (9/50, 30/49, 40/49, 32/50); nerve, olfactory epithelium, atrophy (0/50, 17/49, 14/49, 23/50); olfactory epithelium, pigmentation (0/50, 39/49, 42/49, 30/50); inflammation, chronic active (33/50, 32/49, 38/49, 46/50); goblet cell, respiratory epithelium, hyperplasia (20/50, 18/49, 41/49, 34/50); submucosa, fibrosis (0/50, 0/49, 0/49, 8/50)	<u>Liver</u> : hepatocyte, hypertrophy (7/50, 15/50, 27/50, 33/50); bile duct, hyperplasia (11/50, 31/50, 31/50, 33/50); fatty change, focal (11/50, 25/50, 30/50, 25/50) <u>Thyroid gland</u> : follicular cell, hypertrophy (15/49, 41/50, 45/49, 48/49) <u>Nose</u> : transitional epithelium, hyperplasia (0/49, 6/49, 32/50, 36/46); respiratory epithelium, hyperplasia (9/49, 6/49, 19/50, 34/46); olfactory epithelium, atrophy (0/49, 18/49, 25/50, 37/46); olfactory epithelium, respiratory metaplasia (8/49, 4/49, 32/50, 37/46); nerve, olfactory epithelium, atrophy (0/49, 15/49, 22/50, 33/46); olfactory epithelium, pigmentation (0/49, 37/49, 43/50, 40/46); inflammation, chronic active (22/49, 16/49, 26/50, 38/46); goblet cell, respiratory epithelium, hyperplasia (6/49, 2/49, 18/50, 35/46)	<u>Liver</u> : hypertrophy (3/50, 19/50, 35/50, 23/50); erythrophagocytosis (0/50, 4/50, 11/50, 7/50); hematopoietic cell proliferation (4/50, 9/50, 12/50, 14/50); inflammation (28/50, 35/50, 42/50, 39/50); necrosis (9/50, 15/50, 17/50, 19/50) <u>Thyroid gland</u> : follicle hyperplasia (2/49, 1/49, 7/50, 25/50); follicular cell hypertrophy (2/49, 0/49, 2/50, 38/50) <u>Forestomach</u> : inflammation (11/50, 24/50, 21/50, 45/50); epithelium hyperplasia (14/50, 27/50, 27/50, 45/50); epithelium hyperkeratosis (11/50, 24/50, 24/50, 46/50); epithelium ulcer (7/50, 10/50, 12/50, 24/50) <u>Nose</u> : olfactory epithelium, hyaline droplet accumulation (18/50, 16/50, 15/50, 28/50); olfactory epithelium, pigmentation (0/50, 1/50, 3/50, 13/50)	<u>Liver</u> : hypertrophy (0/50, 18/50, 37/50, 37/50); erythrophagocytosis (0/50, 3/50, 7/50, 16/50); vacuolization cytoplasmic (18/50, 38/50, 44/50, 35/50); eosinophilic focus (26/50, 39/50, 43/50, 45/50); mixed cell focus (7/50, 27/50, 31/50, 31/50) <u>Thyroid gland</u> : follicular cell hypertrophy (1/49, 5/48, 9/49, 39/48) <u>Forestomach</u> : inflammation (4/50, 6/50, 5/50, 19/50); epithelium hyperplasia (8/50, 18/50, 11/50, 20/50); epithelium hyperkeratosis (3/50, 11/50, 5/50, 20/50); epithelium ulcer (1/50, 1/50, 11/50) <u>Nose</u> : olfactory epithelium, hyaline droplet accumulation (5/50, 3/50, 12/50, 17/50); olfactory epithelium, pigmentation (0/50, 1/50, 6/50, 13/50)

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**Summary of the 2-Year Carcinogenesis and Genetic Toxicology Studies of Ginkgo biloba Extract**


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	Male F344/N Rats	Female F344/N Rats	Male B6C3F1/N Mice	Female B6C3F1/N Mice
<b>Neoplastic effects</b>	<u>Thyroid gland</u> : follicular cell, adenoma (2/50, 1/50, 3/49, 5/45)	<u>Thyroid gland</u> : follicular cell, adenoma (1/49, 0/50, 3/49, 1/49); follicular cell, carcinoma (0/49, 0/50, 1/49, 1/49)	<u>Liver</u> : hepatocellular carcinoma (22/50, 31/50, 41/50, 47/50); hepatoblastoma (3/50, 28/50, 36/50, 38/50) <u>Thyroid gland</u> : follicular cell, adenoma (0/50, 0/50, 2/50, 2/50)	<u>Liver</u> : hepatocellular adenoma (17/50, 37/50, 41/50, 48/50); hepatocellular carcinoma (9/50, 10/50, 15/50, 44/50); hepatoblastoma (1/50, 1/50, 8/50, 11/50)
<b>Equivocal findings</b>	<u>Mononuclear cell leukemia</u> : (9/50, 12/50, 22/50, 21/50) <u>Liver</u> : hepatocellular adenoma (0/50, 3/50, 3/50, 0/50)	<u>Nose</u> : respiratory epithelium, adenoma (0/49, 0/49, 2/50, 0/46)	None	None
<b>Level of evidence of carcinogenic activity</b>	Some evidence	Some evidence	Clear evidence	Clear evidence
<b>Genetic toxicology</b>				
Bacterial gene mutations:		Positive in <i>S. typhimurium</i> strains TA98 and TA100 with and without S9; positive in <i>E. coli</i> strain WP2 <i>uvrA</i> /pKM101 with and without S9		
Micronucleated erythrocytes				
Mouse peripheral blood <i>in vivo</i> :		Negative in males and equivocal in females		

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## EXPLANATION OF LEVELS OF EVIDENCE OF CARCINOGENIC ACTIVITY

The National Toxicology Program describes the results of individual experiments on a chemical agent and notes the strength of the evidence for conclusions regarding each study. Negative results, in which the study animals do not have a greater incidence of neoplasia than control animals, do not necessarily mean that a chemical is not a carcinogen, inasmuch as the experiments are conducted under a limited set of conditions. Positive results demonstrate that a chemical is carcinogenic for laboratory animals under the conditions of the study and indicate that exposure to the chemical has the potential for hazard to humans. Other organizations, such as the International Agency for Research on Cancer, assign a strength of evidence for conclusions based on an examination of all available evidence, including animal studies such as those conducted by the NTP, epidemiologic studies, and estimates of exposure. Thus, the actual determination of risk to humans from chemicals found to be carcinogenic in laboratory animals requires a wider analysis that extends beyond the purview of these studies.

Five categories of evidence of carcinogenic activity are used in the Technical Report series to summarize the strength of evidence observed in each experiment: two categories for positive results (**clear evidence and some evidence**); one category for uncertain findings (**equivocal evidence**); one category for no observable effects (**no evidence**); and one category for experiments that cannot be evaluated because of major flaws (**inadequate study**). These categories of interpretative conclusions were first adopted in June 1983 and then revised on March 1986 for use in the Technical Report series to incorporate more specifically the concept of actual weight of evidence of carcinogenic activity. For each separate experiment (male rats, female rats, male mice, female mice), one of the following five categories is selected to describe the findings. These categories refer to the strength of the experimental evidence and not to potency or mechanism.

- **Clear evidence** of carcinogenic activity is demonstrated by studies that are interpreted as showing a dose-related (i) increase of malignant neoplasms, (ii) increase of a combination of malignant and benign neoplasms, or (iii) marked increase of benign neoplasms if there is an indication from this or other studies of the ability of such tumors to progress to malignancy.
- **Some evidence** of carcinogenic activity is demonstrated by studies that are interpreted as showing a chemical-related increased incidence of neoplasms (malignant, benign, or combined) in which the strength of the response is less than that required for clear evidence.
- **Equivocal evidence** of carcinogenic activity is demonstrated by studies that are interpreted as showing a marginal increase of neoplasms that may be chemical related.
- **No evidence** of carcinogenic activity is demonstrated by studies that are interpreted as showing no chemical-related increases in malignant or benign neoplasms
- **Inadequate study** of carcinogenic activity is demonstrated by studies that, because of major qualitative or quantitative limitations, cannot be interpreted as valid for showing either the presence or absence of carcinogenic activity.

For studies showing multiple chemical-related neoplastic effects that if considered individually would be assigned to different levels of evidence categories, the following convention has been adopted to convey completely the study results. In a study with clear evidence of carcinogenic activity at some tissue sites, other responses that alone might be deemed some evidence are indicated as "were also related" to chemical exposure. In studies with clear or some evidence of carcinogenic activity, other responses that alone might be termed equivocal evidence are indicated as "may have been" related to chemical exposure.

When a conclusion statement for a particular experiment is selected, consideration must be given to key factors that would extend the actual boundary of an individual category of evidence. Such consideration should allow for incorporation of scientific experience and current understanding of long-term carcinogenesis studies in laboratory animals, especially for those evaluations that may be on the borderline between two adjacent levels. These considerations should include:

- adequacy of the experimental design and conduct;
- occurrence of common versus uncommon neoplasia;
- progression (or lack thereof) from benign to malignant neoplasia as well as from preneoplastic to neoplastic lesions;
- some benign neoplasms have the capacity to regress but others (of the same morphologic type) progress. At present, it is impossible to identify the difference. Therefore, where progression is known to be a possibility, the most prudent course is to assume that benign neoplasms of those types have the potential to become malignant;
- combining benign and malignant tumor incidence known or thought to represent stages of progression in the same organ or tissue;
- latency in tumor induction;
- multiplicity in site-specific neoplasia;
- metastases;
- supporting information from proliferative lesions (hyperplasia) in the same site of neoplasia or other experiments (same lesion in another sex or species);
- presence or absence of dose relationships;
- statistical significance of the observed tumor increase;
- concurrent control tumor incidence as well as the historical control rate and variability for a specific neoplasm;
- survival-adjusted analyses and false positive or false negative concerns;
- structure-activity correlations; and
- in some cases, genetic toxicology.

**NATIONAL TOXICOLOGY PROGRAM TECHNICAL REPORTS  
PEER REVIEW PANEL**

The members of the Peer Review Panel who evaluated the draft NTP Technical Report on *Ginkgo biloba* extract on February 8, 2012, are listed below. Panel members serve as independent scientists, not as representatives of any institution, company, or governmental agency. In this capacity, panel members have five major responsibilities in reviewing the NTP studies:

- to ascertain that all relevant literature data have been adequately cited and interpreted,
- to determine if the design and conditions of the NTP studies were appropriate,
- to ensure that the Technical Report presents the experimental results and conclusions fully and clearly,
- to judge the significance of the experimental results by scientific criteria, and
- to assess the evaluation of the evidence of carcinogenic activity and other observed toxic responses.

Stephen M. Roberts, Ph.D., Chairperson  
College of Veterinary Medicine  
University of Florida  
Gainesville, FL

Jane Alcorn, D.V.M., Ph.D.  
University of Saskatchewan  
Saskatchewan, Canada

Lucy M. Anderson, Ph.D., Consultant, Principal Reviewer  
Catonsville, MD

Hillary M. Carpenter, III, Ph.D.  
Minnesota Department of Health  
St. Paul, MN

Russell C. Cattley, V.M.D., Ph.D., Principal Reviewer  
College of Veterinary Medicine  
Auburn University  
Auburn, AL

Michael R. Elwell, D.V.M., Ph.D.  
Covance Laboratories, Inc.  
Chantilly, VA

Jon C. Mirsalis, Ph.D., Principal Reviewer  
SRI International  
Menlo Park, CA

Ofelia A. Olivero, Ph.D.  
National Cancer Institute  
Bethesda, MD

Lisa A. Peterson, Ph.D.  
University of Minnesota  
Minneapolis, MN

Michael V. Pino, D.V.M., Ph.D.  
Sanofi  
Bridgewater, NJ

Keith A. Soper, Ph.D.  
Merck Research Laboratories  
West Point, PA



## SUMMARY OF PEER REVIEW PANEL COMMENTS

On February 8, 2012, the draft Technical Report on the toxicology and carcinogenicity studies of *Ginkgo biloba* extract received public review by the National Toxicology Program's Board of Scientific Counselors' Technical Reports Peer Review Panel. The review meeting was held at the National Institute of Environmental Health Sciences, Research Triangle Park, NC.

Dr. C.V. Rider, NIEHS, introduced the draft NTP Technical Report on *Ginkgo biloba* extract by noting that it was nominated by the National Cancer Institute for study based on widespread use as an herbal supplement, the known mutagenicity of the *Ginkgo biloba* extract constituent quercetin, and the lack of toxicity and carcinogenicity data. She provided information on the composition of *Ginkgo biloba* extract and its use as an herbal supplement both historically and currently, noting that in 2002 it was among the top five herbal supplements on the market. The test article was selected based on a wide distribution in commerce and that the ratio of active ingredients was similar to marketed leaf extract EGb 761<sup>®</sup> (which was not available). Dr. Rider presented results of mutagenicity studies and described the nonneoplastic and neoplastic lesions observed in the 2-year gavage studies.

The proposed conclusions were *some evidence of carcinogenic activity* of *Ginkgo biloba* extract in male and female F344/N rats and *clear evidence of carcinogenic activity* of *Ginkgo biloba* extract in male and female B6C3F1/N mice.

Dr. S. Dentali, representing the American Herbal Products Association, said the unique *Ginkgo biloba* leaf extract discussed in the draft Technical Report is not representative of other *Ginkgo biloba* leaf extracts marketed in the United States and is almost certainly not sold in the United States. He said that it is incorrect to represent it as similar to other *Ginkgo biloba* leaf extracts, based on the dissimilarity of its chemical composition to that of other commercially available products. He noted that the supplier had intended to make a unique extract for drug development, and that the extract contains (according to the company) "highly concentrated effective content" along with "further removal of inactive substances." He presented data comparing the test article to other published analyses of *Ginkgo biloba* leaf extracts and to recognized standards and recommended that the report highlight these differences in composition. He also recommended that the report title be changed to delineate that the studies were done with a "specific" *Ginkgo biloba* leaf extract.

Dr. A. Roberts, Intertek Cantox, presented his comments via telephone. He questioned the stability of the dosing formulation over the course of the study period and the dose levels selected in the 2-year mouse study. He noted that the development of liver tumors was not surprising as they are known to occur spontaneously in the mouse population and that the mouse strain used is highly susceptible to chemically induced liver tumors. He added that the NTP should have worked to establish a no-observed-adverse-effect level for risk assessment purposes. He asked the panel to consider downgrading the call in the 2-year rat study from *some evidence* to *equivocal evidence* based on the increased incidence of thyroid tumors. He said that the liver tumors in mice and thyroid tumors in rats may have little if any relevance to humans who consume *Ginkgo biloba* leaf extract at much lower dose levels. He acknowledged that assessment of risk in humans is not the purpose of NTP studies, but suggested the NTP consider discussing the relevance of the findings to humans, given the widespread consumption of the herbal.

Dr. P.C. Howard, FDA, noted for clarification that the panel is specifically not to enter into any risk assessment related to humans in its deliberations.

Dr. Anderson, the first principal reviewer, said the report was well written and that she agreed with the *clear evidence* calls in the male and female mice based on the liver tumors. For the thyroid adenomas in male rats, she noted the low incidence and no pairwise significance, but said several other arguments suggested a chemical-related effect and she agreed with the call, as well as the *some evidence* call for female rats. For the mononuclear cell leukemia in male rats, she wondered whether further data such as age of death might support changing the call from *equivocal evidence* to *some evidence*. Regarding the liver tumors in the rats, she speculated that perhaps a *no evidence* call should be discussed but on balance agreed with the "may have been related" call. For the respiratory adenomas in the females, she wondered whether the call should be changed from *equivocal evidence* to *no evidence*. The call for the thyroid adenomas in the male mice was *some evidence*, which she felt was supported.

Dr. Mirsalis, the second principal reviewer, agreed with the proposed conclusions, although he agreed with Dr. Anderson that many of the calls seemed to fall into a "gray zone," where he didn't strongly agree or disagree. He made three general suggestions for the NTP Technical Reports: clearly state that all animals were

specific pathogen-free (SPF), and what pathogens they are free of, specify the volume of the nonterminal blood collection and include a statement regarding FDA Part 11 Good Laboratory Practice (GLP) compliance in the quality assurance references. He said that his major issue with this study was the material used, in that it was different than the preparation most people are actually taking. He suggested including a table similar to the one shown by Dr. Dentali, comparing the components of the test article blend to commercially available compounds. He also felt that it would be good to point out how test exposures relate to human exposures, since the test exposures were many orders of magnitude higher.

Dr. Cattley, the third principal reviewer, agreed with Dr. Mirsalis' comments for the test material, and the usefulness of a chart for comparison. He agreed with the proposed call for the thyroid tumors in male rats; however, the ancillary evidence that supported the *some evidence* call in the males was lacking for the females; he wondered if the call in females should be *equivocal evidence*.

Dr. Rider responded to the reviewers' comments. She said that the *Ginkgo biloba* products available in the marketplace have a wide range of concentrations, and the test article's composition fell within the range of what is on the market. In response to questions regarding nonneoplastic lesions, study pathologist Dr. A. Nyska, ILS, Inc., noted that the findings were inconsistent across dose groups. Dr. Rider said that information about the SPF status is included in Appendix K of the report. She said that reporting the blood volumes relative to the animals' body weights would be difficult, and that all draws were within the Institutional Animal Care and Use Committee guidelines. She added that the NTP had not yet moved to fully electronic record keeping and thus has not triggered GLP Part 11. She agreed that several of the conclusions were complex, and they had been discussed

thoroughly in staff reviews, where consistency across species and across sex was taken into account.

Drs. Anderson and Cattley suggested there was an over emphasis on genotoxicity in the report. Statistician Dr. G.E. Kissling, NIEHS, said that there was a slight correlation between age of death and dose, and agreed to analyze the available data as Dr. Anderson suggested, to determine average or mean ages of death. While age of death is a factor adjusted for in the statistical analysis of tumor incidence, it could also be addressed as a separate question.

Dr. Mirsalis recommended that the NTP add mouse norovirus to its screening panel, and report the results. Dr. A.P. King-Herbert, NIEHS, said that animals are not screened for norovirus when they are received by the NTP, although such screening does take place frequently by the vendor. Dr. Mirsalis added that although he understood Dr. Rider's explanation regarding the test article's composition, the NTP's rationale should be clear in the report.

In response to the public's suggestion that the NTP consider discussing the relevance of the *Ginkgo biloba* extract findings to humans, Dr. Howard offered caution given that these reports are not meant to evaluate risk for humans. Dr. L.S. Birnbaum, NIEHS, noted such information would need proper context.

Dr. Roberts called for a motion on the conclusions for *Ginkgo biloba* extract. Dr. Mirsalis moved to accept the conclusions as written and Dr. Carpenter seconded the motion. Dr. Cattley felt that the call for the female rats' thyroid tumors should be changed from *some evidence* to *equivocal evidence*. Following further discussion of the issue, Dr. Roberts called for a vote on the motion to accept the conclusions as written. The panel voted in favor of the motion (seven yes, one no). Dr. Cattley voting no, restated his reason. Drs. Pino and Elwell had conflicts of interest related to this report, and did not participate in the peer review or vote on the conclusions.

# INTRODUCTION



## *GINKGO BILOBA* EXTRACT

CAS No. 90045-36-6

**Synonyms:** Ginkgo, Ginkgo biloba, fossil tree, maidenhair tree, Japanese silver apricot, baiguo, bai guo ye, kew tree, yinhsing (yin-hsing)  
**Botanical name:** *Ginkgo biloba*

### CHEMICAL AND PHYSICAL PROPERTIES

The ginkgo tree is often referred to as a “living fossil” because *Ginkgo* species from as early as the Jurassic Period 170 million years ago have been identified (Zhou and Zheng, 2003). The sole surviving member of the Ginkgoaceae family, *Ginkgo biloba*, is a highly adaptable and hardy tree that is dioecious, having separate male and female plants. Some specimens are over 1,000 years old (Del Tredici, 1991; Mahadevan and Park, 2008). Ginkgo trees begin reproducing after approximately 20 years of maturation, at which time the female produces fruit that is distinctly malodorous (Mahadevan and Park, 2008). The unique, bilobed leaves of *Ginkgo biloba* are fan-shaped and are similar in appearance to those of the maidenhair fern, giving rise to the common name “maidenhair tree” (Mahadevan and Park, 2008).

Like other herbals, *Ginkgo biloba* leaves contain a complex mixture of chemical constituents, which can vary depending on the strain of ginkgo, conditions of growth, time of harvest, etc. (Smith and Luo, 2004). The main chemical constituents in *Ginkgo biloba* leaves

include terpene trilactones, flavonol glycosides, biflavones, proanthocyanidins, alkylphenols, phenolic acids, and polyphenols (van Beek and Montoro, 2009). Most of the compounds that have been identified in ginkgo are commonly found in the leaves of other higher plants. However, the terpene trilactones represent a group of chemicals that are unique to the ginkgo (Hasler, 2000).

The terpene trilactones and flavonol glycosides are generally regarded as the major contributors to the positive biological effects attributed to ginkgo (van Beek and Montoro, 2009), whereas, ginkgolic acids are typically regarded as causing negative biological activities (e.g., cytotoxicity, mutagenicity) (Westendorf and Regan, 2000).

Ginkgotoxin, or 4'-*O*-methylpyridoxine, is also associated with toxicity, but is found primarily in ginkgo seeds and only in lesser amounts in the leaves and extracts prepared from the leaves (Arenz *et al.*, 1996). In recent years, the use of fingerprinting to quantify key chemical constituents of plant-based

formulations has been advocated as a quality control measure to ensure appropriate quantities of the biologically-active constituents and a lack of ginkgolic acids (van Beek and Montoro, 2009).

## PRODUCTION, USE, AND HUMAN EXPOSURE

The attractive appearance of ginkgo trees and their robust nature have led to widespread cultivation of *Ginkgo biloba* as an ornamental plant, expanding its range from its origins in China to every country in the temperate zone (Del Tredici, 1991). In addition to its horticultural popularity, various parts of the *Ginkgo biloba* plant have been used for food or medicine. Ginkgo seeds are regularly consumed in Japan, Korea, and China, despite the fact that poisoning, manifesting as gastrointestinal distress, irritability, and tonic or clonic seizures, can result from overconsumption of seeds due to their high 4'-*O*-methylpyridoxine content (Kajiyama *et al.*, 2002; Kobayashi *et al.*, 2011). Seeds from the ginkgo tree have been used medicinally dating back thousands of years. In Chinese medicine, *Ginkgo biloba* seeds have been used to treat pulmonary issues, alcohol abuse, and bladder infections, while ginkgo leaves came into use later to treat skin infections, as well as heart and lung disease (Mahady, 2002; Smith and Luo, 2004). Current use of *Ginkgo biloba* extract centers on leaf-based preparations for the promotion of circulation and brain function, and the treatment of tinnitus.

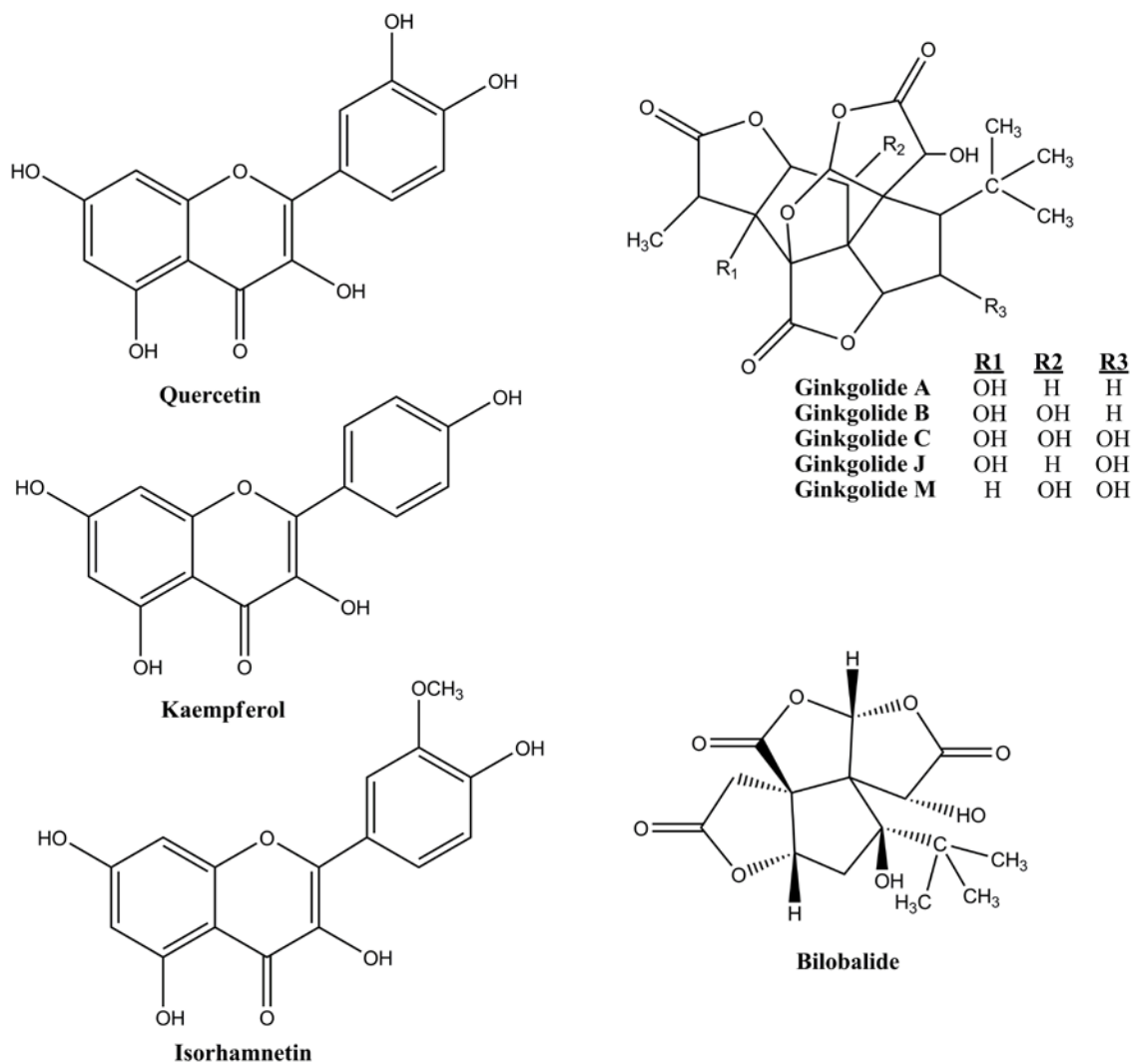
In 1965, the German physician-pharmacist Dr. Willmar Schwabe III developed *Ginkgo biloba* leaf extracts (De Feudis, 2003). The final product, a standardized *Ginkgo biloba* extract (EGb 761®), has been subsequently marketed by Dr. Willmar Schwabe Pharmaceuticals under the trade names Ginkgold® (Nature's Way™), Rökan®, Tanakan®, and Tebonin®. EGb 761® is standardized to contain 24% flavone glycosides (quercetin, kaempferol, isorhamnetin), 6% terpene lactones [3.1% ginkgolides (A, B, C, J) and 2.9% bilobalide], various organic acids (5% to 10%), and other constituents. Many *Ginkgo biloba* components are biologically active, and it is believed that the action of multiple constituents contributes to the medicinal properties of the plant. However, the standardization of EGb 761® and other *Ginkgo biloba* extracts is based on their flavonoid and terpene trilactone contents (Figure 1), as these compounds are thought to be primarily responsible for the pharmacological activity associated with *Ginkgo biloba* extract.

In the United States, herbal formulations, such as *Ginkgo biloba* extract, sold as dietary supplements are

regulated under the Dietary Supplement Health and Education Act of 1994. As such, they are not subject to the same standards of premarket testing as drugs intended to treat, cure, prevent, diagnose, or mitigate disease. In contrast, in Germany and France *Ginkgo biloba* extract is regulated as a prescription drug and therefore, requires registration and adherence to specified content standards. The German Commission E, which evaluated the efficacy and safety of herbals licensed for prescription in Germany, approved the monograph on *Ginkgo biloba* extract specifying contents of 22% to 27% flavone glycosides, 5% to 7% terpene lactones (2.8% to 3.4% ginkgolides A, B, C and 2.6% to 3.2% bilobalide), and not more than 5 ppm ginkgolic acids, due to their cytotoxic and allergenic potential (Blumenthal, 1998; Kressmann *et al.*, 2002). However, *Ginkgo biloba* products on the marketplace in the United States and elsewhere exhibit a wide range of component concentrations (Kressmann *et al.*, 2002; Sloley *et al.*, 2003; Fransen *et al.*, 2010; Gawron-Gzella *et al.*, 2010).

In surveys addressing complementary and alternative medicine use in the United States, *Ginkgo biloba* is among the top five most used herbal supplements on the market (Kennedy, 2005; Abebe *et al.*, 2011). Kennedy (2005) estimated that of the 38 million Americans that used herbal medicines in 2002, 20.1% of that population, or approximately 7.7 million people, took *Ginkgo biloba* extracts. One source cites a figure of over \$249 million per year in United States sales of *Ginkgo biloba* extracts (DeKosky *et al.*, 2008).

The therapeutic effect most frequently ascribed to ginkgo use in popular culture is improvement of memory and brain function, however, there are numerous other health benefits attributed to its use. In Germany, it is indicated for the treatment of intermittent claudication, decreased mental function (including forgetfulness, early dementia, and concentration problems), and tinnitus (van Beek and Montoro, 2009). *Ginkgo biloba* extract has been studied in humans as treatment for the neurological effects associated with Alzheimer's disease, traumatic brain injury, stroke, dementia, normal aging, edema, tinnitus, and macular degeneration (Diamond *et al.*, 2000; McKenna *et al.*, 2001). Additionally, preclinical *in vitro* or experimental animal studies have explored the use of *Ginkgo* for cardiovascular indications (thrombosis, embolism), anxiety/stress, sexual dysfunction, and cancer (McKenna *et al.*, 2001). Despite the popular use of *Ginkgo biloba* extract for numerous ailments, the largest clinical trial of ginkgo effects (Ginkgo Evaluation of Memory Study) failed to find an effect of *Ginkgo biloba* on prevention of dementia (DeKosky *et al.*, 2008), prevention of cognitive decline (Snitz *et al.*, 2009),



**FIGURE 1**  
**Structures of Aglycone Flavanol Glycosides (present primarily in the glycosylated form in extract)**  
**and Terpene Trilactone Contents of Standardized *Ginkgo biloba* Extract**

reduction in cardiovascular disease-related events or mortality (Kuller *et al.*, 2010), or decreases in blood pressure or hypertension (Brinkley *et al.*, 2010).

The diverse conditions for which *Ginkgo biloba* has been explored as a potential treatment are paralleled by a complex array of mechanisms of action associated with various *Ginkgo biloba* components. Although individual components have been found to be pharmacologically active, the multifaceted action of *Ginkgo biloba* is likely due to multiple components and interactions that have yet to be fully understood (De Feudis and Drieu, 2000).

The two mechanisms of action most often associated with the proclaimed health benefits of *Ginkgo biloba* extract are the antagonism of Platelet Activating Factor (PAF) by the ginkgolides and the antioxidant action of the flavonoids (Smith and Luo, 2004). However, there are multiple mechanisms of action that are likely to impact disease pathways. Several mechanisms of action identified through *in vitro* or *in vivo* studies are hypothesized to play a role in the health promoting action of *Ginkgo biloba* extract. These include: antagonism of PAF by the ginkgolides (Smith *et al.*, 1996); antioxidant activity of the flavonoids attributed to scavenging of reactive oxygen species, chelation of metal ions, and increasing the concentration of superoxide dismutase and glutathione-S-transferase (Smith and Luo, 2004; Shi *et al.*, 2010a); antagonism of major inhibitory receptors of the central nervous system, glycine, and GABA receptors (Kondratskaya *et al.*, 2002; Ivic *et al.*, 2003; Strømgaard and Nakanishi, 2004; Heads *et al.*, 2008); modulation of neurotransmitter concentrations or receptor densities (Diamond *et al.*, 2000; Ahlemeyer and Krieglstein, 2003); reduction of NO release (Ahlemeyer and Krieglstein, 2003); inhibition of mitochondrial dysfunction (Abdel-Kader *et al.*, 2007; Shi *et al.*, 2010b,c); and modulation of P450 enzymes (Hellum *et al.*, 2007; Rajaraman *et al.*, 2009).

Diamond *et al.* (2000) reviewed the literature on the effectiveness of *Ginkgo biloba* extract and concluded that positive effects on various endpoints were observed with dosages of 120 to 300 mg per day administered for a period of 3 to 12 weeks. Standardized *Ginkgo biloba* extract is typically taken in tablet or capsule form at doses in the range of 120 to 240 mg per day. In addition to the standardized extract, ginkgo is also available as a mother tincture (ethanol extraction of fresh leaves) and as dry leaves for use in tea (Ehrlich, 2010).

## ABSORPTION, DISTRIBUTION, METABOLISM, AND EXCRETION

Due to the complex nature of *Ginkgo biloba* extract with its many structurally diverse constituents, its precise pharmacokinetic profile remains undetermined. However, there have been many pharmacokinetics studies in humans and experimental animals that focus on key chemical classes such as the terpene trilactones and select flavonol glycosides. In general, *Ginkgo biloba* extract is well absorbed in humans, rats, and rabbits after oral administration (Moreau *et al.*, 1986; Li and Wong, 1997; Woerdenbag and van Beek, 1997).

### Experimental Animals

Moreau *et al.* (1986) used radiolabeled *Ginkgo biloba* extract from leaves to assess its absorption, distribution, and elimination in male and female Sprague-Dawley rats following a single oral administration. The radiolabeled test article was obtained from ginkgo plants grown under a supply of <sup>14</sup>C-acetate. The authors demonstrated that 60% of the extract was absorbed. The pharmacokinetic results were characteristic of a two-compartment model with a half-life of about 4.5 hours. Although the labeling was nonspecific, it was found to be present mainly in the flavonol glycosides. After 72 hours, 38% of the radioactivity was excreted in exhaled CO<sub>2</sub>, 21% in urine, and 29% in feces.

Following single oral doses of 30, 55, or 100 mg/kg *Ginkgo biloba* extract (EGb 761®) in male Sprague-Dawley rats, bilobalide and ginkgolides A and B were bioavailable with linear pharmacokinetics and half-life values of 2.2, 1.7, and 2.0 hours, respectively, for the lowest dose investigated (Biber and Koch, 1999). Ginkgolide C is difficult to detect in plasma due to matrix effects and was not included in many pharmacokinetic profiles of the terpene trilactones; however, improved methodology in a more recent pharmacokinetic study provided a ginkgolide C half-life value of 0.7 hours following intravenous administration of 8 mg/kg *Ginkgo biloba* extract in male and female Sprague-Dawley rats (Xie *et al.*, 2008). Half-life values for ginkgolides A and B, and bilobalide in that study were 1.0, 1.0, and 1.1 hours, respectively. The terpene trilactones (ginkgolides A and B and bilobalide) (Ude *et al.*, 2011) and major flavonoids (kaempferol, quercetin, and isorhamnetin) (Rangel-Ordóñez *et al.*, 2010) were found to cross the blood brain barrier following a single or repeated oral administration of 600 mg/kg EGb 761® in male Sprague-Dawley rats.

A study assessing the metabolism of the flavonoids in rats found no intact flavonol glycosides in the blood, feces, or urine 24 hours following oral administration of *Ginkgo biloba* extract (Pietta *et al.*, 1995). Metabolites identified included 3,4-dihydroxyphenylacetic acid, hippuric acid, 3-hydroxyphenylacetic acid, homovanillic acid, benzoic acid, 3-(4-hydroxyphenyl)propionic acid, and 3-(3-hydroxyphenyl)propionic acid.

## Humans

In unpublished data supplied by the manufacturer (Schwabe, Karlsruhe) to Kleijnen and Knipschild (1992), the bioavailabilities of ginkgolides A and B were greater than 80%, whereas that of ginkgolide C was very low following oral administration of 80 mg EGb 761<sup>®</sup>. Bioavailability of bilobalide was 70% after a dose of 120 mg EGb 761<sup>®</sup>. Half-life values of ginkgolides A and B and bilobalide were 4, 6, and 3 hours, respectively. Ginkgolides A and B and bilobalide were excreted unchanged in the urine at approximately 70%, 50%, and 30%, respectively. Mauri *et al.* (2001) observed a maximum plasma concentration of total ginkgolides (A, B, and bilobalide) of 85 and 181.8 µg/mL, respectively, following administration of 9.6 mg Ginkgoselect<sup>®</sup> and Ginkgoselect<sup>®</sup> phytosome, which were reached at 120 minutes and 180 to 240 minutes. The mean half-life values for ginkgolides A and B and bilobalide in plasma were in the range of 120 to 180 minutes for both formulations. Woelkart *et al.* (2010) conducted a study to assess pharmacokinetics of various ginkgo preparations in healthy volunteers and found similar plasma half-life values across terpene trilactones and different ginkgo preparations. Also, the areas under the plasma concentration versus time curves were comparable.

Watson and Oliveira (1999) conducted a study that measured levels of kaempferol and quercetin in urine before and after oral administration of *Ginkgo biloba* and concluded that model flavonol glycosides kaempferol and quercetin display low bioavailability and are metabolized mainly through glucuronidation. In a review of ginkgo pharmacokinetic data, Biber (2003) described the profile of the flavones as dose-linear with half-lives in the 2- to 4-hour range with rapid metabolism of parent compounds to hydroxybenzoic acids. After oral administration of *Ginkgo biloba*, Pietta *et al.* (1997) identified the flavonol metabolites in humans as 4-hydroxybenzoic acid conjugate, 4-hydroxyhippuric acid, 3-methoxy-4-hydroxyhippuric acid, 3,4-dihydrobenzoic acid, hippuric acid, and 3-methoxy-4-hydroxybenzoic acid (vanillic acid), but the phenylacetic or phenylpropionic acid metabolites observed in rats were not found in humans, suggesting that humans metabolize the flavonoids to a greater

extent. Based on areas under the plasma concentration versus time curves, it was calculated that an oral dose of 240 mg in humans corresponds roughly to an oral dose of 50 mg/kg in rats (De Feudis, 1998).

In a study conducted by Research Triangle Institute in support of the NTP *Ginkgo biloba* extract studies, *Ginkgo biloba* extract normalized to 1 or 10 µM terpene trilactones decreased human hepatic microsomal CYP2C9, CYP3A4, CYP2C8 activities *in vitro* (Etheridge *et al.*, 2007). The deglycosylation of the flavonoid glycosides by acid hydrolysis prior to incubation with the microsomes resulted in further decreases in the activities of these enzymes. Incubation of human hepatocytes with *Ginkgo biloba* extract at concentrations normalized to 10, 30, or 100 µM terpene trilactones had no effect on CYP2C8 activity. However, the hydrolyzed extract decreased the activity of CYP2C8 at 30 and 100 µM.

## TOXICITY

### Experimental Animals

The LD<sub>50</sub> of standardized *Ginkgo biloba* extract administered orally to mice was reported to be 7.73 g/kg and the LD<sub>50</sub> after intravenous administration was 1.1 g/kg for both rats and mice (Salvador, 1995).

There was no evidence of organ damage or impairment of hepatic or renal function when *Ginkgo biloba* extract was administered orally over 27 weeks to rats and mice at doses ranging from 100 to 1,600 mg/kg (Salvador, 1995). Rats exposed to EGb 761<sup>®</sup> at 4, 20, and 100 mg/kg per day for 2 years were reported to show no histopathological changes, however, details of this study are not available (Woerdenbag and De Smet, 2000).

In a chronic study conducted in Fisher 344 rats with quercetin administered by dosed feed at concentrations of 0, 1,000, 10,000, or 40,000 ppm, there were no treatment-related effects on survival, clinical signs, organ weights, or hematological and clinical chemistry parameters (Dunnick and Hailey, 1992). There were decreases in mean body weights and relative liver and kidney weights in the 40,000 ppm male and female rats.

### Humans

In a review of studies of *Ginkgo biloba* extract administered to humans, Diamond *et al.* (2000) concluded that adverse events, as described in case reports, occurred in patients that were taking additional medicines or had comorbid conditions. A large randomized, double-blind clinical trial of *Ginkgo biloba* extract efficacy in reducing dementia was conducted between 2000 and 2008 (DeKosky *et al.*, 2008). The

authors found similar adverse event profiles between the group taking twice-daily doses of 120 mg *Ginkgo biloba* extract and the placebo group. Rates of mortality and incidences of coronary heart disease, angina, angioplasty, or stroke were also similar between the two groups.

Bent *et al.* (2005) assessed case reports and concluded a risk of spontaneous bleeding could be associated with *Ginkgo biloba* use. Kellermann and Kloft (2011) found 21 reported cases of spontaneous bleeding associated with *Ginkgo biloba* extract through 2007, with one third of the cases involving concurrent use of antiplatelet or anticoagulant therapies. The hypothesized mechanism of toxicity is that antagonism of PAF and collagen lead to inhibition of platelet aggregation (Bent *et al.*, 2005). Kellermann and Kloft (2011) conducted a systematic review and meta-analysis that did not find evidence of higher bleeding risk associated with *Ginkgo biloba* extract therapy. In isolated cases, ginkgo use was associated with increased blood pressure when combined with thiazide diuretics and coma when combined with trazodone (Izzo and Ernst, 2001). Seizures occurred in two previously well-controlled epileptics within 2 weeks of beginning *Ginkgo biloba* extract supplementation and resolved after stopping supplementation (Granger, 2001).

The ginkgolic acids present in the ginkgo plant are known to cause contact dermatitis in a manner similar to that elicited by urushiols in poison ivy with limited evidence of cross-reactivity between poison ivy and ginkgo (Sowers *et al.*, 1965; Tomb *et al.*, 1988; Lepoittevin *et al.*, 1989). For this reason, in Germany, ginkgolic acids are restricted to less than 5 ppm in standardized preparations. Two cases of allergic skin reaction (diffuse morbilliform eruptions and acute generalized exanthematous pustulosis) following oral treatment with *Ginkgo biloba* products were reported, one in the United States (Chiu *et al.*, 2002) and one in Australia (Pennisi, 2006).

In reviews of the efficacy and safety of *Ginkgo biloba* extract, no serious side effects were noted in clinical trials and side effects were similar to those seen in the placebo groups (Kleijnen and Knipschild, 1992; Diamond *et al.*, 2000; McKenna *et al.*, 2001; Ahlemeyer and Kriegelstein, 2003).

## REPRODUCTIVE AND DEVELOPMENTAL TOXICITY

### Experimental Animals

Comprehensive reproductive and developmental toxicity assessments with *Ginkgo biloba* extract were

not available in the literature. Yeh *et al.* (2008) treated male Long-Evans rats with 10, 50, or 100 mg *Ginkgo biloba* extract/kg body weight for up to 28 days and found no effect on male reproductive organ weights or serum testosterone levels. Al-Yahya *et al.* (2006) reported decreased caudal epididymis and prostate weights and increased aneuploidy in testes of male Swiss albino mice treated by oral gavage with 50 or 100 mg/kg per day for 90 days and decreased rates of pregnancy and preimplantation loss in 100 mg/kg females. In a developmental study, pregnant Wistar rats were gavaged with up to 14 mg/kg *Ginkgo biloba* extract per day during the tubal transit and implantation period; no significant effects were observed in either the dams or the pups (Fernandes *et al.*, 2010). In another study in pregnant rats, oral gavage with 7 or 14 mg/kg *Ginkgo biloba* extract on gestational days 8 to 20 did result in significant decreases in fetal weight (Pinto *et al.*, 2007).

### Humans

No studies on the reproductive or developmental toxicity of *Ginkgo biloba* extract in humans were found in the literature.

## CARCINOGENICITY

### Experimental Animals

No chronic toxicity studies with *Ginkgo biloba* were identified in the literature. However, quercetin, one of the major flavonol glycosides of ginkgo, has been assessed for carcinogenicity in rats, mice, and hamsters (reviewed in Harwood *et al.*, 2007). In the NTP 2-year quercetin bioassay in male and female F344/N rats, the significant finding was an increased incidence of renal tubule cell adenoma in male rats (Dunnick and Hailey, 1992). In a reevaluation of the kidney neoplasms and renal histopathology from that study, Hard *et al.* (2007) determined that the responsible mechanism of carcinogenicity was chronic progressive nephropathy. Hirono *et al.* (1981) conducted carcinogenicity studies with the flavonol glycosides quercetin and rutin using ACI rats given dosed feed for a period of 540 or 850 days and did not find significant increases in neoplasm incidence with either chemical.

Studies exploring the carcinogenic activity of *Ginkgo biloba* in chemical-induced cancer models have been conducted. In all cases, *Ginkgo biloba* decreased the severity of chemical-induced cancer development (Agha *et al.*, 2001; Dias *et al.*, 2008; Jiang *et al.*, 2009).

### Humans

Two epidemiological studies explored carcinogenicity associated with use of *Ginkgo biloba* supplements. In a



population-based, case-control study reported by Ye *et al.* (2007), in which the case group included 668 women in Massachusetts and New Hampshire diagnosed with epithelial ovarian cancer matched to 721 women in the control group, an inverse association (OR=0.41; 95% confidence interval, 0.20-0.84; P=0.01) was found between *Ginkgo biloba* use and risk for ovarian cancer. A more recent study by Biggs *et al.* (2010) used data from the largest epidemiological study of *Ginkgo biloba* efficacy (Ginkgo Evaluation of Memory Study) conducted to date to analyze cancer as a secondary endpoint. The study population consisted of 3,069 participants, age 75 years or greater, that were randomly assigned to receive twice daily doses of either a placebo or *Ginkgo biloba* extract (120 mg EGb 761<sup>®</sup>) and were followed for approximately 6 years. Researchers found an increased risk of breast (hazard ratio, 2.15; 95% confidence interval, 0.97-4.80; P=0.06) and colorectal (hazard ratio, 1.62; 95% confidence interval, 0.92-2.87; P=0.10) cancers and a decreased risk of prostate cancer (hazard ratio, 0.71; 95% confidence interval, 0.43-1.17; P=0.18) in the population receiving *Ginkgo biloba* extract.

## GENETIC TOXICITY

### *Ginkgo biloba* Extract

The genetic toxicity literature on *Ginkgo biloba* is primarily focused on its antimutagenic effects in experiments using cotreatment with known genotoxicants. However, quercetin, one of the principal components found in *Ginkgo biloba* extracts, was reported to induce genetic damage, as measured by a number of different endpoints.

*Ginkgo biloba* extract (EGb 761<sup>®</sup>), over a concentration range of 5 to 100 µg/mL, reduced the mutagenicity of 15 µg/mL ofloxacin and 5 µg/mL acridine orange in *Euglena gracilis* in a dose-dependent manner (Krizková *et al.* 2008); the mutagenicity of both agents was reduced by 99% at the highest dose of *Ginkgo biloba* extract. From additional experiments designed to determine the mechanisms of *Ginkgo biloba* extract antimutagenicity, the authors concluded that *Ginkgo biloba* extract was an effective antioxidant and it bound directly to acridine orange, inhibiting its ability to interact with DNA.

Significant dose-related reductions in genotoxicant-induced micronuclei were seen in reticulocytes of mice following coadministration of *Ginkgo biloba* extract and either cyclophosphamide or mitomycin C (Vilar *et al.*, 2009). In another experiment, the bacterial mutagenicity of tobacco smoke condensates from cigarettes was significantly reduced when *Ginkgo*

*biloba* leaf extract was added to the cigarette filters (Wang *et al.*, 2010). When rats were exposed for 30 days (twice daily) to the smoke from these cigarettes containing *Ginkgo biloba* leaf extract, the frequency of micronucleated reticulocytes was reported to be lower than the frequency in rats exposed to smoke from control cigarettes containing tobacco but no *Ginkgo biloba*. However, the experimental details provided in this published study were insufficient to independently evaluate the data.

*Ginkgo biloba*-containing tablet supplements were shown to reduce the frequencies of micronucleated lymphocytes over time in radioiodine-treated Graves' disease patients without adversely affecting clinical outcome (Dardano *et al.*, 2007). Similarly, in human lymphocytes *in vitro*, pretreatment with concentrations of 50 µg/mL and higher of *Ginkgo biloba* was shown to reduce the frequency of chromosomally aberrant cells induced by exposure to 10 Gy radiation (Emerit *et al.*, 1995).

Although there is no evidence of genotoxicity from the limited number of studies conducted with *Ginkgo biloba*, ginkgolic acids, which are components of *Ginkgo biloba*, were reported to induce DNA damage as measured by the comet assay in primary rat hepatocytes *in vitro* (Westendorf and Regan, 2000).

### Quercetin

Quercetin, a flavonol, was identified in the *Ginkgo biloba* extract used in the NTP 2-year bioassay. There is a large body of literature on the genetic toxicity of quercetin, and it was the subject of an NTP Technical Report (NTP, 1992). A summary of the extensive genetic toxicology literature for quercetin follows.

Quercetin induced DNA strand breaks, measured by alkaline single cell gel electrophoresis, in HepG2 cells, HeLa cells, and human lymphocytes *in vitro* (Duthie *et al.*, 1997). It was shown to be mutagenic in several strains of *Salmonella typhimurium*, with and without S9 (Bjeldanes and Chang, 1977; Sugimura *et al.*, 1977; Hardigree and Epler, 1978; MacGregor and Jurd, 1978; Brown and Dietrich, 1979; Nagao *et al.*, 1981; Stoewsand *et al.*, 1984; Crebelli *et al.*, 1987; Zeiger *et al.*, 1992).

Quercetin induced micronuclei in V79 cells and human lymphocytes *in vitro*, with and without S9 (Caria *et al.*, 1995). The micronuclei observed in human lymphocytes were kinetochore-negative, suggesting they arose from chromosomal breakage events. Consistent with this mode of action, quercetin was reported to induce chromosomal aberrations in V79 cells, CHO-AT3-2 cells, Don-6 cells, and Chinese

hamster ovary (CHO) cells with and without S9 (Yoshida *et al.*, 1980; Carver *et al.*, 1983; Kubiak and Rudek, 1990; NTP, 1992; Gaspar *et al.*, 1994).

Quercetin was also positive in tests for induction of sister chromatid exchanges in cultured Chinese hamster Don-6 cells, B-131 cells, and ovary cells and in cultured human fibroblast HE2144 cells and human lymphocytes (Yoshida *et al.*, 1980; Kubiak and Rudek, 1990; NTP, 1992).

Although quercetin has clearly been shown to induce cytogenetic damage *in vitro*, it did not induce a consistent or significant increase in gene mutations at the *hprt*, *aprt*, or ATPase loci in CHO cells, V79 cells, or mouse lymphoma L5178Y cells *in vitro* (Carver *et al.*, 1983; Van der Hoeven *et al.*, 1984). However, Maruta *et al.* (1979) reported that quercetin induced 8-azaguanine resistance in V79 cells with and without metabolic activation, and several laboratories demonstrated induction of trifluorothymidine resistance in L5178Y<sup>tk+/-</sup> mouse lymphoma cells (Amacher *et al.*, 1980; Meltz and MacGregor 1981; Van der Hoeven *et al.*, 1984). Quercetin also induced dose-related increases in the frequencies of sex-linked recessive lethal mutations in germ cells of male *Drosophila melanogaster* administered the compound by adult feeding at doses of 8.25 and 16.5 × 10<sup>-2</sup> M (Watson, 1982).

In contrast to the cytogenetic damage seen with quercetin in mammalian cells *in vitro*, results of *in vivo* mouse bone marrow micronucleus tests with quercetin were negative (Aeschbacher *et al.*, 1982; NTP, 1992; Caria *et al.*, 1995).

### Additional Mutagenic Compounds in Ginkgo biloba Extract

#### Kaempferol

The mutagenicity of kaempferol was investigated in a number of standard *in vitro* assays. The compound was

mutagenic in *S. typhimurium* with S9 (Nagao *et al.*, 1981; Silva *et al.*, 1997) and produced dose-dependent increases in chromosomal aberrations and micronuclei in V79 cells, with and without S9 (Silva *et al.*, 1997). Kaempferol (10 to 500 μM) induced DNA damage, as measured by the comet assay, in human lymphocytes treated *in vitro* (Anderson *et al.*, 1997), but when coadministered with the known food mutagens Trp or IQ, kaempferol reduced the levels of DNA damage induced by the food mutagens alone (Anderson *et al.*, 1997). Kaempferol also induced dose-related increases in the frequencies of sex-linked recessive lethal mutations in germ cells of male *Drosophila melanogaster* administered the compound by adult feeding at doses of 8.7 and 17.4 × 10<sup>-2</sup> M (Watson, 1982).

#### Rutin

Rutin was shown to reduce the mutagenic effects of known genotoxicants in *S. typhimurium* strain TA102 (Edenharder and Grünhage, 2003). Rutin (100 to 500 μM) induced DNA damage, as measured by the comet assay, in human lymphocytes treated *in vitro*, but when coadministered at high concentrations (250 to 500 μM) with the known food mutagens Trp or IQ, rutin reduced the levels of DNA damage induced by the food mutagens alone (Anderson *et al.*, 1997).

## STUDY RATIONALE

*Ginkgo biloba* extract was nominated for study by the National Cancer Institute because of its widespread use as an herbal supplement to promote mental function and limited availability of toxicity and carcinogenicity data. Additionally, one of the major ingredients in *Ginkgo biloba* extract, quercetin, is a known mutagen. Oral gavage was chosen as the route most relevant to human exposure through ingestion of *Ginkgo biloba* extract supplements. The test article selection was based on availability of bulk product and market share of the manufacturer at the study initiation.

## MATERIALS AND METHODS

### PROCUREMENT AND CHARACTERIZATION

#### *Ginkgo biloba* Extract

The original intent was to use standardized extract EGb 761<sup>®</sup>, manufactured by Wilhelm Schwabe, due to its use in many human studies. However, this material was not available to the NTP because unformulated EGb 761<sup>®</sup> was exclusively sold to pharmaceutical companies at the time of procurement for the NTP studies. Through industry contacts, the NTP learned that Shanghai Xing Ling Science and Technology Pharmaceutical Company, Ltd (Shanghai, China), produced an extract comparable to the Schwabe extract that was widely distributed in commerce (personal communication to Dr. P. C. Chan, NIEHS). *Ginkgo biloba* extract from leaves was obtained from this company, in two lots (020703 and GBE-50-001003). Lot 020703 was used during the 3-month and 2-year studies. Lot GBE-50-001003 was used only for methods development. Identity, purity, stability, and moisture analyses were conducted by the analytical chemistry laboratory, Midwest Research Institute (Kansas City, MO); in addition, the study laboratory at Battelle Columbus Operations (Columbus, OH) confirmed the identity of the test article by infrared spectroscopy (Appendix I). Reports on analyses performed in support of the *Ginkgo biloba* extract studies are on file at the National Institute of Environmental Health Sciences.

The identity and purity of the test article were determined by using a combination of techniques and authentic standards specific for ginkgo. Estimation of the distribution of particle sizes in lot GBE-50-001003 was determined using a sieve method, and the results indicated that 84.3% of the test article passed through a No. 140 (106  $\mu\text{m}$ ) sieve (Table I1). The bulk density of lot 020703 was determined to be 0.521 g/mL. To evaluate organic constituents of the test article, extracts were prepared, and a combination of chromatographic and spectrometric techniques was used to characterize this lot. High-performance thin layer chromatography (HPTLC) fingerprint analyses were conducted for ginkgolides and flavonoids in methanol extracts of the test article using two systems specified in Application Notes F-16A and F-16B, respectively, obtained from CAMAG Scientific, Inc. (Wilmington, NC). Many components of the test article were tentatively identified

using various chromatography/mass spectrometry techniques, including liquid chromatography/mass spectrometry, gas chromatography/mass spectrometry, and matrix-assisted laser-desorption ionization time-of-flight mass spectrometry. High-performance liquid chromatography (HPLC) was used to profile ethanol:water:12N hydrochloric acid (64:26:10) extracts of the bulk material and to quantitate (using caffeine as an internal standard)  $\alpha$ -glycosides and terpenoids in these extracts. Analyses were conducted on nonhydrolyzed extracts and also on extracts hydrolyzed at 90° C for approximately 1 hour, utilizing commercially obtained standards with matching retention times published in the literature (Hasler *et al.*, 1992). For these assays, methanol:water (50:50) extracts of the *Ginkgo biloba* powder were partitioned with dichloromethane and dried over anhydrous sodium sulfate. The residue was reconstituted with methanol and analyzed using total ion current and single ion response mode following the methodology of Ndjoko *et al.* (2000) and Li *et al.* (2002). Further information on these methods can be found in Gray *et al.* (2005, 2007).

One aliquot each of lot GBE-50-001003 and lot 020703 were submitted to Covance Laboratories, Inc., for nutritional and contaminant testing using standard methods. For lot 020703, heavy metals present in the extract included antimony (57.2 ppb), arsenic (32.4 ppb), cadmium (13.2 ppb), lead (249 ppb), mercury (10.7 ppb), and molybdenum (14.6 ppb). Levels for aflatoxins B1, B2, G1, and G2 were all less than 0.500 ppb and pesticide levels were below the detection limit, with the exception of carbendazim (0.24 ppm) and 2-phenylphenol (0.11 ppm). For lot GBE-50-001003, organochlorine, organophosphorus pesticide, nitrosamine, and aflatoxin levels were below the limit of detection for the analysis method.

As determined by weight loss on drying, moisture content for lot 020703 was 0.90%. Developed, dried HPTLC plates were viewed under ultraviolet (UV) light, and multiple bands were obtained for the test article by both systems; bands consistent with those for standards obtained from Sigma-Aldrich (St. Louis, MO) of the ginkgolides bilobalide, ginkgolide A, and ginkgolide B, and of the flavonoid rutin hydrate were observed. In HPLC/UV profiles of the test article extracts, 37 components were observed to have peak areas

greater than or equal to 0.05% of the total peak area, and three components were identified: quercetin, kaempferol, and isorhamnetin, which had peak areas equal to 34.08%, 27.77%, and 5.43%, respectively, of the total peak area. In HPLC/evaporative light scattering (ELS) profiles of the test article extracts, 18 components were observed to have peak areas greater than or equal to 0.05% of the total peak area, and seven components were identified: bilobalide, ginkgolide C, ginkgolide A, ginkgolide B, quercetin, kaempferol, and isorhamnetin, which had peak areas equal to 17.30%, 3.25%, 9.06%, 2.05%, 28.74%, 12.58%, and 2.24%, respectively, of the total peak area. Quantitation assays of  $\alpha$ -glycosides in the hydrolyzed extracts using HPLC/UV indicated that the test material contained 16.71% quercetin, 12.20% kaempferol, and 2.37% isorhamnetin when reported as glycosides. HPLC/ELS quantitation assays of terpenoids in the hydrolyzed extracts determined that the test material contained 6.94% bilobalide, 3.06% ginkgolide C, 3.74% ginkgolide A, and 1.62% ginkgolide B. HPLC/MS analysis for the presence of colchicine using the colchicine standard from Sigma-Aldrich resulted in no observable peak of colchicine in the test material. HPLC analyses for ginkgolic acids I and II using standards from ChromaDex, Inc. (Irvine, CA), revealed a total ginkgolic acid concentration of 10.45 ppm in the test material.

Stability studies of lot 020703 of the bulk chemical were performed by the analytical chemistry laboratory using HPLC analyses by the same UV and ELS detection techniques used to characterize this lot of the bulk product. Results of these assays were inconclusive due to high amounts of variability in the measurements, but the seven  $\alpha$ -glycosides and terpenoid components in lot 020703 appeared to be stable, within experimental error, at temperatures up to approximately 60° C when the bulk material was stored protected from light. To ensure stability, the bulk chemical was stored at room temperature in amber glass bottles. Periodic reanalyses of the bulk chemical were performed during the 3-month and 2-year studies by the study laboratory, and stability was monitored using an isocratic HPLC/UV system. No degradation of the bulk chemical was detected.

### Corn Oil

NF-grade corn oil was obtained in multiple lots from Spectrum Chemicals and Laboratory Products (Gardena, CA) and was used as the vehicle in the 3-month and 2-year studies. Periodic analyses of the corn oil vehicle performed by the study laboratory using potentiometric titration demonstrated peroxide concentrations less than the rejection level of 3 mEq/kg.

## PREPARATION AND ANALYSIS OF DOSE FORMULATIONS

The dose formulations were prepared three times during the 3-month studies and approximately every 4 weeks during the 2-year studies by mixing *Ginkgo biloba* extract with corn oil (Table I2). Homogeneity studies of the 25 and 400 mg/mL dose formulations were performed by the study laboratory using an isocratic HPLC/UV system; this system was also used by Battelle Chemistry Support Services (Columbus, OH) to perform stability studies of a 1 mg/mL formulation made with lot GBE-50-001003 of *Ginkgo biloba* extract. Homogeneity was confirmed, and stability was confirmed for at least 42 days for formulations stored in sealed plastic bottles protected from light at room temperature or at approximately 5° C, and for at least 3 hours under simulated animal room conditions.

Periodic analyses of the dose formulations of *Ginkgo biloba* extract were conducted by the study laboratory using the isocratic HPLC/UV system. During the 3-month studies, the dose formulations were analyzed three times; all 15 dose formulations for rats and mice were within 10% of the target concentrations (Table I3). Animal room samples of these dose formulations were also analyzed; all 15 animal room samples for rats and all 15 for mice were within 10% of the target concentrations. During the 2-year studies, the dose formulations were analyzed approximately every 12 weeks; animal room samples were also analyzed (Table I4). All 30 dose formulations analyzed for rats and mice were within 10% of the target concentrations; all 12 animal room samples for rats and all 12 for mice were within 10% of the target concentrations.

## 3-MONTH STUDIES

The 3-month studies were conducted to evaluate the cumulative toxic effects of repeated exposure to *Ginkgo biloba* extract and to determine the appropriate doses to be used in the 2-year studies. The high doses for the 3-month studies were based on the limits of gavageability and homogeneity of the substance.

Male and female F344/N rats and B6C3F1/N mice were obtained from Taconic Farms, Inc. (Germantown, NY). On receipt, the rats and mice were 4 to 5 weeks old. Rats were quarantined for 11 (males) or 12 (females) days; mice were quarantined for 13 (females) or 14 (males) days. Rats and mice were 5 to 7 weeks old on the first day of the studies. Before the studies began, five male and five female rats and mice were randomly selected for parasite evaluation and gross observation for evidence of disease. At 1 month and at the end of the studies, serologic analyses were performed on five

male and five female sentinel rats and mice using the protocols of the NTP Sentinel Animal Program (Appendix K).

Groups of 10 male and 10 female rats and mice received *Ginkgo biloba* extract in corn oil by gavage at doses of 0, 62.5 (rats only), 125, 250, 500, 1,000, or 2,000 (mice only) mg/kg 5 days per week for 14 weeks. Vehicle control animals received the corn oil vehicle alone; dosing volumes were 2.5 mL/kg for rats and 5 mL/kg for mice. Groups of 10 male and 10 female clinical pathology rats received the same doses for 23 days. Feed and water were available *ad libitum*. Rats and female mice were housed five per cage; male mice were housed individually. Clinical findings were recorded initially, weekly thereafter, and at the end of the studies for core study rats and mice. Core study animals were weighed initially, weekly, and at the end of the studies. Details of the study design and animal maintenance are summarized in Table 1.

Blood was collected from clinical pathology study rats on days 4 and 23 and from core study rats at the end of the study for hematology and clinical chemistry analyses; blood was collected at the end of the study from all mice for hematology analyses. All animals were anesthetized with a carbon dioxide/oxygen mixture and blood was drawn from the retroorbital plexus (rats) or retroorbital sinus (mice). Whole blood samples for hematology were placed into tubes containing EDTA; clinical chemistry samples were placed into serum collection tubes. Hematology determinations were performed on an ADVIA 120 Hematology system (Bayer Diagnostics, Tarrytown, NY). Clinical chemistry analyses were performed on a Hitachi 911 (Boehringer Mannheim, Indianapolis, IN) using reagents supplied by the manufacturer. The parameters measured are listed in Table 1.

At the end of the 3-month studies, samples were collected for sperm motility and vaginal cytology evaluations on rats in the 0, 250, 500, and 1,000 mg/kg groups and mice in the 0, 500, 1,000, and 2,000 mg/kg groups. The parameters evaluated are listed in Table 1. For 12 consecutive days prior to scheduled terminal kill, the vaginal vaults of the females were moistened with saline, if necessary, and samples of vaginal fluid and cells were stained. Relative numbers of leukocytes, nucleated epithelial cells, and large squamous epithelial cells were determined and used to ascertain estrous cycle stage (i.e., diestrus, proestrus, estrus, and metestrus). Male animals were evaluated for sperm count and motility. The left testis and left epididymis were isolated and weighed. The tail of the epididymis (cauda epididymis) was then removed from the epididymal body (corpus epididymis) and weighed.

Test yolk (rats) or modified Tyrode's buffer (mice) was applied to slides and a small incision was made at the distal border of the cauda epididymis. The sperm effluxing from the incision were dispersed in the buffer on the slides, and the numbers of motile and nonmotile spermatozoa were counted for five fields per slide by two observers. Following completion of sperm motility estimates, each left cauda epididymis was placed in buffered saline solution. Caudae were finely minced, and the tissue was incubated in the saline solution and then heat fixed at 65° C. Sperm density was then determined microscopically with the aid of a hemacytometer. To quantify spermatogenesis, the testicular spermatid head count was determined by removing the tunica albuginea and homogenizing the left testis in phosphate-buffered saline containing 10% dimethyl sulfoxide. Homogenization-resistant spermatid nuclei were counted with a hemacytometer.

Necropsies were performed on all core study animals. The heart, right kidney, liver, lung, right testis, and thymus were weighed. Tissues for microscopic examination were fixed and preserved in 10% neutral buffered formalin (except eyes were first fixed in Davidson's solution), processed and trimmed, embedded in paraffin, sectioned to a thickness of 4 to 6 µm, and stained with hematoxylin and eosin. Complete histopathologic examinations were performed on all core study vehicle control rats and mice, 1,000 mg/kg rats, and 2,000 mg/kg mice; the liver and the thyroid gland of rats and the liver and nose of mice were examined in the remaining groups, and the kidney was examined in the remaining groups of male mice. Table 1 lists the tissues and organs routinely examined.

After a review of the laboratory reports and selected histopathology slides by a quality assessment pathologist, the findings and reviewed slides were submitted to a NTP Pathology Working Group (PWG) coordinator for a second independent review. Any inconsistencies in the diagnoses made by the laboratory and quality assessment pathologists were resolved by the NTP pathology peer review process. Final diagnoses for reviewed lesions represent a consensus between the laboratory pathologist, NTP pathologist, reviewing pathologist(s), and the PWG coordinator. Details of these review procedures have been described, in part, by Maronpot and Boorman (1982) and Boorman *et al.* (1985).

## 2-YEAR STUDIES

### Study Design

Groups of 50 male and 50 female rats and mice received *Ginkgo biloba* extract in corn oil by gavage at doses of

100, 300, or 1,000 mg/kg (rats), or 200, 600, or 2,000 mg/kg (mice) 5 days per week for 104 or 105 (female rats) weeks. Vehicle control animals received the corn oil vehicle alone; the dosing volumes were 2.5 mL/kg for rats and 5 mL/kg for mice. Groups of 10 male and 10 female special study rats received the same doses for 14 weeks.

### Source and Specification of Animals

Male and female F344/N rats and B6C3F1/N mice were obtained from Taconic Farms, Inc. (Germantown, NY), for use in the 2-year studies. Rats were quarantined for 13 (males) or 14 (females) days and mice were quarantined for 14 (males) or 15 (females) days before the beginning of the studies. Five male and five female rats and mice were randomly selected for parasite evaluation and gross observation of disease. Rats and mice were approximately 6 to 7 weeks old at the beginning of the studies. The health of the animals was monitored during the studies according to the protocols of the NTP Sentinel Animal Program using extra rats and mice at 1 month, sentinel rats and mice at 6, 12, and 18 months, and 1,000 mg/kg rats and 2,000 mg/kg mice at study termination; five males and five females were used at each time point (Appendix K).

### Animal Maintenance

All animal studies were conducted in an animal facility accredited by the Association for the Assessment and Accreditation of Laboratory Animal Care International. Studies were approved by the Battelle Columbus Operations Animal Care and Use Committee and conducted in accordance with all relevant NTP animal care and use policies and applicable federal, state, and local regulations and guideline. Rats were housed two or three (core study males) or five (special study males and females and core study females) per cage and mice were housed individually (males) or five per cage (females). Feed and water were available *ad libitum*. Cages and racks were rotated every 2 weeks. Further details of animal maintenance are given in Table 1. Information on feed composition and contaminants is provided in Appendix J.

### Clinical Examinations and Pathology

All animals were observed twice daily. Body weights were recorded initially, weekly for the first 13 weeks, every 4 weeks thereafter and at study termination. Clinical findings for core study rats and mice were recorded during study week 5, every 4 weeks thereafter, and at study termination.

Blood was taken from the retroorbital plexus of special study rats on day 22 and at week 14 and processed into serum for thyroid hormone determinations.

Radioimmunoassays were performed for thyroid stimulating hormone and total triiodothyronine using a Packard Cobra II gamma counter (Packard Instrument Company, Meriden, CT). Assays for total thyroxine were performed on a Hitachi 911 Chemistry Analyzer (Boehringer Mannheim, Indianapolis, IN) using a Roche Diagnostics (Indianapolis, IN) enzyme immunoassay test system.

For special study rats at 14 weeks, the liver and thyroid gland were weighed and examined microscopically. Complete necropsies and microscopic examinations were performed on all core study rats and mice. At necropsy, all organs and tissues were examined for grossly visible lesions, and all major tissues were fixed and preserved in 10% neutral buffered formalin (except eyes were first fixed in Davidson's solution), processed and trimmed, embedded in paraffin, sectioned to a thickness of 4 to 6  $\mu\text{m}$ , and stained with hematoxylin and eosin for microscopic examination. For all paired organs (e.g., adrenal gland, kidney, ovary), samples from each organ were examined. Tissues examined microscopically are listed in Table 1.

Microscopic evaluations were completed by the study laboratory pathologist, and the pathology data were entered into the Toxicology Data Management System. The report, slides, paraffin blocks, residual wet tissues, and pathology data were sent to the NTP Archives for inventory, slide/block match, wet tissue audit, and storage. The slides, individual animal data records, and pathology tables were evaluated by an independent quality assessment laboratory. The individual animal records and tables were compared for accuracy, the slide and tissue counts were verified, and the histotechnique was evaluated. For the 2-year studies, a quality assessment pathologist evaluated slides from all tumors and all potential target organs, which included the kidney and liver of rats and mice; the adrenal cortex, nose, and thyroid gland of rats; the bone marrow, parathyroid gland, spleen, and glandular stomach of male rats; the pancreas, pituitary gland, and uterus of female rats; and the thymus of female mice.

The quality assessment report and the reviewed slides were submitted to the NTP PWG coordinator, who reviewed the selected tissues and addressed any inconsistencies in the diagnoses made by the laboratory and quality assessment pathologists. Representative histopathology slides containing examples of lesions related to chemical administration, examples of disagreements in diagnoses between the laboratory and quality assessment pathologists, or lesions of general interest were presented by the coordinator to the PWG for review. The PWG consisted of the quality assessment pathologist and other pathologists

experienced in rodent toxicologic pathology. This group examined the tissues without any knowledge of dose groups. When the PWG consensus differed from the opinion of the laboratory pathologist, the diagnosis was changed. Final diagnoses for reviewed lesions represent a consensus between the laboratory pathologist, reviewing pathologist(s), and the PWG. Details of these

review procedures have been described, in part, by Maronpot and Boorman (1982) and Boorman *et al.* (1985). For subsequent analyses of the pathology data, the decision of whether to evaluate the diagnosed lesions for each tissue type separately or combined was generally based on the guidelines of McConnell *et al.* (1986).

**TABLE 1**  
**Experimental Design and Materials and Methods in the Gavage Studies of *Ginkgo biloba* Extract**

<b>3-Month Studies</b>	<b>2-Year Studies</b>
<b>Study Laboratory</b> Battelle Columbus Operations (Columbus, OH)	Battelle Columbus Operations (Columbus, OH)
<b>Strain and Species</b> F344/N rats B6C3F1/N mice	F344/N rats B6C3F1/N mice
<b>Animal Source</b> Taconic Farms, Inc. (Germantown, NY)	Taconic Farms, Inc. (Germantown, NY)
<b>Time Held Before Studies</b> Rats: 11 (males) or 12 (females) days Mice: 13 (females) or 14 (males) days	Rats: 13 (males) or 14 (females) days Mice: 14 (males) or 15 (females) days
<b>Age When Studies Began</b> 5 to 7 weeks	6 to 7 weeks
<b>Date of First Dose</b> Rats: February 9, 2004 (males) February 10, 2004 (females) Mice: February 12, 2004 (males) February 11, 2004 (females)	Rats: March 23, 2005 (males) March 24, 2005 (females) Mice: March 17, 2005 (males) March 18, 2005 (females)
<b>Duration of Dosing</b> 5 days/week for 14 weeks	5 days/week for 104 or 105 (female rats) weeks
<b>Date of Last Dose</b> Rats: May 10, 2004 (core males) May 11, 2004 (core females) March 2, 2004 (clinical pathology study males) March 3, 2004 (clinical pathology study females) Mice: May 13, 2004 (males) May 12, 2004 (females)	Rats: March 20, 2007 (core males) March 22, 2007 (core females) June 21, 2005 (special study males) June 22, 2005 (special study females) Mice: March 12, 2007 (males) March 15, 2007 (females)
<b>Necropsy Dates</b> Rats: May 11, 2004 (males) May 12, 2004 (females) Mice: May 14, 2004 (males) May 13, 2004 (females)	Rats: March 19-21, 2007 (males) March 21-23, 2007 (females) Mice: March 12-13, 2007 (males) March 14-16, 2007 (females)
<b>Age at Necropsy</b> 19 to 20 weeks	109 to 111 weeks
<b>Size of Study Groups</b> 10 males and 10 females	Core study rats and mice: 50 males and 50 females Special study rats: 10 males and 10 females

**TABLE 1**  
**Experimental Design and Materials and Methods in the Gavage Studies of Ginkgo biloba Extract**

3-Month Studies	2-Year Studies
<p><b>Method of Distribution</b>            Animals were distributed randomly into groups of approximately equal initial mean body weights.</p>	Same as 3-month studies
<p><b>Animals per Cage</b>            Rats: 5            Mice: 1 (males) or 5 (females)</p>	<p>Rats: 2 or 3 (core study males) or 5 (special study males and all females)            Mice: 1 (males) or 5 (females)</p>
<p><b>Method of Animal Identification</b>            Tail tattoo</p>	Tail tattoo
<p><b>Diet</b>            Irradiated NTP-2000 wafer diet (Zeigler Brothers, Inc., Gardners, PA), available <i>ad libitum</i>, changed at least weekly</p>	Same as 3-month studies
<p><b>Water</b>            Tap water (Columbus municipal supply) via automatic watering system (Edstrom Industries, Inc., Waterford, WI), available <i>ad libitum</i></p>	Same as 3-month studies
<p><b>Cages</b>            Polycarbonate (Lab Products, Inc., Seaford, DE), changed once weekly for individually housed animals and twice weekly for group housed animals</p>	Same as 3-month studies
<p><b>Bedding</b>            Irradiated Sani-Chips<sup>®</sup> hardwood chips (P.J. Murphy Forest Products Corp., Montville, NJ), changed once weekly for individually housed animals and twice weekly for group housed animals</p>	Same as 3-month studies
<p><b>Rack Filters</b>            Spun bonded polyester (Snow Filtration Co., Cincinnati, OH), changed every 2 weeks</p>	Same as 3-month studies
<p><b>Racks</b>            Stainless steel drawer type (Lab Products, Inc., Seaford, DE), changed and rotated every 2 weeks</p>	Same as 3-month studies
<p><b>Animal Room Environment</b>            Temperature: 72° ± 3° F            Relative humidity: 50% ± 15%            Room fluorescent light: 12 hours/day            Room air changes: at least 10/hour</p>	<p>Temperature: 72° ± 3° F            Relative humidity: 50% ± 15%            Room fluorescent light: 12 hours/day            Room air changes: at least 10/hour</p>
<p><b>Doses</b>            Rats: 0, 62.5, 125, 250, 500, or 1,000 mg/kg in corn oil (dosing volume 2.5 mL/kg)            Mice: 0, 125, 250, 500, 1,000, or 2,000 mg/kg in corn oil (dosing volume 5 mL/kg)</p>	<p>Rats: 0, 100, 300, or 1,000 mg/kg in corn oil (dosing volume 2.5 mL/kg)            Mice: 0, 200, 600, or 2,000 mg/kg in corn oil (dosing volume 5 mL/kg)</p>
<p><b>Type and Frequency of Observation</b>            Observed twice daily; core study animals were weighed initially, weekly thereafter, and at the end of the studies; clinical findings (core animals) were recorded initially, weekly thereafter, and at the end of the studies.</p>	<p>Observed twice daily; animals were weighed initially, weekly for 13 weeks, monthly thereafter, and at the end of the studies; clinical findings for core study animals were recorded week 5, monthly thereafter, and at the end of the studies.</p>
<p><b>Method of Kill</b>            Carbon dioxide asphyxiation</p>	Same as 3-month studies



**TABLE 1**  
**Experimental Design and Materials and Methods in the Gavage Studies of Ginkgo biloba Extract**

3-Month Studies	2-Year Studies
<p><b>Necropsy</b>  Necropsies were performed on all core study rats and mice. Organs weighed were heart, right kidney, liver, lung, right testis, and thymus.</p>	<p>Necropsies were performed on all core study rats and mice. The liver and thyroid gland of special study rats were weighed.</p>
<p><b>Clinical Pathology</b>  Blood was collected from the retroorbital plexus (rats) or retroorbital sinus (mice). Clinical pathology rats were bled on days 4 and 23 and core study animals were bled at the end of the studies for hematology and clinical chemistry (rats only).  <b>Hematology:</b> hematocrit; hemoglobin concentration; erythrocyte, reticulocyte, and platelet counts; mean cell volume; mean cell hemoglobin; mean cell hemoglobin concentration; and leukocyte count and differentials  <b>Clinical chemistry:</b> urea nitrogen, creatinine, glucose, total protein, albumin, alanine aminotransferase, alkaline phosphatase, creatine kinase, sorbitol dehydrogenase, and bile salts</p>	<p>Blood was collected from the retroorbital plexus of special study rats at day 22 and at week 14 for thyroid hormone analyses.  <b>Thyroid hormones:</b> thyroid stimulating hormone, triiodothyronine, and thyroxine</p>
<p><b>Histopathology</b>  Complete histopathology was performed on all core study vehicle control rats and mice, 1,000 mg/kg rats, and 2,000 mg/kg mice. In addition to gross lesions and tissue masses, the following tissues were examined: adrenal gland, bone with marrow, brain, clitoral gland, esophagus, eyes, gallbladder (mice), heart, large intestine (cecum, colon, rectum), small intestine (duodenum, jejunum, ileum), kidney, liver, lung, lymph nodes (mandibular and mesenteric), mammary gland, nose, ovary, pancreas, parathyroid gland, pituitary gland, preputial gland, prostate gland, salivary gland, skin, spleen, stomach (forestomach and glandular), testis with epididymis and seminal vesicle, thymus, thyroid gland, trachea, urinary bladder, and uterus. In addition, the liver and thyroid gland of rats, the liver and nose of mice, and the kidney of male mice were examined in the remaining core study groups.</p>	<p>Complete histopathology was performed on all core study rats and mice. In addition to gross lesions and tissue masses, the following tissues were examined: adrenal gland, bone with marrow, brain, clitoral gland, esophagus, eyes, gallbladder (mice), heart, large intestine (cecum, colon, rectum), small intestine (duodenum, jejunum, ileum), kidney, liver, lung, lymph nodes (mandibular and mesenteric), mammary gland, nose, ovary, pancreas, parathyroid gland, pituitary gland, preputial gland, prostate gland, salivary gland, skin, spleen, stomach (forestomach and glandular), testis with epididymis and seminal vesicle, thymus, thyroid gland, trachea, urinary bladder, and uterus. The liver and thyroid gland were examined in special study rats.</p>
<p><b>Sperm Motility and Vaginal Cytology</b>  At the end of the studies, spermatid and sperm samples were collected from male rats in the 0, 250, 500, and 1,000 mg/kg groups and male mice in the 0, 500, 1,000, and 2,000 mg/kg groups. The following parameters were evaluated: spermatid heads per testis and per gram testis, sperm motility, and sperm per cauda epididymis and per gram cauda epididymis. The left cauda, left epididymis, and left testis were weighed. Vaginal samples were collected for up to 12 consecutive days prior to the end of the studies from female rats in the 0, 250, 500, and 1,000 mg/kg groups and female mice in the 0, 500, 1,000, and 2,000 mg/kg groups. The proportion of regularly cycling females, estrous cycle length, and probability of extended or skipped estrous cycle stages were evaluated.</p>	<p>None</p>

## STATISTICAL METHODS

### Survival Analyses

The probability of survival was estimated by the product-limit procedure of Kaplan and Meier (1958) and is presented in the form of graphs. Animals found dead of other than natural causes were censored; animals dying from natural causes were not censored. Statistical analyses for possible dose-related effects on survival used Cox's (1972) method for testing two groups for equality and Tarone's (1975) life table test to identify dose-related trends. All reported P values for the survival analyses are two sided.

### Calculation of Incidence

The incidences of neoplasms or nonneoplastic lesions are presented in Tables A1, A4, B1, B4, C1, C4, D1, and D4 as the numbers of animals bearing such lesions at a specific anatomic site and the numbers of animals with that site examined microscopically. For calculation of statistical significance, the incidences of most neoplasms (Tables A2, B2, C2, and D2) and all nonneoplastic lesions are given as the numbers of animals affected at each site examined microscopically. However, when macroscopic examination was required to detect neoplasms in certain tissues (e.g., mesentery, pleura, peripheral nerve, skeletal muscle, tongue, tooth, and Zymbal's gland) before microscopic evaluation, the denominators consist of the number of animals that had a gross abnormality. When neoplasms had multiple potential sites of occurrence (e.g., leukemia or lymphoma), the denominators consist of the number of animals on which a necropsy was performed. Tables A2, B2, C2, and D2 also give the survival-adjusted neoplasm rate for each group and each site-specific neoplasm. This survival-adjusted rate (based on the Poly-3 method described below) accounts for differential mortality by assigning a reduced risk of neoplasm, proportional to the third power of the fraction of time on study, only to site-specific, lesion-free animals that do not reach terminal kill.

### Analysis of Neoplasm and Nonneoplastic Lesion Incidences

The Poly-k test (Bailer and Portier, 1988; Portier and Bailer, 1989; Piegorsch and Bailer, 1997) was used to assess neoplasm and nonneoplastic lesion prevalence. This test is a survival-adjusted quantal-response procedure that modifies the Cochran-Armitage linear trend test to take survival differences into account. More specifically, this method modifies the denominator in the quantal estimate of lesion incidence to approximate more closely the total number of animal years at risk. For analysis of a given site, each animal is assigned a risk weight. This value is one if the animal had a lesion at that site or if it survived until terminal

kill; if the animal died prior to terminal kill and did not have a lesion at that site, its risk weight is the fraction of the entire study time that it survived, raised to the kth power.

This method yields a lesion prevalence rate that depends only upon the choice of a shape parameter for a Weibull hazard function describing cumulative lesion incidence over time (Bailer and Portier, 1988). Unless otherwise specified, a value of  $k=3$  was used in the analysis of site-specific lesions. This value was recommended by Bailer and Portier (1988) following an evaluation of neoplasm onset time distributions for a variety of site-specific neoplasms in control F344 rats and B6C3F1 mice (Portier *et al.*, 1986). Bailer and Portier (1988) showed that the Poly-3 test gave valid results if the true value of  $k$  was anywhere in the range from 1 to 5. A further advantage of the Poly-3 method is that it does not require lesion lethality assumptions. Variation introduced by the use of risk weights, which reflect differential mortality, was accommodated by adjusting the variance of the Poly-3 statistic as recommended by Bieler and Williams (1993).

Tests of significance included pairwise comparisons of each dosed group with controls and a test for an overall dose-related trend. Continuity-corrected Poly-3 tests were used in the analysis of lesion incidence, and reported P values are one sided. The significance of lower incidences or decreasing trends in lesions is represented as  $1-P$  with the letter N added (e.g.,  $P=0.99$  is presented as  $P=0.01N$ ).

### Analysis of Continuous Variables

Two approaches were employed to assess the significance of pairwise comparisons between dosed and control groups in the analysis of continuous variables. Organ and body weight data, which historically have approximately normal distributions, were analyzed with the parametric multiple comparison procedures of Dunnett (1955) and Williams (1971, 1972). Hematology, clinical chemistry, thyroid hormone, spermatid, and epididymal spermatozoal data, which have typically skewed distributions, were analyzed using the nonparametric multiple comparison methods of Shirley (1977) (as modified by Williams, 1986) and Dunn (1964). Jonckheere's test (Jonckheere, 1954) was used to assess the significance of the dose-related trends and to determine whether a trend-sensitive test (Williams' or Shirley's test) was more appropriate for pairwise comparisons than a test that does not assume a monotonic dose-related trend (Dunnett's or Dunn's test). Prior to statistical analysis, extreme values identified by the outlier test of Dixon and Massey (1957) were examined by NTP personnel, and implausible values were eliminated from the

analysis. Proportions of regular cycling females in each dosed group were compared to the control group using the Fisher exact test (Gart *et al.*, 1979). Tests for extended periods of estrus, diestrus, metestrus, and proestrus, as well as skipped estrus and skipped diestrus, were constructed based on a Markov chain model proposed by Girard and Sager (1987). For each dose group, a transition probability matrix was estimated for transitions among the proestrus, estrus, metestrus, and diestrus stages, with provision for extended stays within each stage as well as for skipping estrus or diestrus within a cycle. Equality of transition matrices among dose groups and between the control group and each dosed group was tested using chi-square statistics.

### Historical Control Data

The concurrent control group represents the most valid comparison to the treated groups and is the only control group analyzed statistically in NTP bioassays. However, historical control data are often helpful in interpreting potential treatment-related effects, particularly for uncommon or rare neoplasm types. For meaningful comparisons, the conditions for studies in the historical database must be generally similar. One significant factor affecting the background incidence of neoplasms at a variety of sites is diet. In 1995, the NTP incorporated a new diet (NTP-2000) that contains less protein and more fiber and fat than the NIH-07 diet previously used in toxicity and carcinogenicity studies (Rao, 1996, 1997). The NTP historical database contains all studies that use the NTP-2000 diet with histopathology findings completed within the most recent 5-year period. A second potential source of variability is route of administration. In general, the historical database for a given study will include studies using the same route of administration, and the overall incidences of neoplasms for all routes of administration are included for comparison, including the present study.

### QUALITY ASSURANCE METHODS

The 3-month and 2-year studies were conducted in compliance with Food and Drug Administration Good Laboratory Practice Regulations (21 CFR, Part 58). In addition, as records from the 2-year studies were submitted to the NTP Archives, these studies were audited retrospectively by an independent quality assurance contractor. Separate audits covered completeness and accuracy of the pathology data, pathology specimens, final pathology tables, and a draft of this NTP Technical Report. Audit procedures and findings are presented in the reports and are on file at NIEHS. The audit findings were reviewed and assessed by NTP staff, and all comments were resolved or

otherwise addressed during the preparation of this Technical Report.

### GENETIC TOXICOLOGY

The genetic toxicity of *Ginkgo biloba* extract was assessed by testing the ability of the chemical to induce mutations in various strains of *Salmonella typhimurium* and *Escherichia coli* and increases in the frequency of micronucleated erythrocytes in mouse peripheral blood. Micronuclei (literally “small nuclei” or Howell-Jolly bodies) are biomarkers of induced structural or numerical chromosomal alterations and are formed when acentric fragments or whole chromosomes fail to incorporate into either of two daughter nuclei during cell division (Schmid, 1975; Heddle *et al.*, 1983). The protocols for these studies and the results are given in Appendix E.

The genetic toxicity studies have evolved from an earlier effort by the NTP to develop a comprehensive database permitting a critical anticipation of a chemical’s carcinogenicity in experimental animals based on numerous considerations, including the molecular structure of the chemical and its observed effects in short-term *in vitro* and *in vivo* genetic toxicity tests (structure-activity relationships). The short-term tests were originally developed to clarify proposed mechanisms of chemical-induced DNA damage based on the relationship between electrophilicity and mutagenicity (Miller and Miller, 1977) and the somatic mutation theory of cancer (Straus, 1981; Crawford, 1985). However, it should be noted that not all cancers arise through genotoxic mechanisms.

DNA reactivity combined with *Salmonella* mutagenicity is highly correlated with induction of carcinogenicity in multiple species/sexes of rodents and at multiple tissue sites (Ashby and Tennant, 1991). A positive response in the *Salmonella* test was shown to be the most predictive *in vitro* indicator for rodent carcinogenicity (89% of the *Salmonella* mutagens are rodent carcinogens) (Tennant *et al.*, 1987; Zeiger *et al.*, 1990). Additionally, no battery of tests that included the *Salmonella* test improved the predictivity of the *Salmonella* test alone. However, these other tests can provide useful information on the types of DNA and chromosomal damage induced by the chemical under investigation.

The predictivity for carcinogenicity of a positive response in acute *in vivo* bone marrow chromosome aberration or micronucleus tests appears to be less than that in the *Salmonella* test (Shelby *et al.*, 1993; Shelby

and Witt, 1995). However, clearly positive results in long-term peripheral blood micronucleus tests have high predictivity for rodent carcinogenicity; a weak response in one sex only or negative results in both sexes in this assay do not correlate well with either negative or positive results in rodent carcinogenicity studies (Witt

*et al.*, 2000). Because of the theoretical and observed associations between induced genetic damage and adverse effects in somatic and germ cells, the determination of *in vivo* genetic effects is important to the overall understanding of the risks associated with exposure to a particular chemical.

## RESULTS

### RATS

#### 3-MONTH STUDY

All rats survived to the end of the study; final mean body weights and mean body weight gains of all dosed groups

were similar to those of the vehicle controls (Table 2 and Figure 2). No chemical-related clinical findings were observed.

**TABLE 2**  
**Survival and Body Weights of Rats in the 3-Month Gavage Study of *Ginkgo biloba* Extract<sup>a</sup>**

Dose (mg/kg)	Survival <sup>b</sup>	Initial Body Weight (g)	Final Body Weight (g)	Change in Body Weight (g)	Final Weight Relative to Controls (%)
<b>Male</b>					
0	10/10	100 ± 4	322 ± 5	222 ± 4	
62.5	10/10	100 ± 4	329 ± 5	229 ± 4	102
125	10/10	99 ± 4	322 ± 3	222 ± 4	100
250	10/10	100 ± 4	326 ± 4	227 ± 3	101
500	10/10	99 ± 4	324 ± 2	225 ± 4	101
1,000	10/10	99 ± 4	314 ± 5	215 ± 5	98
<b>Female</b>					
0	10/10	91 ± 3	192 ± 2	101 ± 3	
62.5	10/10	91 ± 3	191 ± 2	100 ± 4	99
125	10/10	90 ± 3	194 ± 3	104 ± 3	101
250	10/10	90 ± 3	194 ± 4	104 ± 4	101
500	10/10	91 ± 2	193 ± 1	102 ± 3	100
1,000	10/10	90 ± 3	193 ± 2	103 ± 2	101

<sup>a</sup> Weights and weight changes are given as mean ± standard error. Differences from the vehicle control group are not significant by Dunnett's test.

<sup>b</sup> Number of animals surviving at 14 weeks/number initially in group

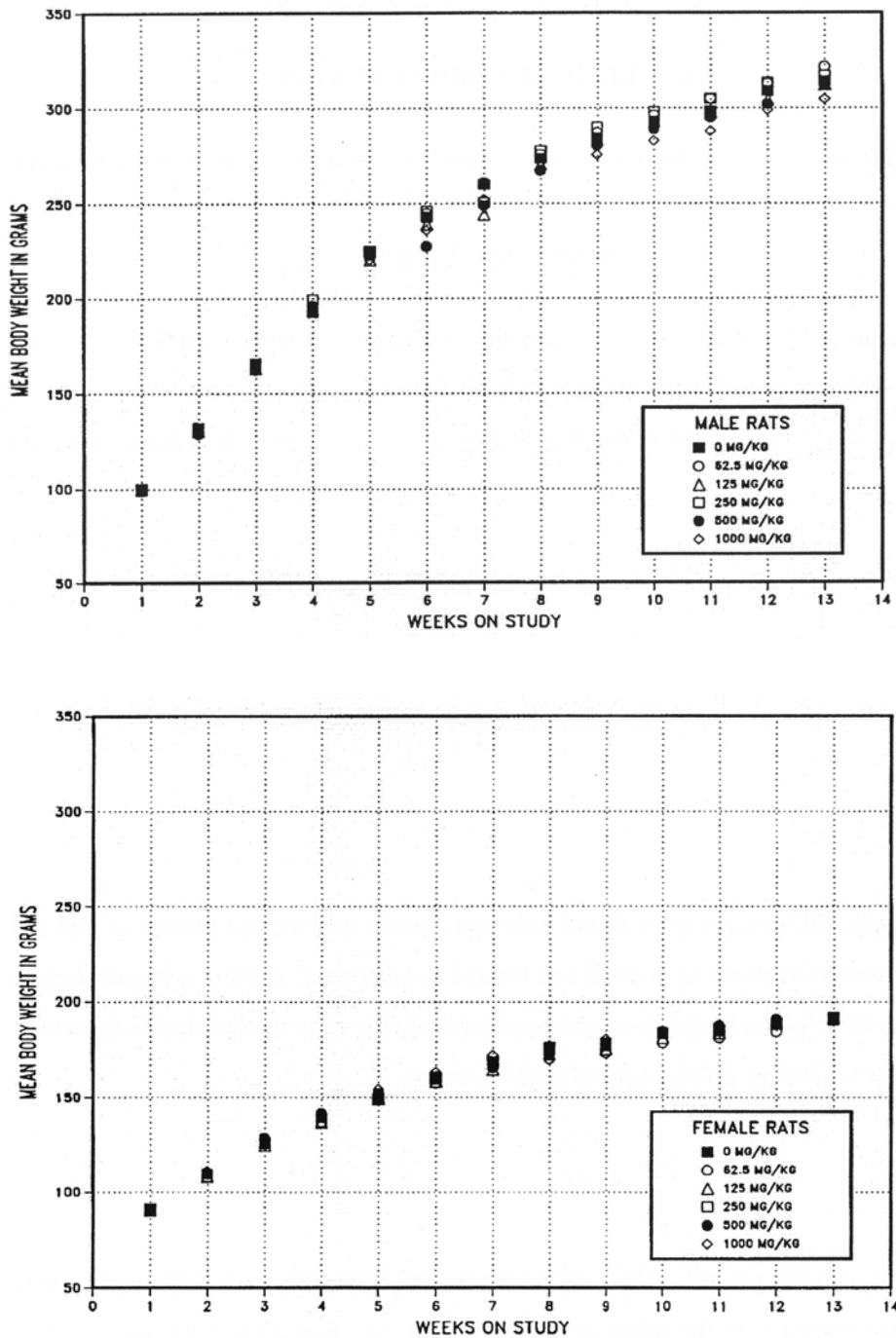


FIGURE 2  
Growth Curves for Rats Administered *Ginkgo biloba* Extract by Gavage for 3 Months

On day 23 and at week 14, there were mild increases in platelet counts in the 500 and 1,000 mg/kg males; at week 14, there were increases in reticulocyte counts in the 250 mg/kg or greater male groups (Table F1). The reticulocyte count increases were not accompanied by changes in other erythrocyte indices. The increases may reflect increased production or altered peripheral distribution.

On day 23, there were mild increases (up to 9%) in serum albumin and total protein concentrations in all dosed male groups, with similar increases in the 125 mg/kg or greater male groups at week 14 (Tables 3 and F1). These increases generally occurred in a dose-related manner. Paired increases in serum albumin and total protein concentrations suggest dehydration.

Decreases in serum bile salt concentrations occurred on day 4 in the 125 mg/kg or greater male groups and at week 14 in the 250 mg/kg or greater males and the 125 mg/kg or greater females (Tables 3 and F1). These decreases may represent disruption of enterohepatic circulation of bile salts (Tolman and Rej, 1999).

At week 14, there were mild (up to 45%) treatment-related decreases in serum activity of alanine aminotransferase in all dosed groups except 62.5 mg/kg females (Tables 3 and F1). The significance and mechanism of the decreased activity are unknown but may indicate decreased hepatocellular enzyme production or release, or enzyme assay interference. In particular, decreases have been associated with perturbations of gluconeogenesis or administration of substances that inhibit the cofactor pyridoxal phosphate (Hall, 2007; Evans, 2009).

On day 23 and at week 14, alkaline phosphatase activities in most groups of dosed males and all groups of dosed females were significantly decreased (Tables 3 and F1). In rats, circulating serum alkaline phosphatase activity is primarily of intestinal or bone origin. While the mechanism in the current study is not known, decreased feed consumption due to toxicity or poor palatability has been associated with decreased alkaline phosphatase activity (Hall, 2007; Evans, 2009). However, body weights were unaffected in the current study, indicating that feed consumption was not reduced.

Absolute and relative liver weights of all dosed groups of males and females were significantly increased compared to those of the vehicle control groups (Table G1).

Other than a slight (11%) decrease in spermatid heads/mg testis in males in the 250 mg/kg group, there

were no significant differences in sperm parameters of male rats or in the estrous cycle of female rats treated with 250, 500, or 1,000 mg/kg when compared to the vehicle controls (Tables H1 and H2). The minimal, non-dose-related decrease in relative spermatid counts, in the absence of any other concordant absolute count or histologic effects, was not considered to be related to administration of *Ginkgo biloba* extract.

The incidences of hepatocyte hypertrophy in all dosed groups of males and in 500 and 1,000 mg/kg females were significantly greater than those in the vehicle control groups (Table 4). Hepatocyte fatty change occurred in all dosed males. The hypertrophy began in the centrilobular areas and expanded to the midzonal areas with a dose-related increase in severity from minimal to moderate in the males and minimal severity in the females. Microscopically, hepatocytic hypertrophy was characterized by an enlargement of the hepatocytes up to approximately one and a half times the normal size. The hypertrophic hepatocytes had increased amounts of cytoplasm and slightly enlarged nuclei. Fatty change consisted of small numbers of scattered midzonal hepatocytes having small to a few large, clear, discrete intracytoplasmic vacuoles that had the typical appearance of lipid droplets filling most or all of the cytoplasm.

The incidences of thyroid gland follicular cell hypertrophy were significantly increased in 500 and 1,000 mg/kg males and in 1,000 mg/kg females (Table 4). The hypertrophy was minimal to mild in severity in males and minimal in females and was characterized by an increase in the size of the follicular cells with the affected cells often assuming a tall cuboidal to low columnar shape. Sometimes enlarged follicular cells formed small protrusions into the lumen, and often there was an increase in clear vacuolation (resorption vacuoles) in the follicular cell cytoplasm due to increased resorptions of colloid. Follicles at the periphery of the vehicle control thyroid glands commonly were dilated and lined with flattened follicular epithelial cells, indicating the follicles were relatively inactive, while peripheral follicles in the affected thyroid glands were usually lined by large cuboidal cells, indicating the follicles were still somewhat active. The incidences of pigmentation in the olfactory epithelium of the nose were significantly increased in 500 and 1,000 mg/kg males and in females administered 125 mg/kg or greater; sporadic incidences of olfactory epithelium atrophy were observed in females treated with 125, 500, or 1,000 mg/kg (Table 4). Pigment accumulation was characterized by the accumulation of golden brown pigment within macrophages scattered throughout the basal aspect of the olfactory epithelium. The macrophages were more

**TABLE 3**  
**Selected Clinical Chemistry Data for Rats in the 3-Month Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Male</b>						
Day 4	10	10	10	10	10	10
Day 23	10	10	10	10	10	9
Week 14	10	10	10	10	10	10
Total protein (g/dL)						
Day 4	5.8±0.1	5.8±0.1	5.8±0.1	5.8±0.1	5.8±0.1	5.9±0.1
Day 23	6.5±0.0	6.7±0.1**	6.8±0.1**	6.7±0.1**	6.8±0.1**	7.0±0.1**
Week 14	6.6±0.0	6.8±0.1	6.9±0.1**	7.0±0.1**	7.2±0.1**	7.2±0.1**
Albumin (g/dL)						
Day 4	4.0±0.0	4.0±0.1	4.1±0.1	4.0±0.0	4.0±0.1	4.0±0.1
Day 23	4.4±0.0	4.5±0.0*	4.5±0.0*	4.4±0.0*	4.5±0.1*	4.6±0.0**
Week 14	4.6±0.0	4.7±0.0	4.8±0.0*	4.8±0.0**	4.9±0.0**	4.9±0.0**
Alanine aminotransferase (IU/L)						
Day 4	64±2	66±3	65±2	64±2	64±2	65±2
Day 23	57±1	62±2	64±4	56±1	58±2	58±3
Week 14	74±6	41±1**	45±2**	42±1**	45±1**	42±1**
Alkaline phosphatase (IU/L)						
Day 4	707±11	699±14	678±17	701±14	699±22	697±13
Day 23	482±6	468±12	464±10	451±13*	450±11*	446±7**
Week 14	224±6	210±5	200±3**	188±3**	194±5**	181±3**
Bile salts (µmol/L)						
Day 4	9.6±1.0	7.3±0.8	5.9±0.8*	7.0±0.8*	5.5±1.2**	5.3±0.5**
Day 23	4.5±0.9	2.7±0.4	3.9±0.6	4.4±0.7	2.7±0.2	2.9±0.4
Week 14	5.5±0.8	3.8±0.4	3.9±0.5	3.3±0.4**	3.8±0.7*	2.8±0.4**
<b>Female</b>						
n	10	10	10	10	10	10
Alanine aminotransferase (IU/L)						
Day 4	54±2	54±2	53±2	57±2	53±2	52±2
Day 23	40±1	44±1*	41±1	43±1	40±1	41±2
Week 14	49±3	45±1	40±1**	39±1**	39±1**	35±1**
Alkaline phosphatase (IU/L)						
Day 4	563±10	536±19	518±10	546±14	517±18	519±20
Day 23	365±5	348±11*	340±9*	339±8*	320±8**	311±9**
Week 14	183±7	160±7*	159±4*	138±4**	146±4**	135±3**
Bile salts (µmol/L)						
Day 4	6.1±1.1	5.8±0.8	3.7±0.4	5.0±0.7	3.6±0.4	3.5±0.4
Day 23	5.6±0.9	6.4±0.9	4.9±1.3	5.0±0.8	5.3±1.0	3.3±0.5
Week 14	10.0±1.2	8.7±0.9	6.0±0.9*	4.3±0.5**	3.4±0.5**	3.1±0.4**

\* Significantly different ( $P \leq 0.05$ ) from the vehicle control group by Dunn's or Shirley's test

\*\*  $P \leq 0.01$

<sup>a</sup> Data are presented as mean ± standard error. Statistical tests were performed on unrounded data.



**TABLE 4**  
**Incidences of Selected Nonneoplastic Lesions in Rats in the 3-Month Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Male</b>						
Liver <sup>a</sup>	10	10	10	10	10	10
Hepatocyte, Hypertrophy <sup>b</sup>	0	10** (1.0) <sup>c</sup>	10** (1.2)	10** (1.7)	10** (2.2)	10** (3.0)
Hepatocyte, Fatty Change	0	10** (1.4)	10** (1.7)	10** (1.8)	10** (1.7)	10** (1.3)
Thyroid Gland	10	10	10	10	10	10
Follicular Cell, Hypertrophy	0	2 (1.0)	0	3 (1.3)	10** (1.3)	10** (2.0)
Nose	10	10	10	10	10	10
Olfactory Epithelium, Pigmentation	0	0	0	0	5* (1.0)	7** (1.0)
<b>Female</b>						
Liver	10	10	10	10	10	10
Hepatocyte, Hypertrophy	0	1 (1.0)	0	0	9** (1.2)	10** (1.1)
Thyroid Gland	10	10	10	10	10	10
Follicular Cell, Hypertrophy	0	0	0	0	3 (1.0)	5* (1.0)
Nose	10	10	10	10	10	10
Olfactory Epithelium, Pigmentation	0	0	5* (1.0)	5* (1.0)	9** (1.2)	7** (1.6)
Olfactory Epithelium, Atrophy	0	0	1 (1.0)	0	3 (1.3)	3 (2.3)

\* Significantly different (P<0.05) from the vehicle control group by the Fisher exact test

\*\* P<0.01

<sup>a</sup> Number of animals with tissue examined microscopically

<sup>b</sup> Number of animals with lesion

<sup>c</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

common in areas of olfactory epithelial atrophy but were also present in nonatrophied areas. Minimal pigment was apparent within the cells of the olfactory epithelium. Atrophy was characterized by thinning, decreased cellularity, and disorganization of the olfactory epithelium.

*Dose Selection Rationale:* The high dose in the 3-month study was based on gavageability and homogeneity of the *Ginkgo biloba* extract dosing solution. No effects on survival or body weights were observed.

The hypertrophy observed in histopathologic assessment of the livers and thyroid glands of rats was not considered to be life-threatening. However, the dose spacing was increased from half intervals in the 3-month study to half-log intervals in the 2-year study based on these histopathologic findings in order to capture a range of effect levels. Therefore, the doses selected for the 2-year gavage study in rats were 100, 300, and 1,000 mg/kg.

## 2-YEAR STUDY

### Survival

Estimates of 2-year survival probabilities for male and female rats are shown in Table 5 and in the Kaplan-Meier survival curves (Figure 3). Survival of 1,000 mg/kg males was significantly less than that of the vehicle controls. However, a notable increase in

deaths was not apparent until late in the study beginning around week 85 of exposure. The most frequent cause of early death noted in male rats administered 1,000 mg/kg *Ginkgo biloba* extract was mononuclear cell leukemia. Survival of dosed groups of females was similar to that of the vehicle controls.

**TABLE 5**  
**Survival of Rats in the 2-Year Gavage Study of *Ginkgo biloba* Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
Animals initially in study	50	50	50	50
Moribund	7	8	10	14
Natural deaths	5	5	9	20
Animals surviving to study termination	38	37	31	16
Percent probability of survival at end of study <sup>a</sup>	76	74	62	32
Mean survival (days) <sup>b</sup>	706	694	695	681
Survival analysis <sup>c</sup>	P<0.001	P=0.993	P=0.190	P<0.001
<b>Female</b>				
Animals initially in study	50	50	50	50
Accidental death <sup>d</sup>	0	0	0	1
Moribund	9	13	7	4
Natural deaths	4	10	6	13
Animals surviving to study termination	37	27	37 <sup>e</sup>	32
Percent probability of survival at end of study	74	54	74	66
Mean survival (days)	700	666	702	660
Survival analysis	P=0.897	P=0.051	P=1.000	P=0.402

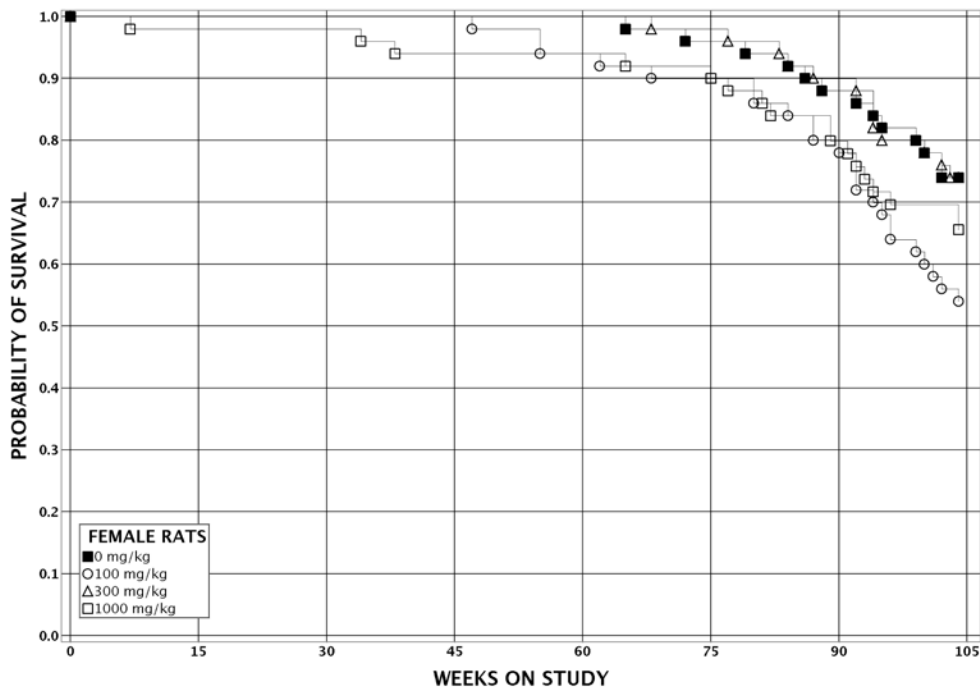
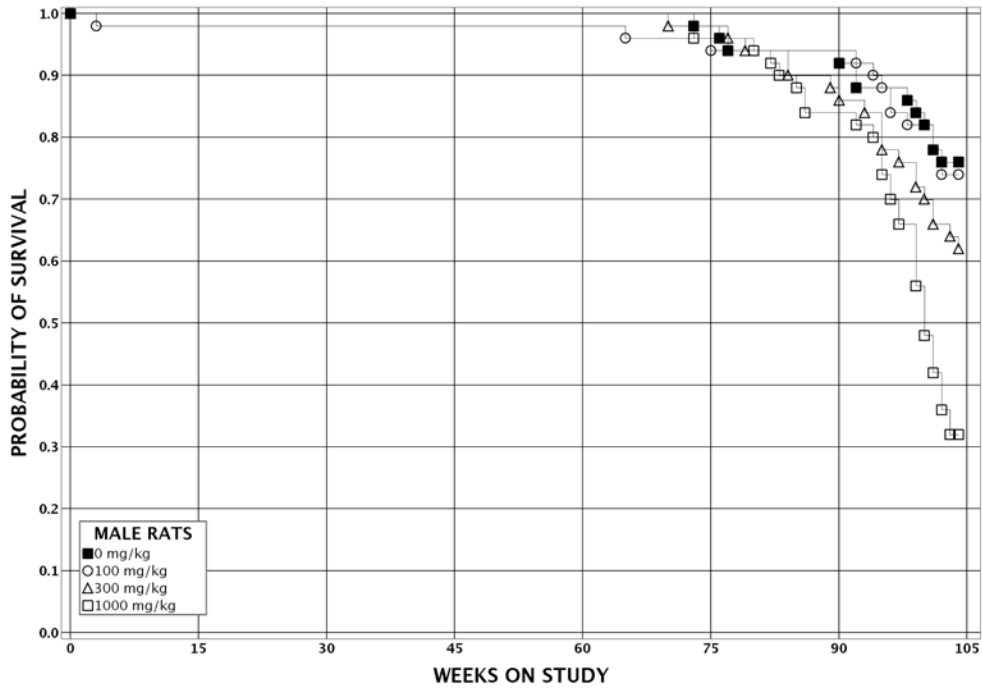
<sup>a</sup> Kaplan-Meier determinations

<sup>b</sup> Mean of all deaths (uncensored, censored, and terminal kill).

<sup>c</sup> The result of the life table trend test (Tarone, 1975) is in the vehicle control column, and the results of the life table pairwise comparisons (Cox, 1972) with the vehicle controls are in the dosed group columns.

<sup>d</sup> Censored from survival analysis

<sup>e</sup> Includes one animal that died during the last week of the study



**FIGURE 3**  
**Kaplan-Meier Survival Curves for Rats Administered *Ginkgo biloba* Extract by Gavage for 2 Years**

### Thyroid Hormones

At week 14, all dosed groups of males and the 1,000 mg/kg female group in the special study had increased levels of thyroid stimulating hormone compared to those of the vehicle controls (Tables 6 and F2). The increase appeared dose-related in male rats. There were no statistically significant changes in the levels of triiodothyronine or total thyroxine.

### Body Weights and Clinical Findings

Mean body weights of 300 mg/kg males and females were less (10% or more) than those of the vehicle controls only after week 93, and those of 1,000 mg/kg males and females were less only after week 89 (Figure 4; Tables 7 and 8). Clinical findings included ruffled fur in seven, eight, and 10 males in the 100, 300, and 1,000 mg/kg groups, respectively, beginning at week 89; four vehicle control males also had ruffled fur.

**TABLE 6**  
**Thyroid Stimulating Hormone Data for Special Study Rats in the 2-Year Gavage Study**  
**of *Ginkgo biloba* Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
n	9	10	10	10
Thyroid stimulating hormone (ng/mL)				
Day 22	8.33 ± 0.47	8.38 ± 0.89 <sup>b</sup>	10.78 ± 1.49 <sup>c</sup>	11.20 ± 0.96
Week 14	6.89 ± 0.56	9.10 ± 0.50**	9.60 ± 0.75**	10.90 ± 0.81**
<b>Female</b>				
n	9	10	10	10
Thyroid stimulating hormone (ng/mL)				
Day 22	9.43 ± 0.48 <sup>d</sup>	10.00 ± 0.82 <sup>c</sup>	9.56 ± 0.53 <sup>c</sup>	10.44 ± 0.56 <sup>c</sup>
Week 14	5.56 ± 0.34	5.70 ± 0.33	6.40 ± 0.54	7.30 ± 0.40**

\*\* Significantly different ( $P \leq 0.01$ ) from the vehicle control group by Shirley's test

<sup>a</sup> Data are presented as mean ± standard error. Statistical tests were performed on unrounded data.

<sup>b</sup> n=8

<sup>c</sup> n=9

<sup>d</sup> n=7

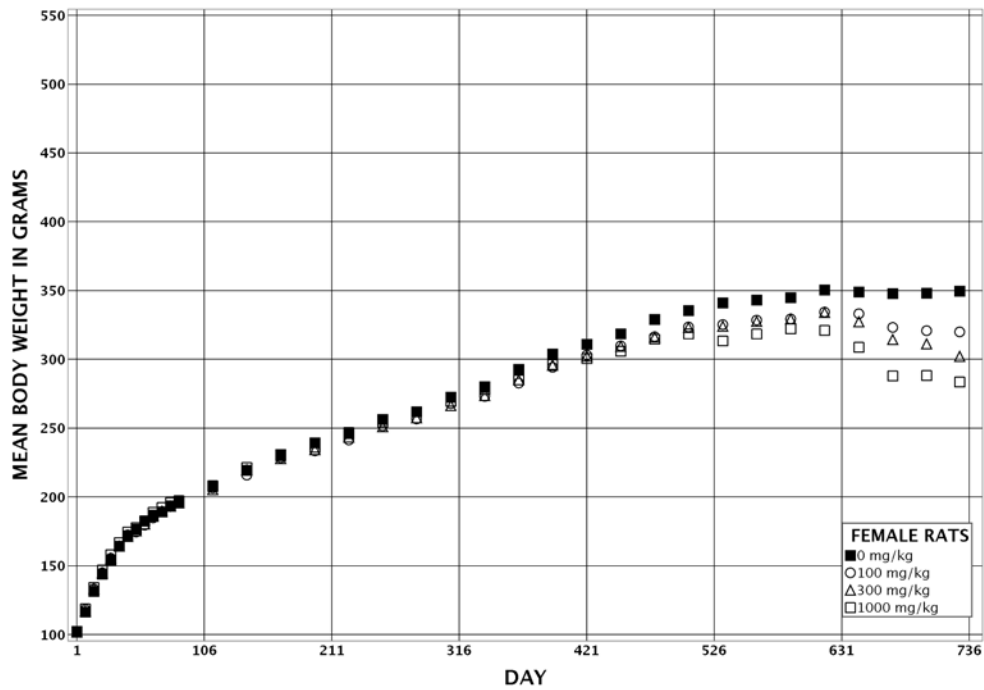
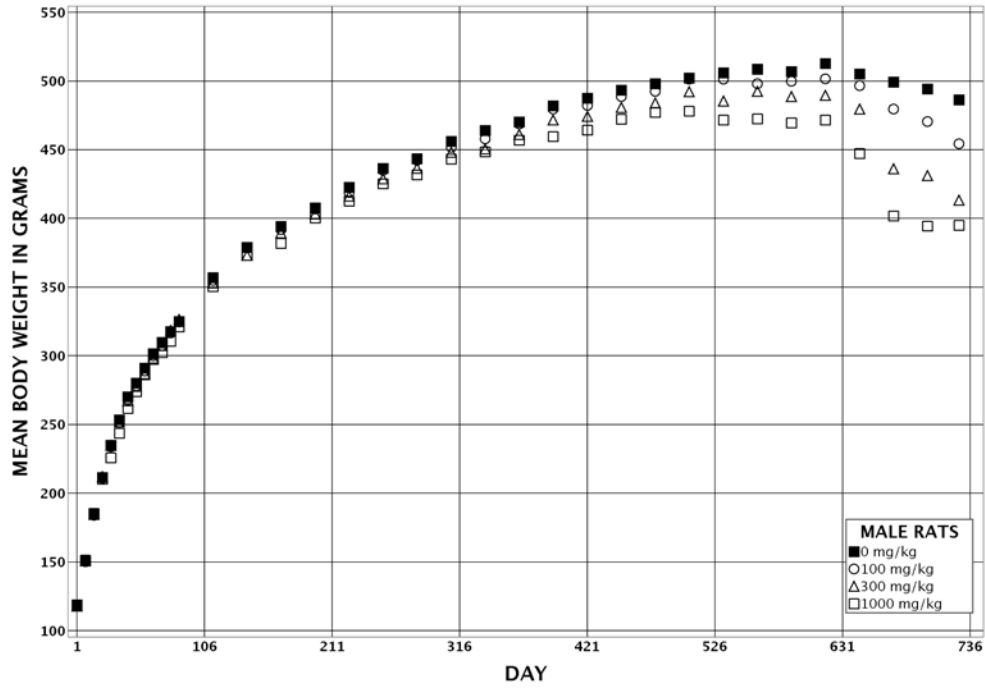


FIGURE 4  
Growth Curves for Rats Administered *Ginkgo biloba* Extract by Gavage for 2 Years

**TABLE 7**  
**Mean Body Weights and Survival of Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

Day	Vehicle Control		100 mg/kg			300 mg/kg			1,000 mg/kg		
	Av. Wt. (g)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt. (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors
1	119	50	118	100	50	118	99	50	119	100	50
8	151	50	150	100	50	151	100	50	151	100	50
15	185	50	184	100	49	185	100	50	185	100	50
22	212	50	211	100	49	212	100	50	210	99	50
29	235	50	234	100	49	235	100	50	226	96	50
36	254	50	252	99	49	252	99	50	244	96	50
43	270	50	268	99	49	267	99	50	262	97	50
50	280	50	278	99	49	278	99	50	274	98	50
57	291	50	289	99	49	287	99	50	286	98	50
64	302	50	300	100	49	298	99	50	298	99	50
71	310	50	307	99	49	307	99	50	302	98	50
78	318	50	317	100	49	319	100	50	311	98	50
85	325	50	325	100	49	327	100	50	321	99	50
113	357	50	355	100	49	353	99	50	351	98	50
141	379	50	379	100	49	373	99	50	373	99	50
169	394	50	392	99	49	390	99	50	382	97	50
197	408	50	407	100	49	403	99	50	401	98	50
225	423	50	419	99	49	416	98	50	413	98	50
253	436	50	435	100	49	429	98	50	425	98	50
281	444	50	442	100	49	436	98	50	432	97	50
309	456	50	452	99	49	448	98	50	443	97	50
337	464	50	458	99	49	451	97	50	449	97	50
365	470	50	469	100	49	461	98	50	457	97	50
393	482	50	480	100	49	472	98	50	460	95	50
421	488	50	482	99	49	474	97	50	465	95	50
449	493	50	489	99	48	481	97	50	472	96	50
477	498	50	493	99	48	484	97	50	477	96	50
505	502	49	501	100	48	492	98	49	478	95	49
533	506	47	501	99	47	485	96	49	472	93	48
561	509	47	498	98	47	493	97	47	473	93	47
589	507	47	500	99	47	489	96	45	470	93	45
617	513	47	502	98	47	490	96	44	472	92	42
645	505	44	497	98	46	480	95	42	447	89	41
673	499	44	480	96	42	436	87	39	402	81	34
701	494	40	470	95	41	431	87	35	395	80	23
<b>Mean for Weeks</b>											
1-13	250		249	100		249	99		245	98	
14-52	418		415	100		411	98		408	98	
53-101	497		489	98		474	95		457	92	

**TABLE 8**  
**Mean Body Weights and Survival of Female Rats in the 2-Year Gavage Study of *Ginkgo biloba* Extract**

Day	Vehicle Control		100 mg/kg			300 mg/kg			1,000 mg/kg		
	Av. Wt. (g)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt. (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors
1	102	50	102	99	50	102	100	50	102	99	50
8	117	50	118	101	50	117	101	50	119	102	50
15	131	50	133	101	50	134	102	50	134	102	50
22	144	50	145	101	50	145	101	50	147	102	50
29	154	50	156	101	50	155	101	50	158	103	50
36	164	50	164	100	50	164	100	50	167	102	50
43	172	50	173	100	50	171	100	50	175	101	50
50	177	50	175	99	50	176	99	50	178	101	49
57	183	50	179	98	50	180	99	50	183	100	49
64	187	50	185	99	50	186	99	50	189	101	49
71	189	50	189	100	50	189	100	50	192	102	49
78	194	50	193	100	50	193	100	50	196	101	49
85	196	50	196	100	50	196	100	50	198	101	49
113	208	50	206	99	50	205	99	50	208	100	49
141	220	50	216	98	50	220	100	50	221	101	49
169	231	50	229	99	50	228	99	50	230	100	49
197	239	50	234	98	50	234	98	50	236	99	49
225	246	50	242	98	50	244	99	50	247	100	49
253	257	50	252	98	50	251	98	50	255	99	48
281	262	50	257	98	50	258	98	50	262	100	47
309	273	50	268	98	50	266	98	50	270	99	47
337	280	50	273	97	49	274	98	50	278	99	47
365	293	50	283	97	49	285	97	50	285	97	47
393	304	50	294	97	47	296	97	50	296	98	47
421	311	50	303	98	47	303	97	50	301	97	47
449	319	50	310	97	46	310	97	50	306	96	46
477	329	49	316	96	45	316	96	49	315	96	46
505	336	48	324	96	45	323	96	49	319	95	46
533	341	48	325	95	45	324	95	48	314	92	44
561	343	47	329	96	43	328	96	48	319	93	44
589	345	46	329	95	42	329	95	46	322	93	41
617	351	44	334	95	40	334	95	45	321	92	41
645	349	43	333	95	36	327	94	44	309	89	37
673	348	41	323	93	32	314	90	40	288	83	34
701	348	39	321	92	30	311	89	39	288	83	34
<b>Mean for Weeks</b>											
1-13	162		162	100		162	100		164	101	
14-52	246		242	98		242	99		245	100	
53-101	332		317	96		315	95		306	93	

## Pathology and Statistical Analyses

This section describes the statistically significant or biologically noteworthy changes in the incidences of mononuclear cell leukemia and neoplasms and/or nonneoplastic lesions of the liver, thyroid gland, nose, uterus, kidney, parathyroid gland, glandular stomach, bone marrow, and pituitary gland. Summaries of the incidences of neoplasms and nonneoplastic lesions, statistical analyses of primary neoplasms that occurred with an incidence of at least 5% in at least one animal group, and historical incidences for the neoplasms mentioned in this section are presented in Appendix A for male rats and Appendix B for female rats.

*Liver:* At 14 weeks, absolute and relative liver weights of all dosed groups of special study rats were significantly greater than those of the vehicle control groups (Table G2). At 2 years, the incidences of hepatocellular adenoma in the 100 and 300 mg/kg males were both 3/50, which exceeds the historical control range for corn oil gavage studies (0% to 2%), but is within the historical control range for all routes of administration (0% to 6%) (Tables 9, A1, and A2). Hepatocellular adenomas were generally well circumscribed neoplasms composed of well differentiated

hepatocytes that varied in size and tinctorial characteristics; i.e., eosinophilic, basophilic, clear, vacuolated, or an admixture.

The incidences of centrilobular hepatocyte hypertrophy and bile duct hyperplasia in all dosed groups of males and females were significantly greater than those in the vehicle controls, and the severity generally increased with dose (Tables 9, A4, and B4). Hepatocyte hypertrophy was characterized by enlargement of centrilobular hepatocytes with increased amounts of eosinophilic cytoplasm and was often varied in its presence and severity between lobes and within regions of the same lobe. Bile duct hyperplasia was characterized by increased numbers of bile ducts within portal triads, and in more severely affected animals, it extended into the parenchyma.

The incidence of oval cell hyperplasia was significantly increased in 1,000 mg/kg males (Tables 9 and A4). The lesion was characterized by numerous small ovoid cells with indistinct cytoplasm within and adjacent to portal areas or extending into the surrounding hepatic lobules. The cells were often interspersed with foci of moderate to severe bile duct hyperplasia.

**TABLE 9**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Liver in Rats in the 2-Year Gavage Study of *Ginkgo biloba* Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
Number Examined Microscopically	50	50	50	50
Hepatocyte, Hypertrophy <sup>a</sup>	1 (1.0) <sup>b</sup>	17** (1.4)	26** (2.1)	27** (2.7)
Bile Duct, Hyperplasia	32 (1.1)	43** (1.5)	46** (2.0)	46** (2.0)
Oval Cell, Hyperplasia	0	1 (2.0)	1 (1.0)	10** (1.8)
Necrosis	1 (3.0)	4 (1.5)	6 (2.0)	7* (2.0)
Degeneration, Cystic	4 (1.0)	14** (1.1)	10 (1.0)	14** (1.1)
Hepatocellular Adenoma <sup>c</sup>	0	3	3	0
<b>Female</b>				
Number Examined Microscopically	50	50	50	50
Hepatocyte, Hypertrophy	7 (1.4)	15* (1.7)	27** (2.2)	33** (2.5)
Bile Duct, Hyperplasia	11 (1.0)	31** (1.1)	31** (1.1)	33** (1.1)
Fatty Change, Focal	11	25**	30**	25**

\* Significantly different ( $P \leq 0.05$ ) from the vehicle control group by the Poly-3 test

\*\*  $P \leq 0.01$

<sup>a</sup> Number of animals with lesion

<sup>b</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

<sup>c</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean  $\pm$  standard deviation): 3/299 (1.0%  $\pm$  1.1%), range 0%-2%; all routes: 18/1,249 (1.4%  $\pm$  1.9%), range 0%-6%



The incidence of necrosis was significantly increased in 1,000 mg/kg males (Tables 9 and A4). Necrosis was characterized by focal, widely scattered, randomly distributed areas of necrotic hepatocytes often infiltrated by small numbers of mixed inflammatory cells. Necrosis was not diagnosed when it was deemed to be secondary to mononuclear cell leukemia.

The incidences of cystic degeneration were significantly increased in 100 and 1,000 mg/kg males (Tables 9 and A4). The lesion was characterized by small numbers of microscopic cyst-like spaces present focally within the hepatic parenchyma. These spaces were filled with wispy, pale eosinophilic material or, occasionally, red blood cells.

Significant, but not dose related, increases in the incidences of focal fatty change occurred in all dosed groups of females (Tables 9 and B4). The lesion was characterized by a focal area of hepatocytes that displayed localized microvesicular and macrovesicular fatty change. The hepatocytes also contained increased amounts of eosinophilic cytoplasm, large open-faced nuclei, and occasionally multiple nucleoli (Plate 1). Numerous microgranulomas were scattered throughout the lesions and were composed predominantly of macrophages with fewer lymphocytes, plasma cells, and occasional neutrophils. The macrophages often contained fine, acicular clefts (cholesterol clefts). Occasional multinucleated giant cells were also present. Microgranulomas were much more numerous in the focal fatty change than in the surrounding hepatic parenchyma, and histiocytes were a much more prominent cellular component of them. Occasional mitotic figures were also present in hepatocytes and portal triads and central veins were preserved within the lesions. The overall size of the lesion was quite variable, ranging from a few too many hepatic lobules. The number of areas displaying focal fatty change tended to increase with dose.

The incidence of basophilic focus was significantly increased in 100 mg/kg males; the incidences of this lesion were decreased in all other dosed groups of males and females, but not significantly (Tables A4 and B4). Basophilic focus was characterized by a focal area in which the hepatocytes were slightly shrunken and had increased cytoplasmic basophilia. The overall size of basophilic foci was highly variable. Portal areas and central veins were typically preserved in both clear cell and basophilic foci.

The incidences of clear cell focus were significantly decreased in 300 and 1,000 mg/kg males and 100 mg/kg

females (Tables A4 and B4). Clear cell focus consisted of a focal area in which the hepatocytes had abundant clear areas within their cytoplasm. The clear areas were irregularly shaped and nuclei tended to be centrally located, consistent with glycogen accumulation. Clear cell foci were generally small, typically measuring less than one or two hepatic lobules in diameter. The reduced incidence of the foci may be explained in part (in the males), by the increased incidences of mononuclear cell leukemia seen in 300 and 1,000 mg/kg males, which potentially masked the presence of foci.

*Thyroid Gland:* The incidences of follicular cell adenoma were increased, though not significantly, in 300 and 1,000 mg/kg males and 300 mg/kg females (Tables 10, A1, A2, B1, and B2). The incidences in these groups exceeded the historical control range for corn oil gavage studies, and the incidences in 1,000 mg/kg males and 300 mg/kg females exceeded the historical control range for all routes of study (Tables 10, A3a, and B3a). Single incidences of follicular cell carcinoma occurred in the 300 and 1,000 mg/kg female groups. Adenomas tended to be larger with more compression of the adjacent parenchyma and more complex epithelial infoldings than hyperplasia (Plate 2). Follicular cell carcinomas (Plate 3) were typically large lesions that were highly cellular, although small follicles with pale colloid were typically present throughout the neoplasms. Invasion was present in some neoplasms. Mitoses and cellular atypia were present in many carcinomas.

The incidences of follicular cell hypertrophy were significantly increased in all dosed groups of males and females (Tables 10, A4, and B4); severity of the lesion increased with increasing dose in both males and females. The incidences of follicle hyperplasia were significantly increased in all dosed groups of males, and severity of the lesion generally increased with increasing dose in males and females. Follicular cell hypertrophy was characterized by enlargement of the follicular epithelial cells. The cells were cuboidal and had finely vacuolated cytoplasm (Plates 4 and 5). Overall, a decreased amount of colloid was present in the affected animals and the colloid had a slightly basophilic hue. Follicle hyperplasia was characterized by enlarged follicles that typically compressed the surrounding parenchyma. The follicles were lined by hyperplastic follicular epithelium and epithelial lined septae, and papillary projections frequently projected into the follicular colloid (Plate 6). Except for the relative weight of 100 mg/kg males, thyroid gland weights were not significantly increased in special study rats at 14 weeks (Table G2).

**TABLE 10**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Thyroid Gland in Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
Number Examined Microscopically	50	50	49	45
Follicular Cell, Hypertrophy <sup>a</sup>	13 (1.0) <sup>b</sup>	37** (1.2)	41** (1.3)	41** (1.8)
Follicle Hyperplasia	0	7** (1.3)	9** (2.3)	5* (2.8)
Follicular Cell, Adenoma <sup>c</sup>				
Overall rate <sup>d</sup>	2/50 (4%)	1/50 (2%)	3/49 (6%)	5/45 (11%)
Adjusted rate <sup>e</sup>	4.3%	2.2%	6.7%	13.2%
Terminal rate <sup>f</sup>	2/38 (5%)	0/37 (0%)	1/31 (3%)	2/16 (13%)
First incidence (days)	727 (T)	685	485	675
Poly-3 test <sup>g</sup>	P=0.040	P=0.503N	P=0.482	P=0.142
<b>Female</b>				
Number Examined Microscopically	49	50	49	49
Follicular Cell, Hypertrophy	15 (1.0)	41** (1.0)	45** (1.1)	48** (2.0)
Follicle Hyperplasia	3 (1.3)	3 (1.0)	1 (2.0)	5 (1.6)
Follicular Cell, Adenoma <sup>h</sup>				
Overall rate	1/49 (2%)	0/50 (0%)	3/49 (6%)	1/49 (2%)
Adjusted rate	2.2%	0.0%	6.6%	2.4%
Terminal rate	1/37 (3%)	0/27 (0%)	3/37 (8%)	0/32 (0%)
First incidence (days)	728 (T)	— <sup>i</sup>	728 (T)	637
Poly-3 test	P=0.573	P=0.519N	P=0.310	P=0.741
Follicular Cell, Carcinoma <sup>j</sup>	0	0	1	1
Follicular Cell, Adenoma or Carcinoma <sup>k</sup>				
Overall rate	1/49 (2%)	0/50 (0%)	4/49 (8%)	2/49 (4%)
Adjusted rate	2.2%	0.0%	8.8%	4.9%
Terminal rate	1/37 (3%)	0/27 (0%)	4/37 (11%)	1/32 (3%)
First incidence (days)	728 (T)	—	728 (T)	637
Poly-3 test	P=0.324	P=0.519N	P=0.183	P=0.469

\* Significantly different (P<0.05) from the vehicle control group by the Poly-3 test

\*\* P<0.01

(T) Terminal kill

<sup>a</sup> Number of animals with lesion

<sup>b</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

<sup>c</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean ± standard deviation): 6/299 (2.0% ± 1.3%), range 0%-4%; all routes: 13/1,239 (1.0% ± 1.7%), range 0%-6%

<sup>d</sup> Number of animals with neoplasm per number of animals with thyroid gland examined microscopically

<sup>e</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>f</sup> Observed incidence at terminal kill

<sup>g</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for the differential mortality in animals that do not reach terminal kill. A lower incidence in a dose group is indicated by N.

<sup>h</sup> Historical incidence for corn oil gavage studies: 3/298 (1.0% ± 1.1%), range 0%-2%; all routes: 8/1,186 (0.7% ± 1.0%), range 0%-2%

<sup>i</sup> Not applicable; no neoplasms in animal group

<sup>j</sup> Historical incidence for corn oil gavage studies: 1/298 (0.3% ± 0.8%), range 0%-2%; all routes: 5/1,186 (0.4% ± 1.0%), range 0%-4%

<sup>k</sup> Historical incidence for corn oil gavage studies: 4/298 (1.4% ± 1.0%), range 0%-2%; all routes: 12/1,186 (1.0% ± 1.3%), range 0%-4%

*Nose:* Two females in the 300 mg/kg groups had adenomas of the respiratory epithelium, and the incidence exceeded the historical control range for all routes of administration (0% to 2%) (Tables 11, B1, and B3b). Respiratory epithelium adenomas were characterized by an exophytic mass, with a pedunculated or sessile base, growing into the lumen of the nasal passage. The mass consisted of papillary and invaginating, gland-like structures that were composed of pseudostratified epithelium on a scant, fibrovascular stroma.

Except for respiratory epithelium hyperplasia in 100 mg/kg females, the incidences of transitional and respiratory epithelium hyperplasia in all dosed groups were significantly greater than those in the vehicle control groups and the severity of these lesions generally increased with dose (Tables 11, A4, and B4). Hyperplasia of the transitional epithelium was most apparent on the lateral aspects of the nasal cavity at Level I. Normal thickness was considered to be two to three cell layers; minimal hyperplasia was four to five cell layers, mild hyperplasia was six to seven cell layers; moderate hyperplasia was eight to nine cell layers, and marked hyperplasia was more than 10 cell layers. Hyperplasia of the respiratory epithelium typically occurred in the ventral aspect of Level III in association with inflammation but also occasionally occurred in other areas of Levels I and II. It was characterized by increased thickness of the respiratory epithelium resulting from an increase in the number of cells. Typically, an increased number of layers of nuclei were present in the hyperplastic areas. In more severe cases, the epithelium had an undulating appearance resulting from the hyperplasia. The severity score was based on both the extent of the hyperplasia throughout the nasal cavity and the degree of hyperplasia in the areas where it was present.

In the olfactory epithelium, the incidences of atrophy, nerve atrophy, and pigmentation were significantly increased in all dosed groups of males and females, the incidences of respiratory metaplasia were increased in all dosed groups of males and in 300 and 1,000 mg/kg females, and the severity of these lesions generally increased with increasing dose (Tables 11, A4, and B4). Atrophy of the olfactory epithelium was characterized by thinning and disorganization of the olfactory epithelial layer with a loss of the epithelial brush border (Plates 7 and 8). The atrophy ranged in severity from minimal to moderate and was localized to nasal Levels II and III. In cases of minimal atrophy, the incidences of respiratory metaplasia were significantly increased in all dosed males and in 300 and 1,000 mg/kg females, and atrophy was typically limited

to the peripheral aspects of the nasal cavity, especially the ventral aspect of the nasal septum. With increasing severity, the epithelium was both thinner and the lesion was more widespread throughout the nasal cavity. Respiratory metaplasia of the olfactory epithelium was characterized by complete replacement of the olfactory epithelium by respiratory epithelium. This change was most common in the peripheral (especially ventral) regions of the nasal cavity of Level III but in severe cases involved large areas including the more central areas of the nasal cavity. Atrophy of the nerve in the olfactory epithelium was commonly diagnosed in the animals that also had olfactory epithelial atrophy, which is an expected finding given that the nerves are composed of axons of the olfactory epithelial neurons. The severity scores generally paralleled the olfactory epithelial atrophy severity scores. Pigment accumulation in the olfactory epithelium was principally characterized by the accumulation of macrophages containing golden brown pigment within the basal aspect of the olfactory epithelium and occasionally in the submucosa (Plate 9). The pigment accumulation was largely restricted to the atrophic areas of the olfactory epithelium of Levels II and III, although small amounts were also occasionally located in areas displaying respiratory metaplasia. Pigment was also present within the olfactory epithelial cells but this was also present in many vehicle control animals, although often to a lesser degree. Grading was subjectively based on the amount of pigment within the macrophages and the number of pigment-containing macrophages throughout the epithelium.

The incidences of chronic active inflammation were significantly increased in 1,000 mg/kg males and females (Tables 11, A4, and B4), and the severity increased with increasing dose. Chronic active inflammation was characterized by a mixed inflammatory infiltrate that involved the submucosa and the lumen of the nasal cavity (Plate 10). The inflammatory infiltrate in the submucosa was composed of a mixture of neutrophils, macrophages, lymphocytes, and plasma cells whereas the inflammatory exudate within the nasal cavity was predominantly suppurative, containing large amounts of neutrophils mixed with necrotic debris. The inflammation in the dosed groups occurred most commonly in the posterior aspects of the nasal cavity and was generally most severe ventrally. It was not uncommon for 25% to 50% of the nasal cavity at Level III to be filled with inflammatory exudates. Inflammation commonly extended into the nasopharyngeal duct. In these animals it was common for the nasopharyngeal ductular epithelium to be hyperplastic and for the submucosa to contain infiltrates of mixed inflammatory cells.

**TABLE 11**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Nose in Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
Number Examined Microscopically	50	49	49	50
Transitional Epithelium, Hyperplasia <sup>a</sup>	2 (1.5) <sup>b</sup>	18** (1.2)	43** (1.9)	31** (2.5)
Respiratory Epithelium, Hyperplasia	14 (1.6)	28** (1.4)	45** (1.8)	35** (2.2)
Olfactory Epithelium, Atrophy	1 (1.0)	26** (1.3)	37** (1.6)	31** (2.2)
Olfactory Epithelium, Respiratory Metaplasia	9 (1.3)	30** (1.5)	40** (2.0)	32** (2.5)
Nerve, Olfactory Epithelium, Atrophy	0	17** (1.4)	14** (2.1)	23** (2.5)
Olfactory Epithelium, Pigmentation	0	39** (1.5)	42** (1.7)	30** (2.1)
Inflammation, Chronic Active	33 (1.2)	32 (1.3)	38 (1.9)	46** (2.2)
Goblet Cell, Respiratory Epithelium, Hyperplasia	20 (1.5)	18 (1.2)	41** (1.7)	34** (2.1)
Submucosa, Fibrosis	0	0	0	8** (1.6)
Olfactory Epithelium, Hyaline Droplet Accumulation	45 (1.9)	43 (1.4)	14** (1.1)	0**
<b>Female</b>				
Number Examined Microscopically	49	49	50	46
Transitional Epithelium, Hyperplasia	0	6** (1.5)	32** (1.8)	36** (2.8)
Respiratory Epithelium, Hyperplasia	9 (1.2)	9 (1.3)	19* (1.7)	34** (2.3)
Olfactory Epithelium, Atrophy	0	18** (1.1)	25** (1.6)	37** (2.1)
Olfactory Epithelium, Respiratory Metaplasia	8 (1.3)	4 (1.3)	32** (2.0)	37** (2.5)
Nerve, Olfactory Epithelium, Atrophy	0	15** (1.1)	22** (1.6)	33** (2.2)
Olfactory Epithelium, Pigmentation	0	37** (1.5)	43** (2.0)	40** (1.9)
Inflammation, Chronic Active	22 (1.0)	16 (1.2)	26 (1.5)	38** (1.9)
Goblet Cell, Respiratory Epithelium, Hyperplasia	6 (1.2)	2 (1.0)	18** (1.6)	35** (1.8)
Olfactory Epithelium, Hyaline Droplet Accumulation	44 (2.0)	39 (1.7)	25** (1.2)	0**
Respiratory Epithelium, Adenoma <sup>c</sup>				
Overall rate <sup>d</sup>	0/49 (0%)	0/49 (0%)	2/50 (4%)	0/46 (0%)
Adjusted rate <sup>e</sup>	0.0%	0.0%	4.4%	0.0%
Terminal rate	0/37 (0%)	0/27 (0%)	2/37 (5%)	0/32 (0%)
First incidence (days) <sup>f</sup>	— <sup>g</sup>	—	728 (T)	—
Poly-3 test <sup>h</sup>	P=0.710N	— <sup>i</sup>	P=0.242	—

\* Significantly different ( $P \leq 0.05$ ) from the vehicle control group by the Poly-3 test

\*\*  $P \leq 0.01$

(T) Terminal kill

<sup>a</sup> Number of animals with lesion

<sup>b</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

<sup>c</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean  $\pm$  standard deviation): 0/299; all routes: 1/1,196 (0.1%  $\pm$  0.4%), range 0%-2%

<sup>d</sup> Number animals with neoplasm per number of animals with nose examined microscopically

<sup>e</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>f</sup> Observed incidence at terminal kill

<sup>g</sup> Not applicable; no neoplasms in animal group

<sup>h</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for differential mortality in animals that do not reach terminal kill. A negative trend is indicated by N.

<sup>i</sup> Value of the statistic cannot be computed.

The incidences of hyperplasia of the goblet cells in the respiratory epithelium were significantly increased in 300 and 1,000 mg/kg males and females; the severity was also increased in these groups (Tables 11, A4, and B4). Goblet cell hyperplasia was characterized by increased numbers of goblet cells throughout the respiratory epithelium.

Submucosal fibrosis occurred only in 1,000 mg/kg males, and the incidence was significantly increased (Tables 11 and A4).

The incidences of hyaline droplet accumulation in the olfactory epithelium were significantly decreased in 300 and 1,000 mg/kg males and females; the severity was also decreased (Tables 11, A4, and B4). Hyaline droplet accumulation in the olfactory epithelium was often present, particularly in the vehicle control animals. Hyaline droplet accumulation was characterized by the accumulation of hyalinized, eosinophilic material in the cytoplasm of cells of the olfactory epithelium, and much less commonly, the respiratory epithelium. This change was present in nasal Levels II and III. The amount of the epithelium affected varied considerably between animals. When a grade of minimal was assigned, the accumulation of eosinophilic material was barely detectable in one to a few focal areas of olfactory epithelium in the nasal cavity (less than 10%). A grade of mild was assigned when the material was present in 10% to 25% of the olfactory epithelium; moderate or marked was assigned when the eosinophilic material was present in 25% to 50% or 50% to 75% of the olfactory epithelium, respectively. The treatment-related decrease in the normally present hyaline droplets may reflect discharge of the cytoplasmic contents, protecting from the irritant effect of the test compound or its metabolites.

*Mononuclear Cell Leukemia:* The incidences of mononuclear cell leukemia in 300 and 1,000 mg/kg males were significantly greater than that in the vehicle controls and exceeded the historical control range for corn oil gavage studies (8%-28%) but not the range for all routes (8%-58%) (Tables 12, A1, A2, and A3b). A comparable range of organs involved by systemic mononuclear cell leukemia was observed in vehicle control and treated males. The splenic parenchyma was typically effaced by large numbers of leukemic cells resulting in a massively enlarged spleen in most cases.

*Uterus:* The incidence of stromal polyp was significantly increased in 1,000 mg/kg females (0 mg/kg, 3/50; 100 mg/kg, 8/50; 300 mg/kg, 8/50; 1,000 mg/kg, 9/50) and the incidences of cystic endometrial hyperplasia were significantly increased in

100 and 300 mg/kg females (3/50, 13/50, 11/50, 7/50) (Tables B1, B2, and B4). Stromal polyps typically were epithelial lined masses of fibrovascular endometrial stroma that protruded into the uterine lumen. Attachment to the uterine wall was rarely apparent in the section. Cystic endometrial hyperplasia was characterized by thickening of the endometrial wall due to an increase in the glandular structures and was sometimes accompanied by increased cellularity of the stroma. Although the incidence of stromal polyp in 1,000 mg/kg females slightly exceeded the historical control range for corn oil gavage studies (6%-16%), it did not exceed the range for all routes (4%-34%), and the increase was not considered to be related to *Ginkgo biloba* extract administration (Table B3c).

*Kidney:* Dose-related increased severity of nephropathy was noted in male rats (1.7, 2.0, 2.4, 2.9). Nephropathy was variable in appearance depending on the severity. Minimally to mildly affected animals had multifocal clusters of tubular regeneration and basement membrane thickening often with minimal to mild interstitial fibrosis, chronic inflammation, and tubular proteinosis. With increasing severity, the kidney changes eventually encompassed nearly 100% of the parenchyma, and marked tubular regeneration, glomerular sclerosis, tubular proteinosis, chronic inflammation, and fibrosis were prominent. Males in the 300 and 1,000 mg/kg groups often had moderate to marked nephropathy.

*Parathyroid Gland:* The incidence of hyperplasia was significantly increased in 1,000 mg/kg males (1/47, 3/48, 2/48, 7/47; Table A4). The lesion was characterized by an increase in the number of parathyroid cells and its occurrence was considered secondary to the kidney nephropathy that occurred in dosed males.

*Glandular Stomach:* The incidence of mineralization was significantly increased in 1,000 mg/kg males (1/50, 1/50, 1/50, 6/50; Table A4). Mineralization occurred in the middle of the glandular epithelial layer and was composed of numerous punctate and deeply basophilic foci (mineral). Occurrence of the lesion was considered secondary to marked nephropathy.

*Bone Marrow:* The incidence of hyperplasia was significantly increased in 1,000 mg/kg males (14/40, 15/50, 21/48, 26/50; Table A4). Hyperplasia was characterized by an increase in the number of hematopoietic cells in the bone marrow and ranged from minimal to marked severity (data not shown). The cellular composition was mixed and, even in severe cases, the regular organization of the hematopoietic cells was retained.

**TABLE 12**  
**Incidences of Mononuclear Cell Leukemia in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>All Organs: Mononuclear Cell Leukemia<sup>a</sup></b>				
Overall rate <sup>b</sup>	9/50 (18%)	12/50 (24%)	22/50 (44%)	21/50 (42%)
Adjusted rate <sup>c</sup>	19.2%	25.7%	45.7%	46.8%
Terminal rate <sup>d</sup>	6/38 (16%)	7/37 (19%)	9/31 (29%)	7/16 (44%)
First incidence (days)	626	643	485	568
Poly-3 test <sup>e</sup>	P=0.004	P=0.308	P=0.004	P=0.003

<sup>a</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean ± standard deviation):

53/299 (17.7% ± 6.6%), range 8%-28%; all routes: 450/1,249 (36.0% ± 14.4%), range 8%-58%

<sup>b</sup> Number of animals with mononuclear cell leukemia per number necropsied

<sup>c</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>d</sup> Observed incidence at terminal kill

<sup>e</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for differential mortality in animals that do not reach terminal kill.

*Pituitary Gland (Pars Distalis):* The incidences of adenoma occurred with negative trends in males and females and were significantly decreased in the 300 and 1,000 mg/kg groups (males: 38/50, 30/50, 25/50, 19/50; females: 34/50, 28/50, 22/50, 16/50; Tables A1, A2, B1, and B2). A dose-related positive trend in the incidences of hyperplasia occurred in females, and the incidence in the 1,000 mg/kg group was significantly increased (11/50, 13/50, 18/50, 23/50; Table B4). Adenoma was characterized by a variably-sized mass that typically

expanded and compressed the remaining pituicytes. Cytologically, the neoplasms were most commonly composed of neoplastic chromophobe cells, although a minority of neoplasms was composed of other pituitary cell lineages such as acidophils. Mitoses and cellular atypia were common in adenomas. Foci of hyperplasia in the pars distalis were generally small and nodular and lacked compression of the adjacent pituitary parenchyma. Minimal cellular atypia and only rare mitoses were present.

## MICE 3-MONTH STUDY

One female mouse in the 1,000 mg/kg group died of a dosing accident during week 11 (Table 13 and Figure 5). The final mean body weights and body weight gains of 2,000 mg/kg females were significantly less than those of the vehicle control group. Ruffled fur was observed in two 1,000 mg/kg males between

weeks 7 and 8 and all 2,000 mg/kg males between weeks 5 and 9.

In 500 mg/kg or greater female mice, there were significant decreases in the total leukocyte counts, with associated decreases in the differential counts. Reticulocyte counts were decreased in 500 mg/kg or greater males and females, and platelet counts were increased in the 500 mg/kg or greater males (Table F3).

**TABLE 13**  
**Survival and Body Weights of Mice in the 3-Month Gavage Study of *Ginkgo biloba* Extract<sup>a</sup>**

Dose (mg/kg)	Survival <sup>b</sup>	Initial Body Weight (g)	Final Body Weight (g)	Change in Body Weight (g)	Final Weight Relative to Controls (%)
<b>Male</b>					
0	10/10	21.0 ± 0.3	33.6 ± 0.9	12.6 ± 0.8	
125	10/10	21.1 ± 0.3	34.4 ± 0.6	13.4 ± 0.5	103
250	10/10	21.1 ± 0.2	34.3 ± 0.8	13.2 ± 0.8	102
500	10/10	21.3 ± 0.3	34.0 ± 1.0	12.8 ± 0.9	101
1,000	10/10	20.8 ± 0.2	33.2 ± 0.3	12.4 ± 0.3	99
2,000	10/10	20.9 ± 0.2	32.4 ± 0.6	11.5 ± 0.5	97
<b>Female</b>					
0	10/10	17.9 ± 0.4	27.8 ± 0.3	9.9 ± 0.5	
125	10/10	17.8 ± 0.3	27.9 ± 1.1	10.1 ± 0.9	101
250	10/10	17.6 ± 0.2	27.4 ± 0.5	9.8 ± 0.5	99
500	10/10	17.8 ± 0.3	27.3 ± 0.6	9.5 ± 0.5	98
1,000	9/10 <sup>c</sup>	17.9 ± 0.3	26.1 ± 0.5	8.3 ± 0.3	94
2,000	10/10	17.7 ± 0.2	25.4 ± 0.2*	7.8 ± 0.2**	92

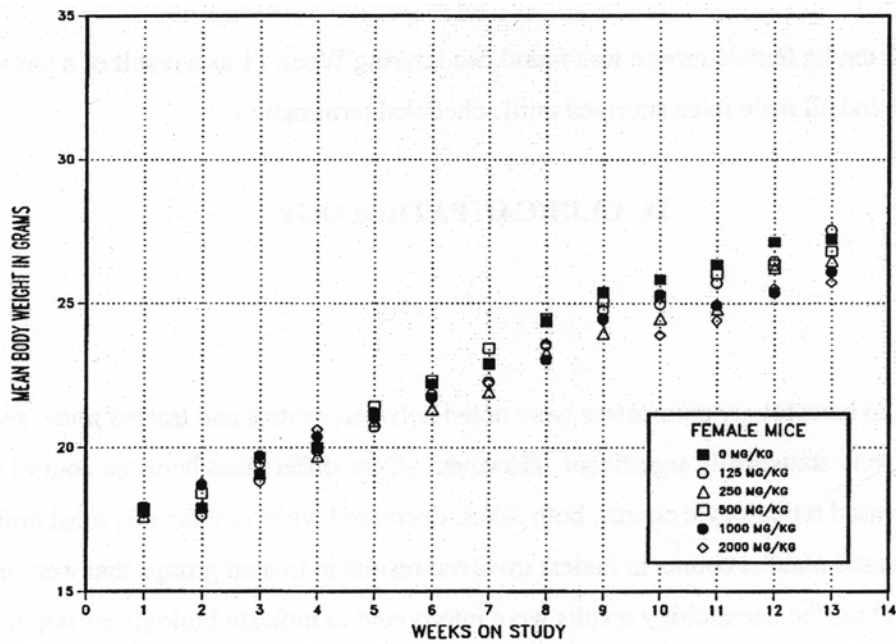
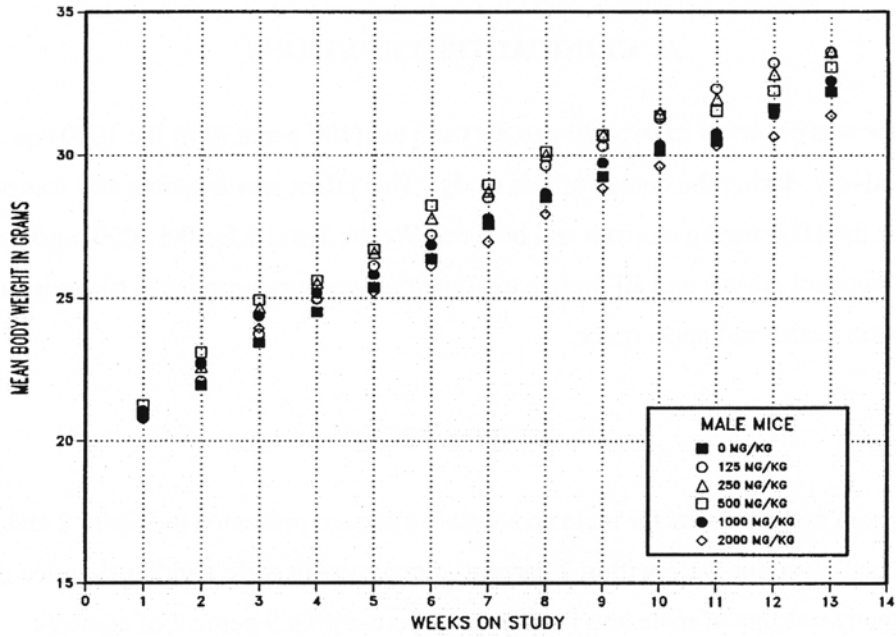
\* Significantly different (P≤0.05) from the vehicle control group by Williams' test

\*\* P≤0.01

<sup>a</sup> Weights and weight changes are given as mean ± standard error.

<sup>b</sup> Number of animals surviving at 14 weeks/number initially in group

<sup>c</sup> Week of accidental death: 11



**FIGURE 5**  
Growth Curves for Mice Administered *Ginkgo biloba* Extract by Gavage for 3 Months



Absolute and relative liver weights of 250 mg/kg or greater males and all dosed groups of females were significantly increased relative to those of the vehicle control groups (Table G3). Absolute and relative kidney weights of 2,000 mg/kg males were significantly decreased relative to the vehicle control group.

There were no significant differences in sperm parameters of male mice administered 500, 1,000, or 2,000 mg/kg when compared to the vehicle controls or in the estrous cycles of female mice administered 500 or 1,000 mg/kg (Tables H3 and H4). Female mice administered 2,000 mg/kg had a significantly higher probability of extended estrus when compared to the vehicle controls, which indicates potential for *Ginkgo biloba* extract to be a reproductive toxicant in female mice under these study conditions.

The incidences of hepatocytic hypertrophy were significantly increased in males and females in the 250 mg/kg or greater groups, and the severity of the lesion generally increased with increasing dose in both sexes and was greater in males than females (Table 14). Significantly increased incidences of focal hepatocytic necrosis occurred in 1,000 and 2,000 mg/kg males. Hepatocytic hypertrophy began in the centrilobular areas and expanded with increasing severity to the midzonal areas; the lesion was characterized by an enlargement of the hepatocytes up to approximately one and a half times the normal size. Hypertrophic hepatocytes had increased amounts of cytoplasm and slightly enlarged nuclei. Focal hepatocytic necrosis was a slight change consisting of one, and occasionally more, minute foci of hepatocytes with brightly eosinophilic cytoplasm and pyknotic or fragmented nuclei.

The incidences of hyaline droplet accumulation in the respiratory epithelium of the nose were significantly increased in 500 mg/kg males and 1,000 and 2,000 mg/kg females (Table 14). The incidences of hyaline droplet accumulation in the olfactory epithelium were significantly increased in males in the 500 and 1,000 mg/kg groups and females in the 125, 500, and 1,000 mg/kg groups. The incidences of atrophy of the

olfactory epithelium were significantly increased in 1,000 mg/kg males and females. The incidences of pigment accumulation in macrophages in the olfactory epithelium were significantly increased in males in the 500 mg/kg or greater groups and in 1,000 and 2,000 mg/kg females. Hyaline droplet accumulation was characterized by an accumulation of globular hyaline material in the cytoplasm of respiratory or olfactory epithelial cells. The globules occupied sub- or supra-nuclear positions and stained brightly eosinophilic with hematoxylin and eosin. Atrophy of the olfactory epithelium was characterized by decreased numbers of nuclei (sustentacular and olfactory neurons), mild disorganization of the nuclei, and was often associated with increased numbers of pigment-containing macrophages. Scattered individual or small clusters of apoptotic cells were frequently noted in the areas of atrophy. The olfactory epithelium on the tips of the nasal turbinates and lining the lateral surfaces of the posterior nasal cavity, particularly in the more ventral aspect of the Level III section, was most often affected. Pigment accumulation was characterized by macrophages with an abundant amount of golden-brown granular cytoplasm. Macrophages were usually located immediately above the basal cell layer and below the nuclear layer of the sustentacular cells and olfactory neurons. Macrophages containing pigment were often noted near areas of atrophy of the olfactory epithelium, but the presence of the macrophages themselves did not appear to cause the atrophy.

*Dose Selection Rationale:* The high dose in the 3-month study was based on gavageability and homogeneity limitations of the *Ginkgo biloba* extract dosing solution. *Ginkgo biloba* administration in the 3-month study did not have any effects on survival. Body and organ weight changes and liver hypertrophy observed in the histopathologic assessment were not considered to be life-threatening. However, the dose spacing was increased from half intervals in the 3-month study to half-log intervals in the 2-year study based on these histopathologic findings in order to capture a range of effect levels. Therefore, the doses selected for the 2-year gavage study in mice were 200, 600, and 2,000 mg/kg.

**TABLE 14**  
**Incidences of Selected Nonneoplastic Lesions in Mice in the 3-Month Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg	2,000 mg/kg
<b>Male</b>						
Liver <sup>a</sup>	10	10	10	10	10	10
Hepatocyte, Hypertrophy <sup>b</sup>	0	0	10** (1.4) <sup>c</sup>	10** (1.7)	10** (2.7)	10** (2.7)
Hepatocyte, Necrosis, Focal	0	0	1 (1.0)	0	5* (1.0)	9** (1.0)
Nose	10	10	10	10	10	10
Respiratory Epithelium, Accumulation, Hyaline Droplet	1 (1.0)	3 (1.0)	4 (1.0)	9** (1.3)	2 (2.0)	4 (1.0)
Olfactory Epithelium, Accumulation, Hyaline Droplet	1 (1.0)	1 (1.0)	4 (1.3)	9** (1.0)	8** (1.4)	5 (1.0)
Olfactory Epithelium, Hyaline Droplet, Atrophy	0	0	1 (3.0)	2 (1.5)	5* (1.8)	3 (1.7)
Olfactory Epithelium, Pigmentation	0	0	0	7** (1.0)	7** (1.6)	8** (1.0)
<b>Female</b>						
Liver	10	10	10	10	10	10
Hepatocyte, Hypertrophy	0	0	4* (1.0)	10** (1.2)	9** (1.6)	10** (1.9)
Nose	10	10	10	10	10	10
Respiratory Epithelium, Accumulation, Hyaline Droplet	2 (1.0)	4 (1.0)	4 (1.0)	6 (1.5)	9** (1.7)	8* (1.1)
Olfactory Epithelium, Accumulation, Hyaline Droplet	1 (1.0)	7** (1.0)	3 (1.0)	6* (1.3)	8** (1.4)	5 (1.0)
Olfactory Epithelium, Hyaline droplet, Atrophy	0	0	0	0	5* (1.2)	1 (2.0)
Olfactory Epithelium, Pigmentation	0	0	0	3 (1.0)	7** (1.4)	6** (1.2)

\* Significantly different ( $P \leq 0.05$ ) from the vehicle control group by the Fisher exact test

\*\*  $P \leq 0.01$

<sup>a</sup> Number of animals with tissue examined microscopically

<sup>b</sup> Number of animals with lesion

<sup>c</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

## 2-YEAR STUDY

### Survival

Estimates of 2-year survival probabilities for male and female mice are shown in Table 15 and in the Kaplan-Meier survival curves (Figure 6). Survival of 600 and 2,000 mg/kg males was significantly less than that of the vehicle controls. The majority of early deaths in the 600 and 2,000 mg/kg males were due to liver tumors. Survival of 600 mg/kg females was significantly greater than that of the vehicle controls.

### Body Weights and Clinical Findings

Mean body weights of 600 and 2,000 mg/kg males were less (10% or more) than those of the vehicle controls only after weeks 85 and 77, respectively; mean body weights of 2,000 mg/kg females were generally less than those of the vehicle controls between weeks 17 and 69 and after week 93 (Figure 7; Tables 16 and 17). There were no clinical findings related to *Ginkgo biloba* extract administration.

**TABLE 15**  
**Survival of Mice in the 2-Year Gavage Study of *Ginkgo biloba* Extract**

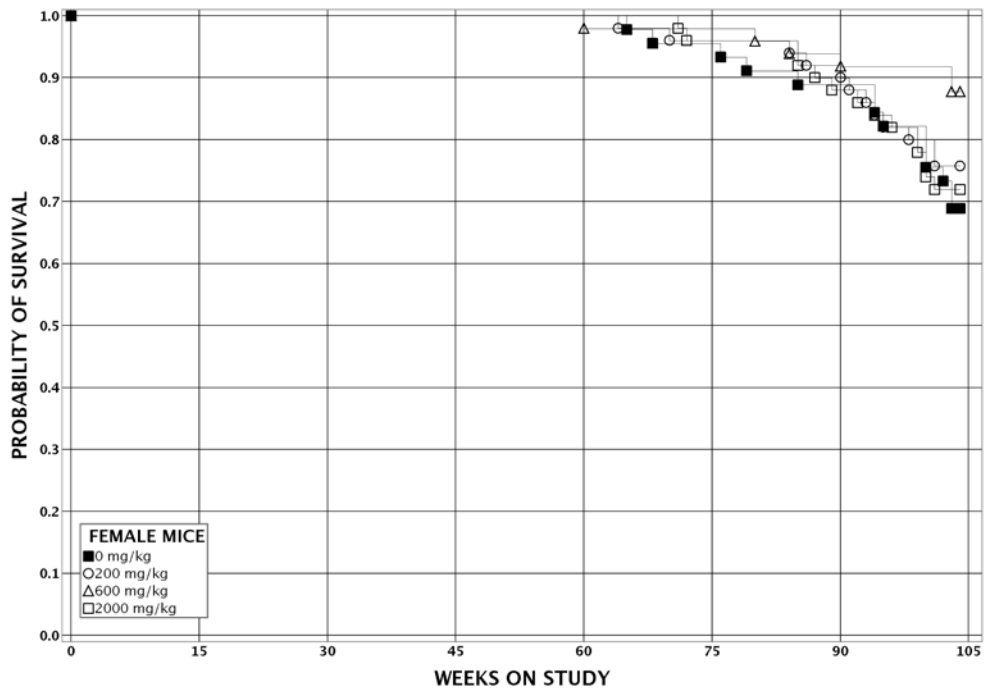
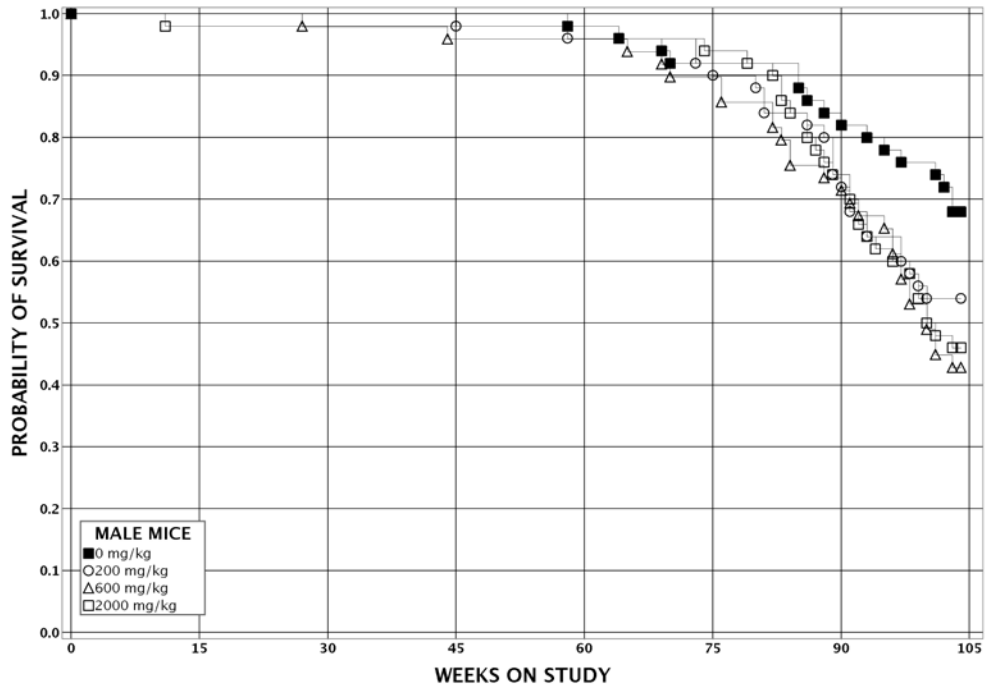
	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Male</b>				
Animals initially in study	50	50	50	50
Accidental death <sup>a</sup>	0	0	1	0
Moribund	8	16	23	13
Natural deaths	8	7	5	14
Animals surviving to study termination	34	27	21	23
Percent probability of survival at end of study <sup>b</sup>	68	54	43	46
Mean survival (days) <sup>c</sup>	687	665	637	661
Survival analysis <sup>d</sup>	P=0.129	P=0.180	P=0.017	P=0.039
<b>Female</b>				
Animals initially in study	50	50	50	50
Accidental deaths <sup>a</sup>	5	2	1	0
Moribund	8	8	3	3
Natural deaths	6	4	3	11
Animals surviving to study termination	31	36	43	36
Percent probability of survival at end of study	69	76	88	72
Mean survival (days)	628	700	698	701
Survival analysis	P=0.947	P=0.648N	P=0.048N	P=0.938N

<sup>a</sup> Censored from survival analysis

<sup>b</sup> Kaplan-Meier determinations

<sup>c</sup> Mean of all deaths (uncensored, censored, and terminal kill).

<sup>d</sup> The result of the life table trend test (Tarone, 1975) is in the vehicle control column, and the results of the life table pairwise comparisons (Cox, 1972) with the vehicle controls are in the dosed group columns. A lower mortality in a dosed group is indicated by N.



**FIGURE 6**  
**Kaplan-Meier Survival Curves for Mice Administered *Ginkgo biloba* Extract by Gavage for 2 Years**

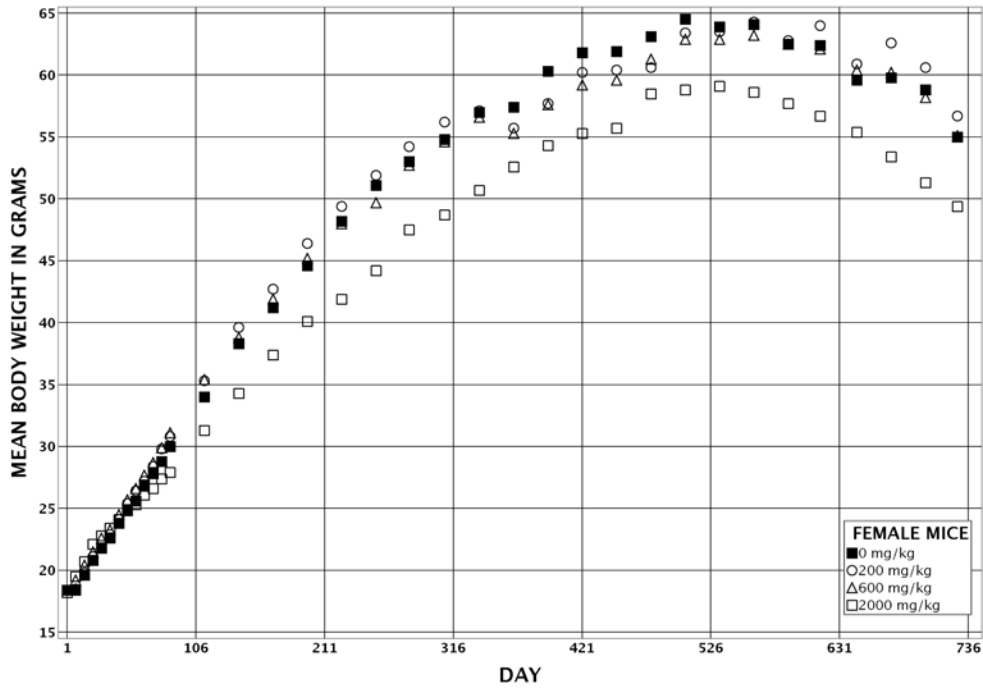
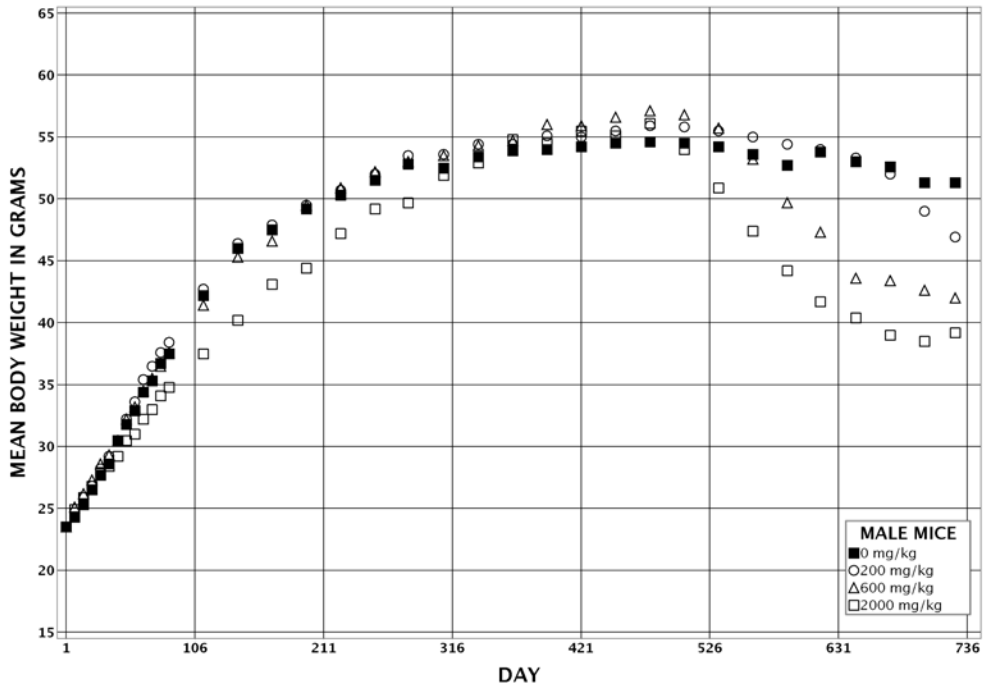


FIGURE 7  
Growth Curves for Mice Administered *Ginkgo biloba* Extract by Gavage for 2 Years

**TABLE 16**  
**Mean Body Weights and Survival of Male Mice in the 2-Year Gavage Study of Ginkgo biloba Extract**

Day	Vehicle Control		200 mg/kg			600 mg/kg			2,000 mg/kg		
	Av. Wt. (g)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt. (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors
1	23.5	50	23.5	100	50	23.5	100	50	23.5	100	50
8	24.3	50	24.7	102	50	25.1	103	49	24.9	103	50
15	25.3	50	25.9	102	50	26.2	104	49	25.9	103	50
22	26.5	50	26.8	101	50	27.3	103	49	26.8	101	50
29	27.7	50	28.2	102	50	28.6	103	49	27.9	101	50
36	28.6	50	29.2	102	50	29.3	103	49	28.4	99	50
43	30.5	50	30.5	100	50	30.5	100	49	29.2	96	50
50	31.8	50	32.2	101	50	32.2	101	49	30.5	96	50
57	32.9	50	33.6	102	50	33.2	101	49	31.0	94	50
64	34.4	50	35.4	103	50	34.5	100	49	32.2	93	50
71	35.3	50	36.5	103	50	35.5	101	49	33.0	94	50
78	36.7	50	37.6	103	50	36.5	100	49	34.1	93	49
85	37.5	50	38.4	102	50	37.6	100	49	34.8	93	49
113	42.2	50	42.7	101	50	41.4	98	49	37.5	89	49
141	46.0	50	46.4	101	50	45.3	99	49	40.2	87	49
169	47.5	50	47.9	101	50	46.6	98	49	43.1	91	49
197	49.2	50	49.5	101	50	49.5	101	48	44.4	90	49
225	50.3	50	50.7	101	50	50.9	101	48	47.2	94	49
253	51.5	50	52.0	101	50	52.2	101	48	49.2	96	49
280	52.8	50	53.5	101	50	53.0	100	48	49.7	94	49
309	52.5	50	53.6	102	50	53.5	102	47	51.9	99	49
337	53.4	50	54.4	102	49	54.3	102	47	52.9	99	49
365	53.9	50	54.4	101	49	54.7	101	47	54.8	102	49
393	54.0	50	55.1	102	49	56.0	104	47	54.5	101	49
421	54.2	49	55.0	101	48	55.9	103	47	55.5	102	49
449	54.5	48	55.5	102	48	56.6	104	47	55.1	101	48
477	54.6	48	55.9	102	48	57.1	105	45	56.1	103	48
505	54.5	46	55.8	102	47	56.8	104	44	54.0	99	48
533	54.2	46	55.5	102	45	55.7	103	42	50.9	94	47
561	53.6	46	55.0	103	44	53.2	99	42	47.4	88	46
589	52.7	46	54.4	103	42	49.7	94	37	44.2	84	42
616	53.8	42	54.0	100	40	47.3	88	36	41.7	78	38
645	53.0	41	53.3	101	32	43.6	82	33	40.4	76	33
673	52.6	39	52.0	99	32	43.4	82	29	39.0	74	30
701	51.3	38	49.0	96	27	42.6	83	23	38.5	75	25
<b>Mean for Weeks</b>											
1-13	30.4		31.0	102		30.8	101		29.4	97	
14-52	49.5		50.1	101		49.6	100		46.2	93	
53-101	53.6		54.2	101		51.7	96		48.6	91	

**TABLE 17**  
**Mean Body Weights and Survival of Female Mice in the 2-Year Gavage Study of *Ginkgo biloba* Extract**

Day	Vehicle Control		200 mg/kg			600 mg/kg			2,000 mg/kg		
	Av. Wt. (g)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt. (g)	Wt. (% of Controls)	No. of Survivors	Av. Wt (g)	Wt. (% of Controls)	No. of Survivors
1	18.4	50	18.4	100	50	18.4	100	50	18.2	99	50
8	18.4	47	18.5	101	50	19.2	104	49	19.5	106	50
15	19.6	45	19.8	101	50	20.4	104	49	20.7	106	50
22	20.8	45	21.1	101	50	21.5	103	49	22.1	106	50
29	21.8	45	21.8	100	50	22.6	104	49	22.8	105	50
36	22.6	45	22.9	101	50	23.3	103	49	23.4	103	50
43	23.8	45	24.1	101	50	24.5	103	49	24.1	102	50
50	24.8	45	25.4	102	50	25.7	104	49	24.9	100	50
57	25.6	45	26.4	103	50	26.6	104	49	25.3	99	50
64	26.8	45	27.2	102	50	27.7	104	49	26.1	98	50
71	27.8	45	28.4	102	50	28.7	103	49	26.6	96	50
78	28.8	45	29.8	103	50	29.9	104	49	27.4	95	50
85	30.0	45	30.8	103	50	31.1	104	49	27.9	93	50
113	34.0	45	35.3	104	50	35.4	104	49	31.3	92	50
141	38.3	45	39.6	104	50	38.8	101	49	34.3	90	50
169	41.2	45	42.7	104	50	41.9	102	49	37.4	91	50
197	44.6	45	46.4	104	50	45.2	101	49	40.1	90	50
225	48.2	45	49.4	103	50	48.0	100	49	41.9	87	50
253	51.1	45	51.9	102	50	49.7	97	49	44.2	87	50
280	53.0	45	54.2	102	50	52.7	100	49	47.5	90	50
309	54.8	45	56.2	103	50	54.6	100	49	48.7	89	50
337	57.0	45	57.1	100	50	56.6	99	49	50.7	89	50
365	57.4	45	55.7	97	50	55.3	96	49	52.6	92	50
393	60.3	45	57.7	96	50	57.6	96	49	54.3	90	50
421	61.8	45	60.2	98	50	59.2	96	48	55.3	90	50
449	61.9	45	60.4	98	49	59.6	96	48	55.7	90	50
477	63.1	43	60.6	96	49	61.3	97	48	58.5	93	50
505	64.5	43	63.4	98	48	62.9	98	48	58.8	91	48
533	63.9	42	63.5	100	48	62.9	99	48	59.1	93	48
561	64.1	41	64.3	100	48	63.2	99	47	58.6	91	48
589	62.5	40	62.8	101	47	62.5	100	46	57.7	92	47
615	62.4	40	64.0	103	46	62.1	99	46	56.7	91	45
645	59.6	40	60.9	102	44	60.4	101	45	55.4	93	43
673	59.8	37	62.6	105	41	60.2	101	45	53.4	89	41
701	58.8	34	60.6	103	38	58.2	99	45	51.3	87	37
<b>Mean for Weeks</b>											
1-13	23.8		24.2	102		24.6	103		23.8	101	
14-52	46.9		48.1	103		47.0	100		41.8	89	
53-101	61.5		61.3	100		60.4	98		56.0	91	

## Pathology and Statistical Analyses

This section describes the statistically significant or biologically noteworthy changes in the incidences of malignant lymphoma and neoplasms and/or non-neoplastic lesions of the liver, thyroid gland, forestomach, nose, and lung. Summaries of the incidences of neoplasms and nonneoplastic lesions, statistical analyses of primary neoplasms that occurred with an incidence of at least 5% in at least one animal group, and historical incidences for the neoplasms mentioned in this section are presented in Appendix C for male mice and Appendix D for female mice.

A number of gross lesions were noted in vehicle control and dosed mice at necropsy. These included masses and nodules in the liver, nodules and foci in the forestomach, and enlargement of the Harderian gland and spleen. Microscopic lesions were found that correlated with these gross findings and often indicated a chemical-related effect.

*Liver:* The incidences of multiple hepatocellular adenoma, hepatocellular carcinoma, and hepatoblastoma were increased in all dosed groups of males; multiple hepatocellular adenoma incidences were increased in all dosed groups of females, and multiple hepatocellular carcinoma and hepatoblastoma incidences were increased in 600 and 2,000 mg/kg females (Tables 18, C1, and D1). When single and multiple neoplasm incidences were combined, significant increases were seen in the incidences of hepatocellular adenoma in 200 mg/kg males and all dosed groups of females, hepatocellular carcinoma in all dosed groups of males and 2,000 mg/kg females, and hepatoblastoma in all dosed groups of males and 600 and 2,000 mg/kg females (Tables 18, C2, and D2). These significantly increased incidences also exceeded the historical control ranges for these neoplasms from corn oil gavage studies and all routes of administration (except for hepatocellular adenoma in 200 mg/kg females) (Tables 18, C3a, and D3).

The incidences of hepatocellular adenoma or hepatocellular carcinoma (combined) were significantly increased in all dosed groups of males and females; incidences of these combined lesions exceeded the historical control ranges for corn oil gavage studies and all routes of administration in males, and the historical control ranges for corn oil gavage studies in females (Tables 18, C1, C2, C3a, D1, D2, and D3). The incidences of hepatocellular carcinoma or hepatoblastoma (combined) were significantly increased in all dosed groups of males and in 2,000 mg/kg females; incidences of these combined lesions in these groups

exceeded the historical control ranges for corn oil gavage studies and for all routes of administration. The incidences of hepatocellular adenoma, hepatocellular carcinoma, or hepatoblastoma (combined) were significantly increased in all dosed groups of males and females; incidences of these combined lesions exceeded the historical control ranges for corn oil gavage studies and for all routes of administration (all dosed groups except 200 and 600 mg/kg females).

Hepatocellular adenomas were generally well-circumscribed neoplasms composed of well-differentiated hepatocytes that were variable in size and tinctorial characteristics (i.e., eosinophilic, basophilic, clear, vacuolated, or an admixture) (Plate 11). Vacuolated cytoplasm was likely due to fatty change. Adenomas had a lack of normal architecture as opposed to foci of alteration, which retained normal architecture. Hepatocytes showed an altered growth pattern and frequently grew at right angles to the cords of hepatocytes at the periphery of the mass. Although compression was present in some adenomas, it was not always a consistent feature. Adenomas varied from solid to growth patterns containing plates of cells one to three cell layers thick. Some adenomas were atypical and consisted of large cells with abundant eosinophilic cytoplasm, large nuclei and areas with numerous mitotic figures (two to three per high-power field). Adenomas frequently had large venous profiles throughout the mass. Fatty change (lipidosis) and eosinophilic intracytoplasmic inclusions were noted in some adenomas. Hepatocellular carcinomas were not always well demarcated and had irregular borders as cells infiltrated into the surrounding parenchyma. Hepatocellular carcinomas tended to occur as larger masses than adenomas, often replacing nearly all of a lobe of the liver. Cellular atypia and mitotic figures were common. Nucleoli were often enlarged and multiple. Cells had variable tinctorial appearance from eosinophilic, basophilic, vacuolated, or a mixture. Some carcinomas had a solid growth pattern while a trabecular pattern composed of cords of hepatocytes three or more cell layers thick was also common (Plate 12). Trabeculae were separated by dilated vascular spaces. When the solid growth pattern was present, the cells tended to be anaplastic consisting of large cells with large hyperchromatic irregular shaped nuclei, double nuclei, two or three nucleoli, abundant eosinophilic cytoplasm, or scant basophilic cytoplasm, and numerous areas with two or three mitotic figures per high-power field. Hepatoblastomas were characterized by an irregular mass of compacted basophilic neoplastic cells arranged in sheets with palisading around vascular spaces. Nuclei were generally irregularly oval to round with a scant amount



**TABLE 18**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Liver in Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Male</b>				
Number Examined Microscopically	50	50	50	50
Hypertrophy <sup>a</sup>	3 (1.7) <sup>b</sup>	19** (2.6)	35** (3.0)	23** (3.2)
Erythrophagocytosis	0	4* (2.0)	11** (1.2)	7** (1.3)
Hematopoietic Cell Proliferation	4 (1.0)	9 (1.1)	12* (1.2)	14** (1.0)
Inflammation	28 (1.2)	35 (1.5)	42** (1.8)	39** (1.8)
Necrosis	9 (1.9)	15 (2.1)	17* (1.9)	19* (2.3)
Basophilic Focus	15	14	5*	4**
Clear Cell Focus	21	22	14	12*
Mixed Cell Focus	15	13	12	9
Hepatocellular Adenoma, Multiple	18	40**	26**	27**
Hepatocellular Adenoma (includes multiple) <sup>c</sup>				
Overall rate <sup>d</sup>	31/50 (62%)	46/50 (92%)	33/50 (66%)	33/50 (66%)
Adjusted rate <sup>e</sup>	66.2%	96.0%	74.3%	71.0%
Terminal rate <sup>f</sup>	22/34 (65%)	27/27 (100%)	16/21 (76%)	16/23 (70%)
First incidence (days)	482	400	308	443
Poly-3 test <sup>g</sup>	P=0.171N	P<0.001	P=0.260	P=0.388
Hepatocellular Carcinoma, Multiple	11	23**	32**	43**
Hepatocellular Carcinoma (includes multiple) <sup>h</sup>				
Overall rate	22/50 (44%)	31/50 (62%)	41/50 (82%)	47/50 (94%)
Adjusted rate	47.0%	70.6%	92.5%	98.8%
Terminal rate	13/34 (38%)	20/27 (74%)	20/21 (95%)	23/23 (100%)
First incidence (days)	442	555	490	553
Poly-3 test	P<0.001	P<0.015	P<0.001	P<0.001
Hepatocellular Adenoma or Carcinoma <sup>i</sup>				
Overall rate	39/50 (78%)	46/50 (92%)	46/50 (92%)	49/50 (98%)
Adjusted rate	79.4%	96.0%	98.5%	100.0%
Terminal rate	25/34 (74%)	27/27 (100%)	21/21 (100%)	23/23 (100%)
First incidence (days)	442	400	308	443
Poly-3 test	P<0.001	P=0.011	P=0.002	P<0.001
Hepatoblastoma, Multiple	1	12**	26**	21**
Hepatoblastoma (includes multiple) <sup>j</sup>				
Overall rate	3/50 (6%)	28/50 (56%)	36/50 (72%)	38/50 (76%)
Adjusted rate	6.8%	61.0%	80.6%	79.6%
Terminal rate	3/34 (9%)	13/27 (48%)	14/21 (67%)	16/23 (70%)
First incidence (days)	726 (T)	400	477	516
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
Hepatocellular Carcinoma or Hepatoblastoma <sup>k</sup>				
Overall rate	24/50 (48%)	42/50 (84%)	45/50 (90%)	48/50 (96%)
Adjusted rate	51.3%	88.3%	97.1%	99.5%
Terminal rate	15/34 (44%)	23/27 (85%)	20/21 (95%)	23/23 (100%)
First incidence (days)	442	400	477	516
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
Hepatocellular Adenoma, Hepatocellular Carcinoma, or Hepatoblastoma <sup>l</sup>				
Overall rate	39/50 (78%)	48/50 (96%)	48/50 (96%)	49/50 (98%)
Adjusted rate	79.4%	98.5%	100.0%	100.0%
Terminal rate	25/34 (74%)	27/27 (100%)	21/21 (100%)	23/23 (100%)
First incidence (days)	442	400	308	443
Poly-3 test	P<0.001	P=0.002	P<0.001	P<0.001

**TABLE 18**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Liver in Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Male (continued)</b>				
Number Examined Microscopically	50	50	50	50
Hepatocolangiocarcinoma <sup>m</sup>	0	2	0	1
<b>Female</b>				
Number Examined Microscopically	50	50	50	50
Hypertrophy	0	18** (2.2)	37** (2.1)	37** (2.9)
Erythrophagocytosis	0	3 (1.0)	7* (1.0)	16** (1.0)
Hematopoietic Cell Proliferation	14 (1.5)	12 (1.3)	9 (1.3)	4** (1.8)
Inflammation	38 (1.3)	45 (1.6)	46 (1.3)	41 (1.5)
Vacuolization Cytoplasmic	18 (1.7)	38** (2.1)	44** (2.6)	35** (2.3)
Necrosis	4 (2.3)	2 (2.0)	6 (1.5)	11 (2.0)
Eosinophilic Focus	26	39*	43**	45**
Mixed Cell Focus	7	27**	31**	31**
Hepatocellular Adenoma, Multiple	10	30**	37**	43**
Hepatocellular Adenoma (includes multiple) <sup>n</sup>				
Overall rate	17/50 (34%)	37/50 (74%)	41/50 (82%)	48/50 (96%)
Adjusted rate	41.0%	78.3%	86.9%	96.0%
Terminal rate	14/31 (45%)	29/36 (81%)	38/43 (88%)	34/36 (94%)
First incidence (days)	589	596	628	497
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
Hepatocellular Carcinoma, Multiple	2	2	5	31**
Hepatocellular Carcinoma (includes multiple) <sup>o</sup>				
Overall rate	9/50 (18%)	10/50 (20%)	15/50 (30%)	44/50 (88%)
Adjusted rate	21.7%	21.8%	32.1%	91.7%
Terminal rate	5/31 (16%)	8/36 (22%)	14/43 (33%)	34/36 (94%)
First incidence (days)	653	656	718	593
Poly-3 test	P<0.001	P=0.596	P=0.197	P<0.001
Hepatocellular Adenoma or Carcinoma <sup>p</sup>				
Overall rate	20/50 (40%)	39/50 (78%)	41/50 (82%)	49/50 (98%)
Adjusted rate	47.7%	82.1%	86.9%	98.0%
Terminal rate	15/31 (48%)	30/36 (83%)	38/43 (88%)	35/36 (97%)
First incidence (days)	589	596	628	497
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
Hepatoblastoma, Multiple	0	0	1	4
Hepatoblastoma (includes multiple) <sup>q</sup>				
Overall rate	1/50 (2%)	1/50 (2%)	8/50 (16%)	11/50 (22%)
Adjusted rate	2.5%	2.2%	17.1%	23.8%
Terminal rate	1/31 (3%)	1/36 (3%)	8/43 (19%)	8/36 (22%)
First incidence (days)	727 (T)	727 (T)	727 (T)	609
Poly-3 test	P<0.001	P=0.735N	P=0.028	P=0.004
Hepatocellular Carcinoma or Hepatoblastoma <sup>r</sup>				
Overall rate	10/50 (20%)	11/50 (22%)	18/50 (36%)	44/50 (88%)
Adjusted rate	24.1%	24.0%	38.5%	91.7%
Terminal rate	6/31 (19%)	9/36 (25%)	17/43 (40%)	34/36 (94%)
First incidence (days)	653	656	718	593
Poly-3 test	P<0.001	P=0.594N	P=0.110	P<0.001

**TABLE 18**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Liver in Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Female (continued)</b>				
Hepatocellular Adenoma, Hepatocellular Carcinoma, or Hepatoblastoma <sup>P</sup>				
Overall rate	20/50 (40%)	39/50 (78%)	41/50 (82%)	49/50 (98%)
Adjusted rate	47.7%	82.1%	86.9%	98.0%
Terminal rate	15/31 (48%)	30/36 (83%)	38/43 (88%)	35/36 (97%)
First incidence (days)	589	596	628	497
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001

\* Significantly different (P<0.05) from the vehicle control group by the Poly-3 test

\*\* P<0.01

(T) Terminal kill

<sup>a</sup> Number of animals with lesion

<sup>b</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

<sup>c</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean ± standard deviation): 181/350 (51.7% ± 6.9%), range 44%-62%; all routes: 658/1,149 (57.3% ± 12.6%), range 24%-78%

<sup>d</sup> Number of animals with neoplasm per number of animals with liver examined microscopically

<sup>e</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>f</sup> Observed incidence at terminal kill

<sup>g</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for differential mortality in animals that do not reach terminal kill. A negative trend or a lower incidence in a dose group is indicated by **N**.

<sup>h</sup> Historical incidence for corn oil gavage studies: 116/350 (33.1% ± 10.5%), range 16%-44%; all routes: 399/1,149 (34.7% ± 10.8%), range 16%-56%

<sup>i</sup> Historical incidence for corn oil gavage studies: 239/350 (68.3% ± 8.9%), range 56%-78%; all routes: 844/1,149 (73.5% ± 11.3%), range 52%-90%

<sup>j</sup> Historical incidence for corn oil gavage studies: 14/350 (4.0% ± 2.8%), range 2%-8%; all routes: 61/1,149 (5.3% ± 7.1%), range 0%-34%

<sup>k</sup> Historical incidence for corn oil gavage studies: 125/350 (35.7% ± 9.5%), range 22%-48%; all routes: 433/1,149 (37.7% ± 11.1%), range 18%-58%

<sup>l</sup> Historical incidence for corn oil gavage studies: 242/350 (69.1% ± 8.0%), range 58%-78%; all routes: 852/1,149 (74.2% ± 11.5%), range 52%-92%

<sup>m</sup> Historical incidence for corn oil gavage studies: 7/350 (2.0% ± 3.1%), range 0%-8%; all routes: 13/1,149 (1.1% ± 2.1%), range 0%-8%

<sup>n</sup> Historical incidence for corn oil gavage studies: 75/347 (21.6% ± 10.8%), range 6%-34%; all routes: 380/1,195 (31.8% ± 21.4%), range 2%-78%

<sup>o</sup> Historical incidence for corn oil gavage studies: 29/347 (8.3% ± 5.5%), range 2%-18%; all routes: 144/1,195 (12.1% ± 10.8%), range 0%-46%

<sup>p</sup> Historical incidence for corn oil gavage studies: 91/347 (26.2% ± 12.7%), range 8%-40%; all routes: 444/1,195 (37.2% ± 22.9%), range 6%-82%

<sup>q</sup> Historical incidence for corn oil gavage studies: 1/347 (0.3% ± 0.8%), range 0%-2%; all routes: 4/1,195 (0.3% ± 0.8%), range 0%-2%

<sup>r</sup> Historical incidence for corn oil gavage studies: 30/347 (8.6% ± 6.1%), range 2%-20%; all routes: 148/1,195 (12.4% ± 11.2%), range 0%-46%

of basophilic cytoplasm; mitotic figures were numerous (Plate 13). Blood-filled cystic spaces, necrosis, and hemorrhage were often common. Hepatoblastomas frequently arose within hepatocellular carcinomas and hepatocellular adenomas. Hepatoblastomas arising within or at the margin of either a hepatocellular adenoma or a hepatocellular carcinoma were recorded as a hepatoblastoma.

The incidences of hemangiosarcoma were significantly decreased in the 600 mg/kg males; single incidences of the lesion occurred in 200 and 600 mg/kg females

(Tables C1, C2, and D1). However, the incidence in vehicle control males in the current study is the highest in any gavage study in the historical control database (0%-18%). Hemangiosarcomas in the liver were poorly demarcated vascular neoplasms characterized by

neoplastic spindle-shaped endothelial cells lining cords of hepatocytes and producing small to large dilated blood-filled spaces. Nuclei were hyperchromatic, oval to elongate, and often bulged into vascular lumens. Necrosis and hemorrhage were common.

Two incidences of hepatocholangiocarcinoma (single or multiple) occurred in 200 mg/kg males and a single incidence occurred in 2,000 mg/kg males; these incidences were within the historical control ranges for corn oil gavage (0% to 8%) studies and for all routes of administration (0% to 8%) (Tables 18 and C1). Hepatocholangiocarcinomas were characterized by both neoplastic hepatocytes and neoplastic bile ducts. In many areas, the neoplasms were consistent with hepatocellular carcinomas while in smaller areas the neoplasms were typical of cholangiocarcinomas. The hepatocellular component formed sheets and trabeculae while the biliary component formed irregular acinar structures. In some areas there was a transition from hepatocellular carcinoma to cholangiocarcinoma.

The incidences of hepatocytic hypertrophy were significantly increased in all dosed groups of males and females and a dose-related increase in severity occurred in the males (Tables 18, C4, and D4). Hypertrophy was variable in distribution and severity among animals. In males, the hypertrophy first appeared in the midzonal areas and tended to spread to the portal triad and centrilobular areas with increasing severity; in females, the hypertrophy first was noted in the centrilobular areas and then progressed to involve the midzonal and portal areas. Hypertrophy was graded as follows: minimal = less than 20% of hepatocytes affected; mild = 20% to 60% of hepatocytes affected; moderate = 60% to 80% of hepatocytes affected; marked = greater than 80% of hepatocytes affected.

The incidences of hepatocytic erythrophagocytosis were significantly increased in all dosed groups of males and in the 600 and 2,000 mg/kg females (Tables 18, C4, and D4). Erythrophagocytosis was characterized by enlarged hepatocytes in which the cytoplasm was filled with red blood cells (Plate 14). The nucleus was either margined to the side of the cell or centrally located surrounded by intracytoplasmic red blood cells. Remaining cytoplasm often formed a distinct band at the peripheral circumference of the hepatocyte.

The incidences of hematopoietic cell proliferation were significantly increased in 600 and 2,000 mg/kg males and significantly decreased in 2,000 mg/kg females (Tables 18, C4, and D4). Hematopoietic cell proliferation was generally characterized by small clusters of nucleated red blood cells and lesser numbers of immature hematopoietic precursor cells in sinusoids, portal areas, or near central veins. In some animals, myeloid precursors were the predominant cell type.

The incidences of inflammation were significantly increased in 600 and 2,000 mg/kg males (Tables 18, C4, and D4). Inflammation in the liver was characterized by

foci of mixed inflammatory cells consisting primarily of mononuclear cells and neutrophils in the parenchyma but also including a mixture of lymphocytes, plasma cells, and macrophages in portal areas. Inflammation was recorded when one or more foci of inflammation were noted in nonneoplastic tissue within a section of liver. Inflammation was graded as follows: minimal = 1 to 10 foci observed in a typical section; mild = 11 to 20 foci observed in a typical section; moderate = 21 to 30 foci observed in a typical section; marked = more than 30 foci observed in a typical section.

The incidences of cytoplasmic vacuolization were significantly increased in all dosed groups of females (Tables 18 and D4). Cytoplasmic vacuolization was diagnosed when affected hepatocytes were distended with colorless to lightly eosinophilic, delicately reticulated cytoplasm as seen when hepatocytes contain glycogen. More severely affected livers had discrete round cytoplasmic vacuoles suggestive of lipid as well. Liver vacuolization was graded for severity based on the percentage of vacuolated hepatocytes: minimal = 5% to 10%; mild = 11% to 20%; moderate = 21% to 50%; marked = 51% or greater.

Incidences of necrosis were significantly increased in 600 and 2,000 mg/kg males (Tables 18 and C4). Necrosis was diagnosed when one or more focal areas of necrosis (usually coagulative) were randomly distributed within liver sections; necrosis present in neoplasms or within one millimeter of a malignant neoplasm was not recorded. Single-cell necrosis in areas of hypertrophy was not recorded.

The incidences of basophilic focus in 600 and 2,000 mg/kg males and clear cell focus in 2,000 mg/kg males were significantly decreased (Tables 18 and C4). Basophilic foci were randomly distributed in liver sections. Foci were generally oval to round with irregular, although distinct, margins, and hepatic cords were arranged in a relatively normal pattern that merged with the surrounding hepatic cords. Hepatocytes in basophilic foci were generally smaller than normal hepatocytes and had a basophilic cytoplasm (due to the presence of free ribosomes or rough endoplasmic reticulum). Clear cell foci were often small with fairly distinct margins, although cords merged with surrounding normal hepatic cords. Clear cell foci were composed of hepatocytes in which the cytoplasm was less dense or clear due to loss of glycogen during processing. The clear cytoplasm was usually more prominent in the perinuclear region and lacked discrete vacuoles. The hepatocytes were generally of normal size or slightly enlarged and had a centrally located nucleus.

The incidences of eosinophilic foci were significantly increased in all dosed groups of females (Tables 18 and D4). Eosinophilic foci were well circumscribed lesions one to several lobules in diameter and consisted of enlarged hepatocytes with distinct granular eosinophilic cytoplasm. Minimal to slight compression of surrounding hepatocytes was noted. The architecture of the liver lobule was retained, as is generally typical of foci of cellular alteration.

The incidences of mixed cell foci were significantly increased in all dosed groups of females (Tables 18 and D4). Mixed cell foci were generally round to oval and varied from less than one hepatic lobule to up to several lobules in diameter. The hepatic plates merged imperceptibly with the surrounding hepatocytes and caused little to no compression of the surrounding parenchyma. The normal architecture was retained with triad areas and central veins found within the focus. Mixed cell foci were composed of a mixture of hepatocyte cell types as found in basophilic, eosinophilic, or clear cell foci with no one cell type predominant. Vacuolated hepatocytes containing clear vacuoles with smooth distinct borders consistent with lipid were also common in mixed cell foci.

Incidences of tension lipidosis were significantly decreased in the 600 mg/kg males (Table C4). Tension lipidosis consisted of focal fairly well demarcated areas of hepatocytes containing numerous small, round, well circumscribed vacuoles in the cytoplasm consistent with lipid accumulation, and was noted near the attachment of the gallbladder.

*Thyroid Gland:* Two incidences each of follicular cell adenoma occurred in the 600 and 2,000 mg/kg male groups (Tables 19 and C1). The incidences in these groups exceeded the historical control ranges for corn oil gavage studies and for all routes of administration (Tables 19 and C3b). Thyroid gland follicular cell adenomas were well circumscribed nonencapsulated masses formed by the proliferation of follicular cells within the thyroid gland (Plate 15). Follicular cell

adenomas were small and generally there was minimal compression of surrounding follicles. The neoplastic cells were generally hyperchromatic and formed colloid-containing follicles of variable size. Neoplastic cells formed papillary projections with complex branching protruding into lumens of larger cystically dilated follicles. The neoplastic cells varied from cuboidal to columnar in shape and there was often an increase in the nuclear to cytoplasmic ratio.

The incidence of follicle hyperplasia was significantly increased in 2,000 mg/kg males (Tables 19 and C4). Four 600 mg/kg females also had this lesion (Table D4). Follicle hyperplasia was characterized by follicles lined by a crowded cuboidal to low columnar single cell layer epithelium (Plate 16). Occasional follicles were enlarged with increased colloid while other hyperplastic follicles were small with decreased colloid. In some follicles the epithelium formed papillary proliferations that protruded into the follicle lumen. Hyperplasia was usually focal to multifocal and only rarely involved the majority of follicles. In no cases were all of the follicles in a gland hyperplastic (diffuse). Foci of hyperplasia were not encapsulated and there was no to minimal compression of the adjacent normal thyroid follicles. Atypia and mitotic figures were not noted.

The incidences of follicular cell hypertrophy were significantly increased in 2,000 mg/kg males and 600 and 2,000 mg/kg females (Tables 19, C4, and D4). Follicular cell hypertrophy was characterized by follicles lined by tall cuboidal epithelial cells that were one to two times larger than normal follicle epithelial cells (Plate 17). These cells often contained yellow to pink globules in the cytoplasm or fine vacuoles. Additional features noted in thyroid follicles in which the follicle cells were hypertrophied were abnormal colloid characterized by eosinophilic to basophilic globules, increased sloughed thyroid epithelial cells in the colloid, and frequently enlarged follicles at the periphery of the thyroid gland, especially near the parathyroid glands. Atypia and mitotic figures were not features of hypertrophy.

**TABLE 19**  
**Incidences of Neoplasms and Nonneoplastic Lesions of the Thyroid Gland in Mice**  
**in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Male</b>				
Number Examined Microscopically	49	49	50	50
Follicle, Hyperplasia <sup>a</sup>	2 (1.0) <sup>b</sup>	1 (1.0)	7 (1.1)	25** (1.4)
Follicular Cell Hypertrophy	2 (1.0)	0	2 (1.5)	38** (1.2)
Follicular Cell Adenoma <sup>c</sup>				
Overall rate <sup>d</sup>	0/49 (0%)	0/49 (0%)	2/50 (4%)	2/50 (4%)
Adjusted rate <sup>e</sup>	0.0%	0.0%	5.3%	5.0%
Terminal rate <sup>f</sup>	0/33 (0%)	0/26 (0%)	2/21 (10%)	2/23 (9%)
First incidence (days)	— <sup>g</sup>		726 (T)	726 (T)
Poly-3 test <sup>h</sup>	P=0.125	— <sup>i</sup>	P=0.211	P=0.222
<b>Female</b>				
Number Examined Microscopically	49	48	49	48
Follicular Cell Hypertrophy	1 (3.0)	5 (1.4)	9* (1.0)	39** (1.0)

\* Significantly different (P≤0.05) from the vehicle control group by the Poly-3 test

\*\* P≤0.01

(T) Terminal kill

<sup>a</sup> Number of animals with lesion

<sup>b</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

<sup>c</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean ± standard deviation): 1/349 (0.3% ± 0.8%), range 0%-2%; all routes: 7/1,143 (0.6% ± 1.0%), range 0%-2%

<sup>d</sup> Number animals with neoplasm per number of animals with thyroid gland examined microscopically

<sup>e</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>f</sup> Observed incidence at terminal kill

<sup>g</sup> Not applicable; no neoplasms in animal group

<sup>h</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for differential mortality in animals that do not reach terminal kill.

<sup>i</sup> Value of the statistic cannot be computed.

*Forestomach:* Squamous cell papilloma (including multiple) occurred in all dosed groups of males (Tables 20 and C1); the incidences were within the historical control range for corn oil gavage studies (0% to 16%). Squamous papillomas were characterized by a solitary stalk of lamina propria protruding into the lumen with multiple finger-like projections arising from the stalk. The epithelium covering the projections was usually markedly hyperplastic and covered with excessive keratin; squamous pearl formation was not noted and maturation was fairly orderly. Invasion of epithelium into the stalk or into the submucosa, as seen in squamous cell carcinomas, was not a feature of papillomas.

The incidences of inflammation, epithelium hyperplasia, and epithelium hyperkeratosis were significantly increased in all dosed groups of males and in the 2,000 mg/kg females; the incidences of epithelium ulcer were significantly increased in 2,000 mg/kg males and females (Tables 20, C4, and D4). Epithelium erosion occurred sporadically in all dosed groups of males and in the 200 mg/kg females.

Inflammation was characterized by focal to multifocal infiltrates of a mixed inflammatory infiltrate in the lamina propria in the areas of hyperplasia. Inflammatory infiltrates consisted of lymphocytes, plasma cells, macrophages, neutrophils and eosinophils.

**TABLE 20**  
**Incidences of Selected Neoplasms and Nonneoplastic Lesions in Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Male</b>				
Forestomach <sup>a</sup>	50	50	50	50
Inflammation <sup>b</sup>	11 (2.3) <sup>c</sup>	24** (2.3)	21** (2.8)	45** (2.6)
Epithelium, Hyperplasia	14 (2.9)	27** (3.0)	27** (3.2)	45** (3.6)
Epithelium, Hyperkeratosis	11 (2.5)	24** (3.0)	24** (3.1)	46** (3.1)
Epithelium, Ulcer	7 (2.3)	10 (2.5)	12 (2.1)	24** (2.2)
Epithelium, Erosion	0	2 (2.0)	1 (4.0)	3 (3.3)
Squamous Cell Papilloma <sup>d</sup> (includes multiple)	0	2	1	1
Nose	50	50	50	50
Olfactory Epithelium				
Accumulation, Hyaline Droplet	18 (1.4)	16 (1.9)	15 (1.8)	28* (1.8)
Olfactory Epithelium Pigmentation	0	1 (1.0)	3 (1.0)	13** (1.1)
<b>Female</b>				
Forestomach	50	50	50	50
Inflammation	4 (1.8)	6 (2.3)	5 (1.8)	19** (2.6)
Epithelium, Hyperplasia	8 (2.1)	18* (1.8)	11 (2.0)	20** (3.4)
Epithelium, Hyperkeratosis	3 (2.7)	11 (2.0)	5 (1.8)	20** (2.9)
Epithelium, Ulcer	1 (2.0)	1 (3.0)	1 (2.0)	11* (2.5)
Epithelium, Erosion	0	1 (3.0)	0	0
Nose	50	50	50	50
Olfactory Epithelium				
Accumulation, Hyaline Droplet	5 (1.0)	3 (1.7)	12 (1.2)	17** (1.6)
Olfactory Epithelium, Pigmentation	0	1 (1.0)	6* (1.5)	13** (1.2)

\* Significantly different (P<0.05) from the vehicle control group by the Poly-3 test

\*\* P<0.01

<sup>a</sup> Number of animals with tissue examined microscopically

<sup>b</sup> Number of animals with lesion

<sup>c</sup> Average severity grade of lesions in affected animals: 1=minimal, 2=mild, 3=moderate, 4=marked

<sup>d</sup> Historical incidence for 2-year gavage studies with corn oil vehicle control groups (mean ± standard deviation): 10/350 (2.9% ± 5.9%), range 0%-16%; all routes: 22/1,150 (1.9% ± 3.6%), range 0%-16%

Perivascular cuffs of lymphocytes and plasma cells were noted in the submucosa. Neutrophils often migrated into the stratum corneum of the hyperplastic areas to form intracorneal pustules. Epithelium hyperplasia was characterized by focal to multifocal thickening of the squamous epithelium of the forestomach. Multiple, finger-like projections, each with its own lamina propria, oriented perpendicularly to the basal lamina often occurred focally (Plate 18). Maturation was generally orderly and invasion beneath the basement membrane was not noted. Hyperplastic areas of the mucosa were also hyperkeratotic and had

inflammation in the lamina propria and often erosions or ulcers in the hyperplastic epithelium. Hyperkeratosis was characterized by increased thickness of the stratum corneum with excessive keratin on the surface of the squamous mucosa. Generally, the hyperkeratosis was orthokeratotic. Hyperkeratosis was noted only in the areas of hyperplasia and the severity of the hyperkeratosis increased with the severity of the hyperplasia. Ulceration and erosion were only noted in the areas of hyperplasia and were characterized by loss of keratinocytes from the squamous epithelium of the short finger-like projections of hyperplastic squamous

epithelium. Erosions were diagnosed when squamous epithelial cells were lost from the hyperplastic epithelium but at least one layer of basal epithelial cells was retained. Ulcers were diagnosed when epithelial cell loss extended full thickness through the hyperplastic epithelium down to the underlying propria.

*Nose:* The incidences of hyaline droplet accumulation in the olfactory epithelium were significantly increased in 2,000 mg/kg males and females (Tables 20, C4, and D4). The incidences of pigmentation in the olfactory epithelium were significantly increased in 2,000 mg/kg males and 600 and 2,000 mg/kg females. Hyaline droplet accumulation was characterized by an accumulation of globular hyaline material in the cytoplasm of olfactory epithelial cells. The globules occupied sub- or supranuclear positions and stained brightly eosinophilic with hematoxylin and eosin. The presence of globules was associated with decreased numbers of nuclei, presumably both the sustentacular cells and olfactory neurons. Pigmentation was characterized by macrophages with an abundant amount of golden brown granular cytoplasm (Plate 19). Macrophages were usually located immediately above the basal cell layer and below the nuclear layer of the sustentacular cells and olfactory neurons. Occasionally the macrophages were located in the lamina propria between Bowman's glands. Occasionally a slight increase in numbers of apoptotic nuclei in the nuclear layer of the sustentacular cells and olfactory neurons was noted.

*Lung:* The incidences of alveolar/bronchiolar adenoma (0 mg/kg, 8/50; 200 mg/kg, 6/50; 600 mg/kg, 5/50; 2,000 mg/kg, 1/50), alveolar/bronchiolar carcinoma (single or multiple combined) (11/50, 8/50, 5/50, 3/50), or alveolar bronchiolar adenoma or carcinoma (combined) (17/50, 14/50, 10/50, 4/50) were significantly decreased in 2,000 mg/kg males (Tables C1 and C2). The combined incidence in this group was also less than the historical control range for all routes (14% to 40%; Table C3c). The incidences of alveolar epithelium hyperplasia were decreased, but not

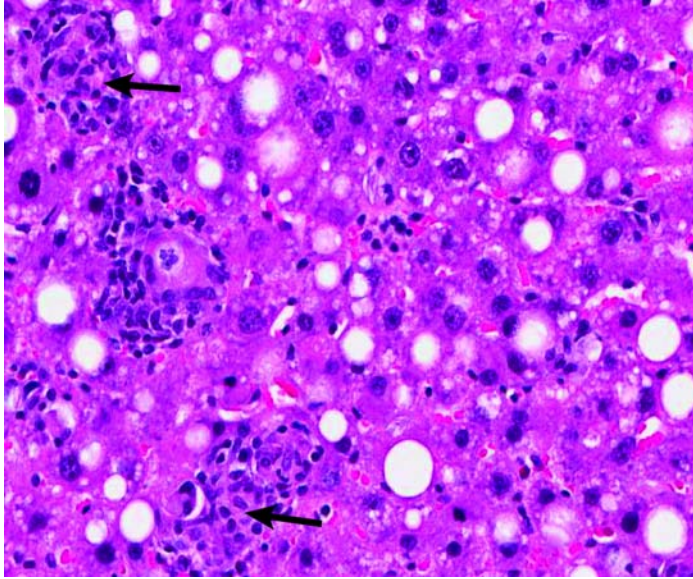
significantly, in 600 and 2,000 mg/kg males (4/50, 3/50, 1/50, 1/50; Table C4).

*Malignant Lymphoma:* The incidence of malignant lymphoma was significantly decreased in 2,000 mg/kg females (11/50, 9/50, 7/50, 2/50; Tables D1 and D2). Malignant lymphoma was generally either the follicle center lymphoma (mixed cell type) or small cell type. In the follicle center lymphoma, neoplastic cells consisted of a mixture of large and small lymphocytes. The larger cells tended to have a vesicular nucleus with prominent nucleoli and abundant cytoplasm. Mitotic figures were numerous. Small cell lymphoma was characterized by a neoplastic proliferation of a monomorphic population of small to medium sized well-differentiated lymphocytes; the mitotic index was low. Malignant lymphoma was generally a systemic process occurring in multiple organs, in addition to the liver.

## GENETIC TOXICOLOGY

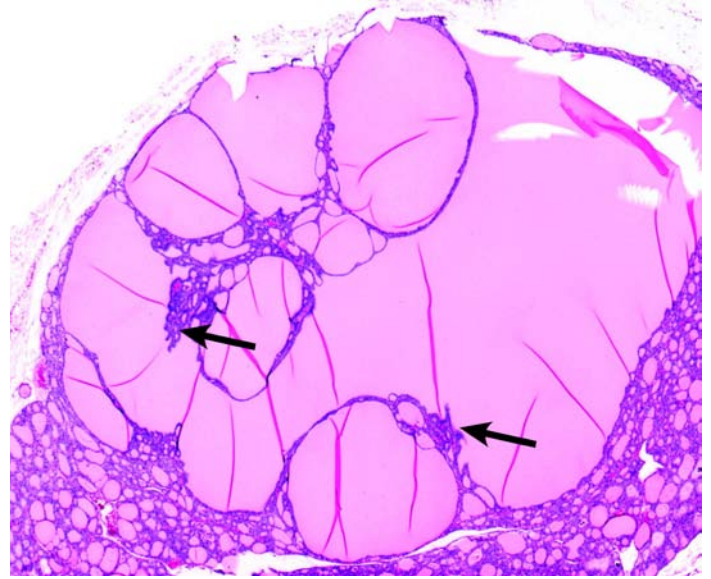
*Ginkgo biloba* extract (1,000 to 10,000 µg/plate) was mutagenic in *Salmonella typhimurium* strains TA98 and TA100 and in *Escherichia coli* strain WP2 *uvrA/pKM101*, with and without 10% induced rat liver S9 mix (Table E1). No increase in the frequency of micronucleated erythrocytes was observed in peripheral blood of male B6C3F1/N mice administered *Ginkgo biloba* extract (125 to 2,000 mg/kg per day) for 3 months by gavage (Table E2). In female mice administered these doses, the results of the micronucleus test were judged to be equivocal based on a significant trend test and no individual dose groups being significantly elevated over the vehicle control group (Table E2). A significant ( $P < 0.001$ ) dose-related decrease in the percentage of circulating PCEs was observed in male mice, suggesting that increasing doses of *Ginkgo biloba* extract induced bone marrow toxicity (Table E2). In female mice, a significant ( $P = 0.001$ ) decrease in the percentage of circulating PCEs was also observed, although the response in females was less well correlated with dose than in males.





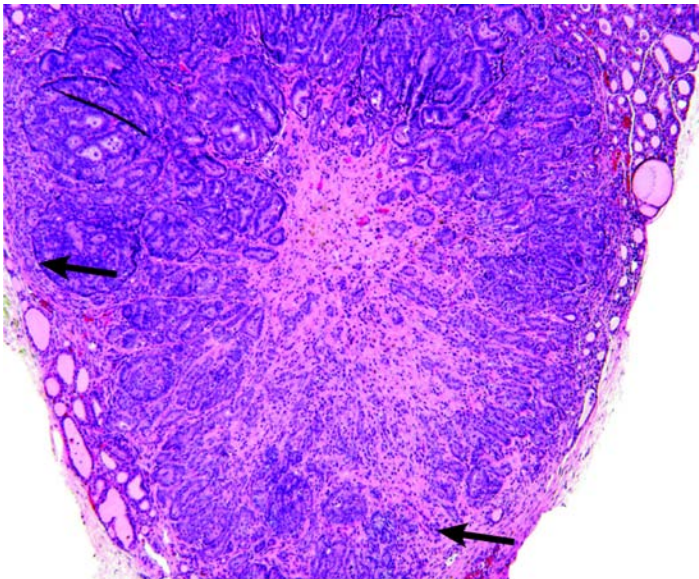
**PLATE 1**

Focal fatty change in the liver of a female F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note hepatocytes displaying microvesicular and macrovesicular fatty change associated with microgranulomas scattered throughout the lesion and composed predominantly of macrophages with fewer lymphocytes, plasma cells, and occasional neutrophils (arrows). The macrophages often contained fine, acicular clefts (cholesterol clefts). H&E



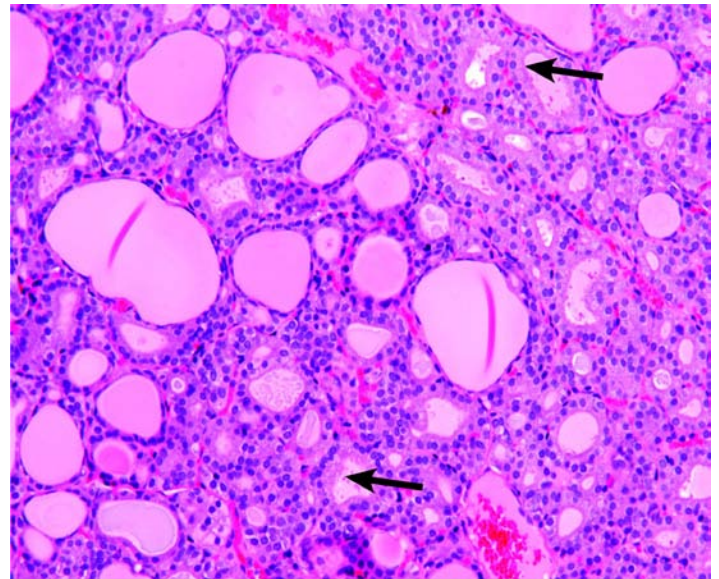
**PLATE 2**

Thyroid gland follicular cell adenoma in a male F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. The adenoma tends to be larger with more compression of the adjacent parenchyma and more complex epithelial infoldings than in hyperplasia (arrows). H&E



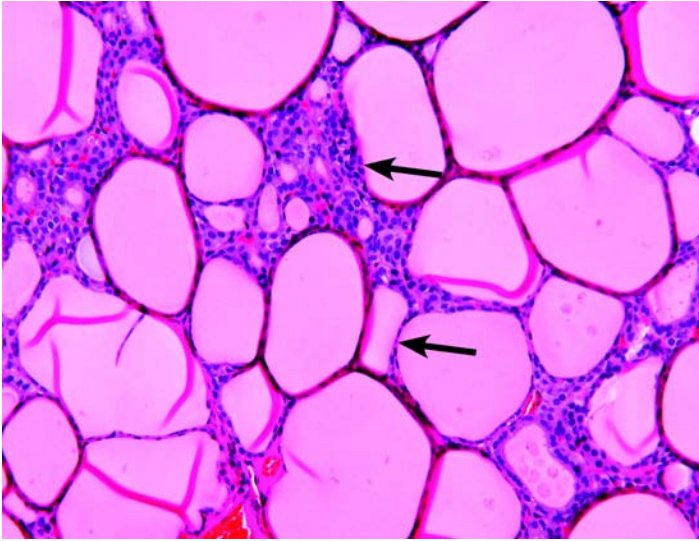
**PLATE 3**

Thyroid gland follicular cell carcinoma in a female F344/N rat administered 300 mg/kg *Ginkgo biloba* extract by gavage for 2 years. The neoplasm is highly cellular with local invasion (arrows). H&E



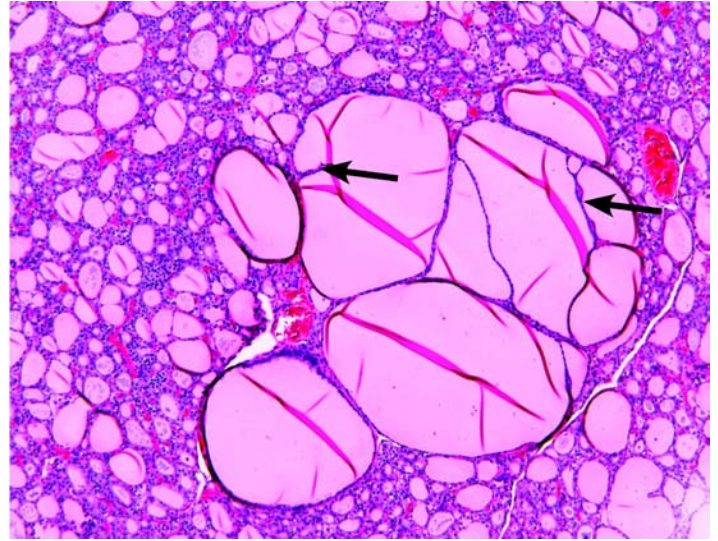
**PLATE 4**

Thyroid gland follicular cell hypertrophy in a female F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Most of the follicles are lined by cuboidal epithelium (arrows), and there is a decreased amount of colloid. Compare to Plate 5. H&E



**PLATE 5**

Normal aspect of thyroid gland follicles from a male vehicle control F344/N rat in the 2-year gavage study of *Ginkgo biloba* extract. Most of the follicles are lined by flattened epithelium (arrows) and the follicles are distended with homogeneous colloid. H&E



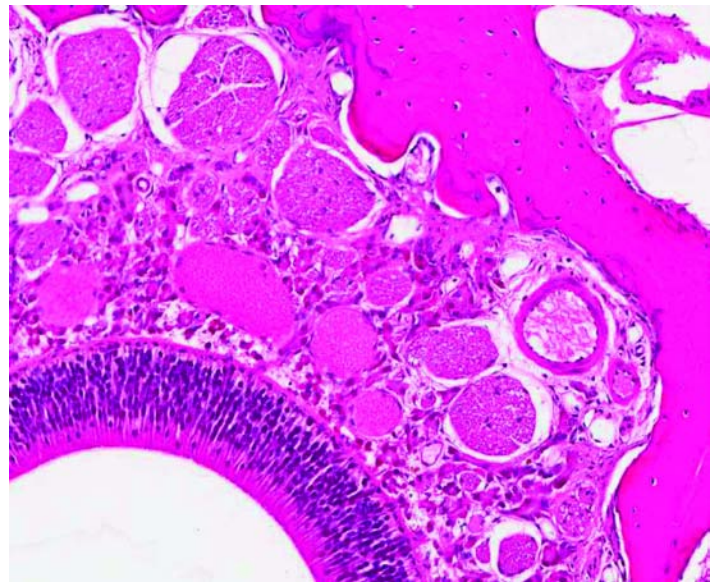
**PLATE 6**

Thyroid gland follicular cell hyperplasia in a male F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the focal enlargement of follicles that typically compress the surrounding parenchyma. The follicles are lined by hyperplastic follicular epithelium and epithelial-lined septae, and papillary projections (arrows) frequently project into the follicular colloid. H&E



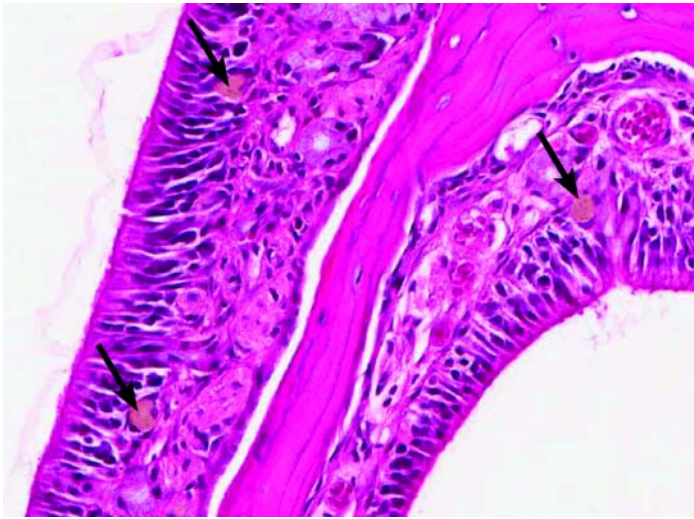
**PLATE 7**

Atrophy of the olfactory epithelium in the nose (Level III) of a female F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the thinning and disorganization of the olfactory epithelial layer (arrows). Compare to Plate 8. H&E



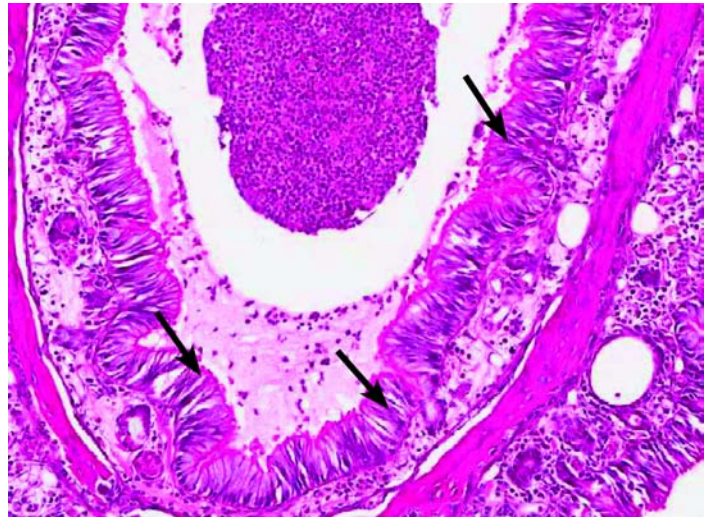
**PLATE 8**

Normal aspect of the nose (olfactory epithelium, Level III) of a female vehicle control F344/N rat in the 2-year gavage study of *Ginkgo biloba* extract. Note the normal thickness of the epithelium. H&E



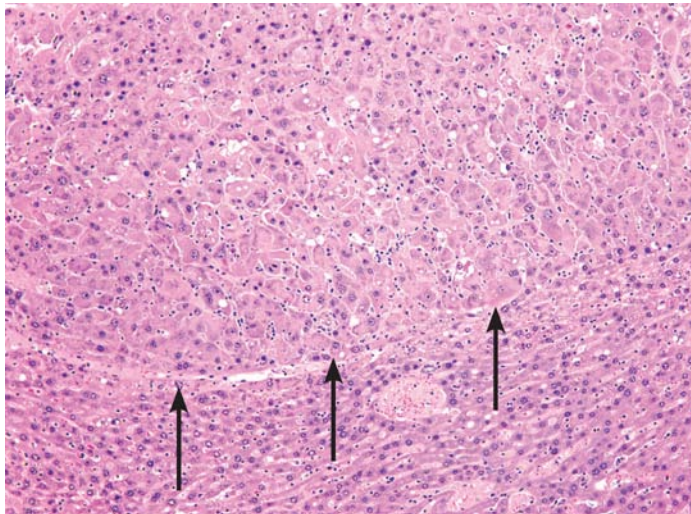
**PLATE 9**

Atrophy of the olfactory epithelium associated with pigment accumulation in the nose (Level III) of a female F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the thinning of the olfactory epithelial layer, associated with accumulation of macrophages containing golden brown pigment within the basal aspect of the olfactory epithelium and occasionally in the submucosa (arrows). H&E



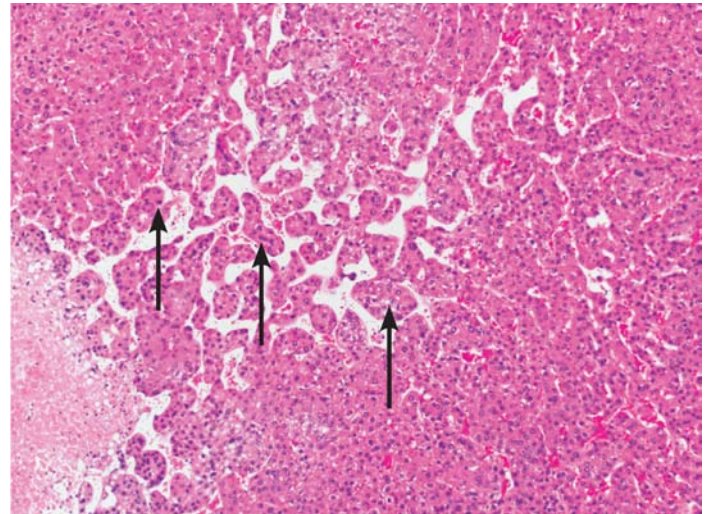
**PLATE 10**

Chronic active inflammation in the nose (Level III) of a female F344/N rat administered 1,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the presence of mixed inflammatory infiltrate that involves the submucosa and the lumen of the nasal cavity. There is also respiratory metaplasia of the olfactory epithelium (arrows). H&E



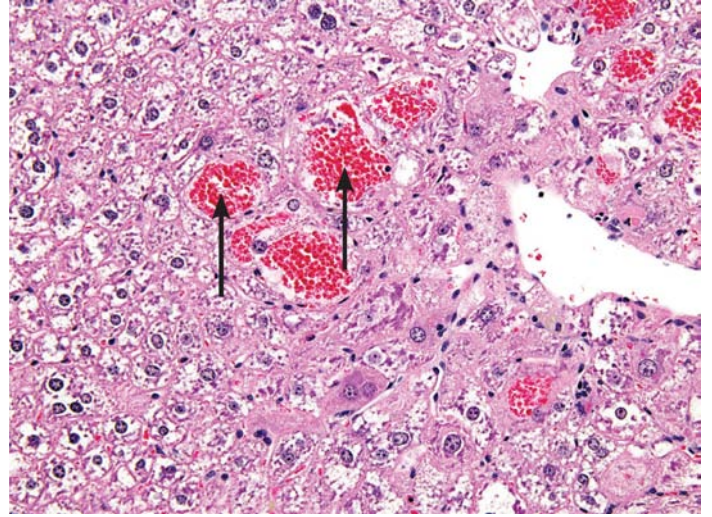
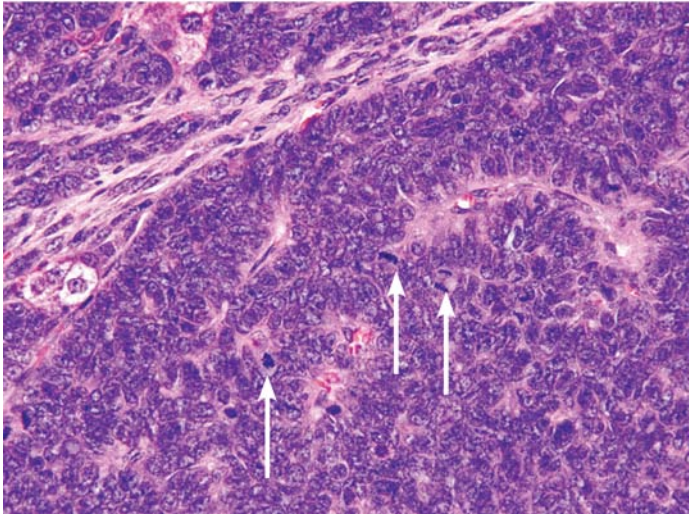
**PLATE 11**

Hepatocellular adenoma in the liver of a male B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the well-circumscribed nodule (arrows) composed of well-differentiated hepatocytes, having solid growth pattern; the hepatocytes are large cells with abundant eosinophilic cytoplasm. H&E



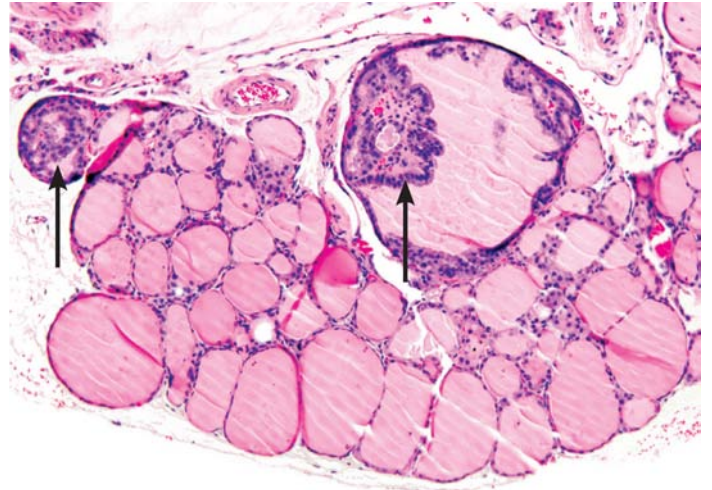
**PLATE 12**

Hepatocellular carcinoma in the liver of a female B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. The carcinoma has areas with a solid growth pattern and a trabecular pattern composed of cords of hepatocytes three or more cell layers thick (arrows) separated by dilated vascular spaces. H&E



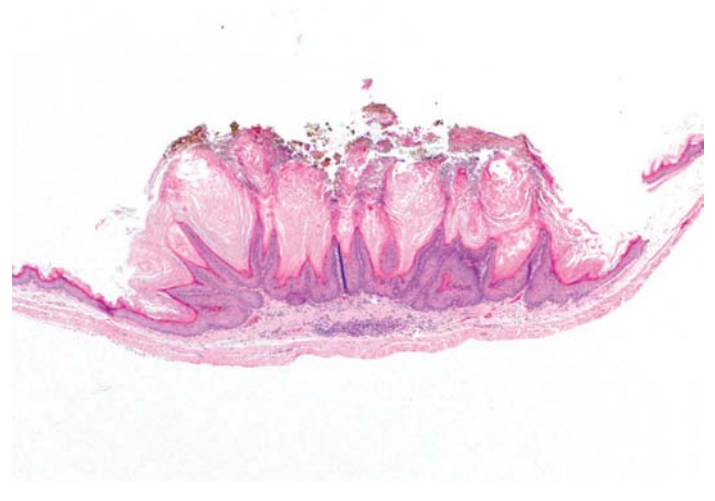
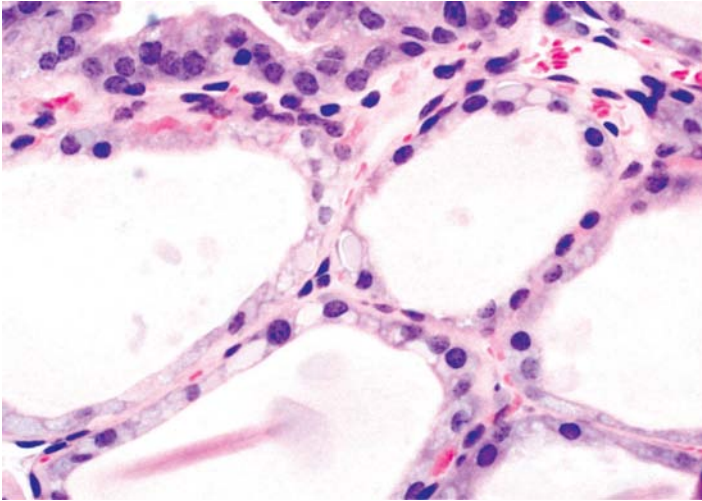
**PLATE 13**  
Hepatoblastoma in the liver of a male B6C3F1/N mouse administered 200 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the basophilic neoplastic cells arranged in sheets with palisading around vascular spaces. Nuclei are generally irregularly oval to round with a scant amount of basophilic cytoplasm; mitotic figures are numerous (white arrows). H&E

**PLATE 14**  
Erythrophagocytosis in the liver of a male B6C3F1/N mouse administered 200 mg/kg *Ginkgo biloba* extract by gavage for 2 years. The erythrophagocytosis is characterized by enlarged hepatocytes in which the cytoplasm is filled with red blood cells (arrows). H&E



**PLATE 15**  
Follicular cell adenoma in the thyroid gland of a male B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the well-circumscribed nonencapsulated mass formed by the proliferation of follicular cells within the thyroid gland. The neoplastic cells form papillary projections with complex branching protruding into lumens (arrow). H&E

**PLATE 16**  
Follicle hyperplasia in the thyroid gland of a male B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. The hyperplastic nodules (arrows) are characterized by follicles lined by a crowded cuboidal to low columnar single cell layer epithelium. The right nodule is enlarged due to increased colloid. H&E

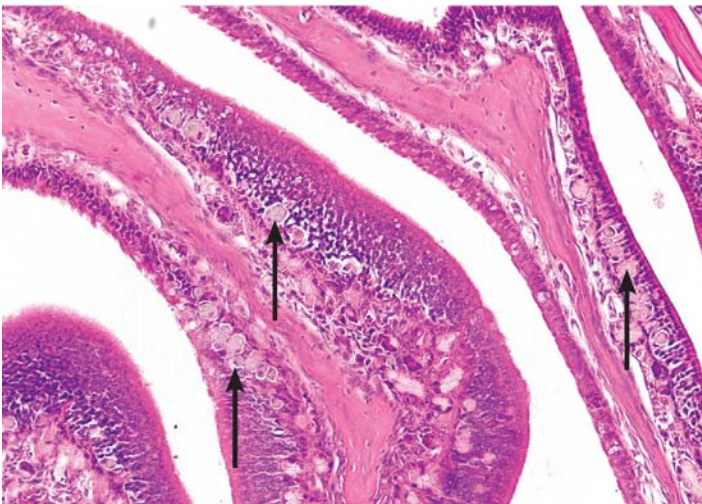


**PLATE 17**

Follicular cell hypertrophy in the thyroid gland of a male B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. The follicles are lined by tall cuboidal epithelial cells, which are one to two times larger than normal follicle epithelial cells. These cells often contain yellow to pink globules in the cytoplasm or fine vacuoles. H&E

**PLATE 18**

Epithelium hyperplasia in the forestomach of a female B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the focal presence of finger-like projections, each with its own lamina propria, oriented perpendicularly to the basal lamina. H&E



**PLATE 19**

Pigmentation in the olfactory epithelium of the nose (Level III) in a male B6C3F1/N mouse administered 2,000 mg/kg *Ginkgo biloba* extract by gavage for 2 years. Note the presence of macrophages with an abundance of golden brown granular cytoplasm usually located immediately above the basal cell layer and below the nuclear layer of the sustentacular cells and olfactory neurons (arrows). H&E

## DISCUSSION AND CONCLUSIONS

*Ginkgo biloba* extract is a popular herbal supplement used to improve brain function. As with many natural products, there is significant variability in the contents of *Ginkgo biloba* extract available in the marketplace (Table 21) (Kressmann *et al.*, 2002; Sloley *et al.*, 2003; Agnolet *et al.*, 2010; Fransen *et al.*, 2010; Gawron-Gzella *et al.*, 2010; Chandra *et al.*, 2011). In a 2002 study analyzing *Ginkgo biloba* extract constituents from products available in the United States, Kressmann *et al.* (2002) found a range of concentrations for flavonol glycosides (24% to 36%), terpene trilactones (4% to 11%), and ginkgolic acids (less than 500 ppm to 90,000 ppm). Furthermore, the majority of products evaluated did not meet the specifications for *Ginkgo biloba* extract outlined in the German Commission E Monographs on herbal medicines, which is often referenced by manufacturers (Kressmann *et al.*, 2002). Another analysis of products available in Europe, found that only one of 29 products adhered to a standard of 90% to 110% of the declared concentrations of active ingredients, with terpene trilactones present at 27% to 358% and flavonol glycosides present at 86% to 418% of the target concentrations (Fransen *et al.*, 2010). The *Ginkgo biloba* extract used in the present studies contained 31.2% flavonol glycosides, 15.4% terpene trilactones (6.94% bilobalide, 3.74% ginkgolide A, 1.62% ginkgolide B, 3.06% ginkgolide C), and 10.45 ppm ginkgolic acids.

In male and female rats and mice, the liver, thyroid gland, and nose were the major targets of *Ginkgo biloba* extract toxicity. Many of the toxic and carcinogenic effects associated with *Ginkgo biloba* extract administration are characteristic of lesions related to hepatic enzyme induction. In general, the carcinogenic activity of *Ginkgo biloba* extract was more pronounced in mice than rats.

A variety of liver lesions occurred in rats and mice following *Ginkgo biloba* extract administration. At 3 months, *Ginkgo biloba* extract caused increased liver weight, centrilobular hepatocytic hypertrophy, minimal focal necrosis (male mice) or fatty change of hepatocytes (male rats). These findings are consistent with changes associated with hepatic enzyme induction (Maronpot *et al.*, 2010). Allen *et al.* (2004) retrospectively analyzed the relative predictive value of these

3-month parameters on 2-year liver tumor outcomes and concluded that hepatocellular hypertrophy and increased liver weight accompanied by degenerative changes (i.e. hepatocyte necrosis, vacuolization and/or fatty change) were significant predictors of hepatocellular neoplasm development in the mouse or rat.

Liver carcinogenicity was evident following 2 years of *Ginkgo biloba* extract administration in male and female mice, and to a lesser extent in male rats. In male and female mice, the incidences of hepatocellular carcinoma and hepatoblastoma increased with dose, and in female mice, incidences of hepatocellular adenoma also increased with dose. Additionally, the incidences of multiple hepatocellular carcinomas and hepatoblastomas in male and female mice and of multiple adenomas in female mice increased in a dose-dependent manner. These findings were considered clear evidence for carcinogenic activity of *Ginkgo biloba* extract in male and female mice.

Hepatoblastomas are relatively rare tumors in mice, although they can occur spontaneously or be induced by various chemicals (Turusov *et al.*, 2002). The incidence rate of hepatoblastoma in mice administered *Ginkgo biloba* extract is among the highest generated from chemical exposures in NTP studies to date (Turusov *et al.*, 2002). There is evidence that the development of hepatoblastomas in a mouse model (D2B6F1) is mediated by promoting agents, rather than initiating agents (Diwan *et al.*, 1995). Furthermore, the prototypical promoting agent phenobarbital, as well as other enzyme inducing compounds, oxazepam and primidone, elicit significant increases in hepatoblastomas in mice (Bucher *et al.*, 1994; Diwan *et al.*, 1995; NTP, 2000).

In male rats, the incidences of hepatocellular adenoma in the 100 and 300 mg/kg groups were above the historical control range for corn oil gavage studies. It was concluded that the hepatocellular adenomas in male rats may have been related to *Ginkgo biloba* extract administration.

Many nonneoplastic effects were observed in the livers of rats and mice administered *Ginkgo biloba* extract for

**TABLE 21**  
**Constituents of Ginkgo biloba Extract<sup>a</sup>**

Class	Identified Chemical Constituents	Target Specification in EGb 761 <sup>®b</sup>	Range in Other Preparations <sup>c</sup>	NTP Test Article
Terpene trilactones	Total	6	0.07 – 14.23	15.4
	Bilobalide		0.00 – 8.64	6.94
	Ginkgolide A		0.01 – 3.82	3.74
	Ginkgolide B		ND – 2.00	1.62
	Ginkgolide C		ND – 2.35	3.06
	Ginkgolide J		0.03 – 0.78	NM
Flavonol glycosides	Total	24	24 – 36	31.2
	Quercetin		ND – 20.93*	16.71
	Kaempferol		0.05 – 13.98*	12.20
	Isorhamnetin		0.13 – 2.84*	2.37
Biflavones	Bilobetin, ginkgetin, isoginkgetin, sciadopitysin	0	0.05 – 1.7	NM
Proanthocyanidins	Dimers of procyanidin and prodelphinidin classes	7	4 – 12	NM
Alkylphenols	Ginkgolic acids, cardanols	≤ 5 ppm	<500 ppm – ~90,000 ppm	10.45
Carboxylic acids	Non-phenolic acids (ascorbic acid, D-glucaric acid, quinic acid, shikimic acid), phenolic acids (protocatechuic, <i>p</i> -hydroxybenzoic, vanillic, caffeic, <i>p</i> -coumaric, ferulic and chlorogenic acids)	13	NA	NM
Flavanols	Catechin, epicatechin, gallocatechin, and epigallocatechin <sup>d</sup>	2	NA	NM
Polyprenols	C <sub>85</sub> , C <sub>90</sub> , C <sub>95</sub> polyprenol <sup>e</sup>	0	NA	NM

ND= Not Detected

NA=Not Available

NM=Not Measured

\* Values represent the aglycone values multiplied by 2.51 (the factor used to convert aglycone values to glycoside values) (Sloley *et al.*, 2003)

<sup>a</sup> All values are percent except where indicated

<sup>b</sup> van Beek and Montoro, 2009

<sup>c</sup> Kressmann *et al.*, 2002; Sloley *et al.*, 2003; Gawron-Gzella *et al.*, 2010

<sup>d</sup> Hasler *et al.*, 1992

<sup>e</sup> Huh *et al.*, 1992

2 years. In rats, 2-year *Ginkgo biloba* extract administration was associated with increased incidences of centrilobular hepatocytic hypertrophy and bile duct hyperplasia in males and females; cystic degeneration, oval cell hyperplasia, and hepatocellular necrosis in males; and focal fatty change in females. In mice, *Ginkgo biloba* extract administration was associated with hepatocytic hypertrophy and hepatocytic erythrophagocytosis in males and females; hematopoietic cell proliferation, inflammation, and necrosis in males; and increased eosinophilic and mixed cell foci of altered hepatocytes in females.

The thyroid gland was another important target for *Ginkgo biloba* extract toxicity and the pathology at this site is consistent with a hepatic microsomal enzyme induction mechanism of toxicity. Increased thyroid stimulating hormone (TSH) levels were observed in all male dosed groups and the high dose female special study rats following 14 weeks of *Ginkgo biloba* extract administration. In the 3-month rat study, follicular cell hypertrophy was observed in dosed male and female rats.

In the 2-year studies, neoplastic findings included incidences of thyroid gland follicular cell adenoma in male and female rats and male mice above the historical control incidences for corn oil gavage studies. Additionally, in the 300 and 1,000 mg/kg groups of female rats there were single occurrences of follicular cell carcinoma, which is a rare neoplasm observed in only five of 1,186 (0.4%) historical control female rats from studies representing all routes of administration. The occurrence of these neoplasms, as well as the support from nonneoplastic lesions (follicular cell hypertrophy in male and female rats and mice and follicular cell hyperplasia in male rats and mice) and elevated TSH levels in treated male and female rats indicated that follicular cell neoplasms in male and female rats and male mice were related to *Ginkgo biloba* administration.

The third target of *Ginkgo biloba* extract toxicity was the nose. In the 3-month studies, atrophy of the olfactory epithelium was observed in male and female mice. Hyaline droplet accumulation of the respiratory epithelium and olfactory epithelium were noted in mice. Additionally, there were dose-related increases in pigmentation of the macrophages in the olfactory epithelium in male and female rats and mice. In the 2-year study, neoplasms were confined to two respiratory epithelial adenomas at the middle dose (300 mg/kg) of *Ginkgo biloba* extract in female rats. This is a rare neoplasm in rats, occurring in only one of 1,196 (0.1%) female rats in the historical controls for all routes of administration. A conclusion of equivocal

evidence of carcinogenic activity was based on the rarity of this tumor and the supporting nonneoplastic lesions discussed below.

Nonneoplastic lesions observed in the nose of male and female rats in the 2-year study included transitional epithelium hyperplasia, respiratory epithelium hyperplasia, olfactory epithelium atrophy, respiratory metaplasia, nerve atrophy, and pigmentation. In mice in the 2-year study, there were increased incidences of hyaline droplet accumulation and pigmentation in the olfactory epithelium.

The pathogenesis of nasal lesions associated with *Ginkgo biloba* extract administration could be related to systemic exposure to *Ginkgo biloba* extract or its metabolites (Sells *et al.*, 2007). It is of note that the CYP450 concentration in the rat olfactory epithelium is second only to the liver (Reed, 1993). Furthermore, in both studies, the olfactory epithelium was more severely affected compared to the respiratory epithelium, which corresponds to its higher levels of enzymatic activity (Walsh and Courtney, 1998).

In addition to the major targets of *Ginkgo biloba* extract toxicity (liver, thyroid gland, and nose) that were consistent across species and sex, male rats had dose-related increased incidences of mononuclear cell leukemia, one of the most commonly reported lesions in aging Fisher rats (Stromberg and Vogtberger, 1983). The 18% rate observed in vehicle control male rats in the current study is consistent with the historical control rate for corn oil gavage studies (range of 8% to 28% for combined lymphocytic, monocytic, mononuclear, or undifferentiated leukemias in F344/N male rats). The significant dose-dependent increases reached 44% and 42% in the 300 and 1,000 mg/kg groups, respectively. Therefore, the increase in mononuclear cell leukemia in male rats may have been related to *Ginkgo biloba* extract administration. However, due to the variability in the occurrence of this lesion in historical control animals across all routes ( $36\% \pm 14\%$ ; range of 8% to 58%), the increased incidence in this study could not be definitively attributed to *Ginkgo biloba* extract administration.

In the present studies, there was a dose-related increase in the severity of nephropathy in male rats. However, significant increases in incidences of renal neoplasms were not noted in treated male rats. This contrasts with findings from a previous 2-year study with quercetin, in which *some evidence* of carcinogenic activity in male rats was based on an increased incidence of renal tubule cell adenoma (NTP, 1992). Although *Ginkgo biloba* extract contains quercetin, the levels of quercetin in the current study were well below the high dose of



quercetin (40,000 ppm) that induced renal neoplasms in male rats (NTP, 1992).

*Ginkgo biloba* extract was shown to be genotoxic in bacterial mutagenicity assays conducted by the NTP (Table E1). Positive responses in such assays are considered to be alerts to carcinogenic activity in rodents. The flavonol glycosides, quercetin and kaempferol, present in *Ginkgo biloba* extract, are demonstrated mutagens in a variety of *in vitro* test systems and could contribute to the genotoxicity observed with the extract.

A companion gene expression study was conducted to aid in identifying a mechanism of tumorigenicity for *Ginkgo biloba* extract. Microarray and supporting polymerase chain reaction assessments were performed on RNA samples from liver tissue of male mice in the 2-year study (Guo *et al.*, 2010). Male mice exposed to 2,000 mg/kg *Ginkgo biloba* extract for 2 years displayed differential expression of 68 out of a possible 313 drug metabolizing enzymes present on the array (i.e., 22%). Pathway analysis revealed the top canonical pathway to be “metabolism of xenobiotics by P450.” Additionally, the Myc-centered network was identified as an important target of *Ginkgo biloba* extract. Myc is a proto-oncogene involved in cell growth, proliferation, differentiation, and apoptosis that has been found to cooperate with non-genotoxic hepatotoxicants to accelerate the development of liver tumors in mice (Beer *et al.*, 2008).

There is concern that the modulation of drug metabolizing enzymes by herbal products could lead to significant drug-herb interactions (Sparreboom *et al.*, 2004). *In vitro* studies conducted in support of the NTP assays examined the effects of *Ginkgo biloba* extract (and its hydrolyzed derivative) on the activity of xenobiotic metabolizing enzymes in human hepatocytes (Etheridge *et al.*, 2007). Several cytochrome P450s (1A2, 2C8, 2C9, and 3A4) exhibited decreased activity.

Lending further support to potential drug-herb interactions of *Ginkgo biloba* extract, Robertson *et al.* (2008) found that *Ginkgo biloba* extract treatment significantly reduced the area under the curve and  $C_{max}$  of midazolam, and Shinozuka *et al.* (2002) found decreased efficacy of the hypotensive drug nicardipine following 4 weeks of *Ginkgo biloba* extract treatment in rats.

## CONCLUSIONS

Under the conditions of these 2-year gavage studies, there was *some evidence of carcinogenic activity\** of *Ginkgo biloba* extract in male F344/N rats based on increased incidences of thyroid gland follicular cell adenoma. The increased incidences of mononuclear cell leukemia and hepatocellular adenoma may have been related to *Ginkgo biloba* extract administration. There was *some evidence of carcinogenic activity* of *Ginkgo biloba* extract in female F344/N rats based on increased incidences of thyroid gland follicular cell neoplasms. Increased occurrence of respiratory epithelium adenomas in the nose may have been related to *Ginkgo biloba* extract administration. There was *clear evidence of carcinogenic activity* of *Ginkgo biloba* extract in male B6C3F1/N mice based on increased incidences of hepatocellular carcinoma and hepatoblastoma. The increased incidences of thyroid gland follicular cell adenoma were also related to *Ginkgo biloba* extract administration. There was *clear evidence of carcinogenic activity* of *Ginkgo biloba* extract in female B6C3F1/N mice based on increased incidences of hepatocellular adenoma, hepatocellular carcinoma, and hepatoblastoma.

Administration of *Ginkgo biloba* extract resulted in increased incidences of nonneoplastic lesions in the liver, thyroid gland, and nose of male and female rats and mice and the forestomach of male and female mice. Increased severity of nephropathy in male rats was also due to administration of *Ginkgo biloba* extract.

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\* Explanation of Levels of Evidence of Carcinogenic Activity is on page 13. A summary of the Peer Review Panel comments and the public discussion on this Technical Report appears on page 15.

## REFERENCES

- Abdel-Kader, R., Hauptmann, S., Keil, U., Scherping, I., Leuner, K., Eckert, A., and Müller, W.E. (2007). Stabilization of mitochondrial function by *Ginkgo biloba* extract (EGb 761). *Pharmacol. Res.* **56**, 493-502.
- Abebe, W., Herman, W., and Konzelman, J. (2011). Herbal supplement use among adult dental patients in a USA dental school clinic: Prevalence, patient demographics, and clinical implications. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.* **111**, 320-325.
- Aeschbacher, H.U., Meier, H., and Ruch, E. (1982). Nonmutagenicity in vivo of the food flavonol quercetin. *Nutr. Cancer* **4**, 90-98.
- Agha, A.M., El-Fattah, A.A., Al-Zuhair, H.H., and Al-Rikabi, A.C. (2001). Chemopreventive effect of *Ginkgo biloba* extract against benzo(a)pyrene-induced forestomach carcinogenesis in mice: Amelioration of doxorubicin cardiotoxicity. *J. Exp. Clin. Cancer Res.* **20**, 39-50.
- Agnolet, S., Jaroszewski, J.W., Verpoorte, R., and Staerk, D. (2010). (1)HNMR-based metabolomics combined with HPLC-PDA-MS-SPE-NMR for investigation of standardized *Ginkgo biloba* preparations. *Metabolomics* **6**, 292-302.
- Ahlemeyer, B., and Krieglstein, J. (2003). Neuroprotective effects of *Ginkgo biloba* extract. *Cell. Mol. Life Sci.* **60**, 1779-1792.
- Allen, D.G., Pearse, G., Haseman, J.K., and Maronpot, R.R. (2004). Prediction of rodent carcinogenesis: An evaluation of prechronic liver lesions as forecasters of liver tumors in NTP carcinogenicity studies. *Toxicol. Pathol.* **32**, 393-401.
- Al-Yahya, A.A., Al-Majed, A.A., Al-Bekairi, A.M., Al-Shabanah, O.A., and Qureshi, S. (2006). Studies on the reproductive, cytological and biochemical toxicity of *Ginkgo biloba* in Swiss albino mice. *J. Ethnopharmacol.* **107**, 222-228.
- Amacher, D.E., Paillet, S.C., Turner, G.N., Ray, V.A., and Salsburg, D.S. (1980). Point mutations at the thymidine kinase locus in L5178Y mouse lymphoma cells. II. Test validation and interpretation. *Mutat. Res.* **72**, 447-474.
- Anderson, D., Basaran, N., Dobrzyńska, M.M., Basaran, A.A., and Yu, T.W. (1997). Modulating effects of flavonoids on food mutagens in human blood and sperm samples in the comet assay. *Teratog. Carcinog. Mutagen.* **17**, 45-58.
- Arenz, A., Klein, M., Fiehe, K., Gross, J., Drewke, C., Hemscheidt, T., and Leistner, E. (1996). Occurrence of neurotoxic 4'-O-methylpyridoxine in *Ginkgo biloba* leaves, *Ginkgo* medications and Japanese *Ginkgo* food. *Planta Med.* **62**, 548-551.
- Ashby, J., and Tennant, R.W. (1991). Definitive relationships among chemical structure, carcinogenicity and mutagenicity for 301 chemicals tested by the U.S. NTP. *Mutat. Res.* **257**, 229-306.
- Bailer, A.J., and Portier, C.J. (1988). Effects of treatment-induced mortality and tumor-induced mortality on tests for carcinogenicity in small samples. *Biometrics* **44**, 417-431.
- Beer, S., Komatsubara, K., Bellovin, D.I., Kurobe, M., Sylvester, K., and Felsher, D.W. (2008). Hepatotoxin-induced changes in the adult murine liver promote MYC-induced tumorigenesis. *PLoS One* **3**, e2493.
- Bent, S., Goldberg, H., Padula, A., and Avins, A.L. (2005). Spontaneous bleeding associated with *Ginkgo biloba*: A case report and systematic review of the literature. *J. Gen. Intern. Med.* **20**, 657-661.
- Biber, A. (2003). Pharmacokinetics of *Ginkgo biloba* extracts. *Pharmacopsychiatry* **36** (Suppl. 1), S32-S37.
- Biber, A., and Koch, E. (1999). Bioavailability of ginkgolides and bilobalide from extracts of *Ginkgo biloba* using GC/MS. *Planta Med.* **65**, 192-193.

- Bieler, G.S., and Williams, R.L. (1993). Ratio estimates, the delta method, and quantal response tests for increased carcinogenicity. *Biometrics* **49**, 793-801.
- Biggs, M.L., Sorkin, B.C., Nahin, R.L., Kuller, L.H., and Fitzpatrick A.L. (2010). Ginkgo biloba and risk of cancer: Secondary analysis of the Ginkgo Evaluation of Memory (GEM) Study. *Pharmacoepidemiol. Drug Saf.* **19**, 694-698.
- Bjeldanes L.F., and Chang G.W. (1977). Mutagenic activity of quercetin and related compounds. *Science* **197**, 577-578.
- Blumenthal, M., Ed. (1998). *The Complete German Commission E Monographs: Therapeutic Guide to Herbal Medicines*. American Botanical Council, Austin, TX.
- Boorman, G.A., Montgomery, C.A., Jr., Eustis, S.L., Wolfe, M.J., McConnell, E.E., and Hardisty, J.F. (1985). Quality assurance in pathology for rodent carcinogenicity studies. In *Handbook of Carcinogen Testing* (H.A. Milman and E.K. Weisburger, Eds.), pp. 345-357. Noyes Publications, Park Ridge, NJ.
- Brinkley, T.E., Lovato, J.F., Arnold, A.M., Furberg, C.D., Kuller, L.H., Burke, G.L., Nahin, R.L., Lopez, O.L., Yasar, S., and Williamson, J.D. (2010). Effect of *Ginkgo biloba* on blood pressure and incidence of hypertension in elderly men and women. *Am. J. Hypertens.* **23**, 528-533.
- Brown J.P., and Dietrich P.S. (1979). Mutagenicity of plant flavonols in the Salmonella/mammalian microsome test: Activation of flavonol glycosides by mixed glycosidases from rat cecal bacteria and other sources. *Mutat. Res.* **66**, 223-240.
- Bucher, J.R., Shackelford, C.C., Haseman, J.K., Johnson, J.D., Kurtz, P.J., and Persing R.L. (1994). Carcinogenicity studies of oxazepam in mice. *Fundam. Appl. Toxicol.* **23**, 280-297.
- Caria, H., Chaveca, T., Laires, A., Rueff, J. (1995). Genotoxicity of quercetin in the micronucleus assay in mouse bone marrow erythrocytes, human lymphocytes, V79 cell line and identification of kinetochore-containing (CREST staining) micronuclei in human lymphocytes. *Mutat. Res.* **343**, 85-94.
- Carver, J.H., Carrano, A.V., and MacGregor, J.T. (1983). Genetic effects of the flavonols quercetin, kaempferol, and galangin on Chinese hamster ovary cells in vitro. *Mutat. Res.* **113**, 45-60.
- Chandra, A., Li, Y.Q., Rana, J., Persons, K., Hyun, C., Shen, S., and Mulder, T. (2011). Qualitative categorization of supplement grade *Ginkgo biloba* leaf extracts for authenticity. *J. Funct. Foods* **3**, 107-114.
- Chiu, A.E., Lane, A.T., and Kimball, A.B. (2002). Diffuse morbilliform eruption after consumption of *Ginkgo biloba* supplement. *J. Am. Acad. Dermatol.* **46**, 145-146.
- Code of Federal Regulations (CFR) **21**, Part 58.
- Cox, D.R. (1972). Regression models and life-tables. *J. R. Stat. Soc.* **B34**, 187-220.
- Crawford, B.D. (1985). Perspectives on the somatic mutation model of carcinogenesis. In *Advances in Modern Environmental Toxicology. Mechanisms and Toxicity of Chemical Carcinogens and Mutagens* (M.A. Mehlman, W.G. Flamm, and R.J. Lorentzen, Eds.), pp. 13-59. Princeton Scientific Publishing Co., Inc., Princeton, NJ.
- Crebelli, R., Aquilina, G., Falcone, E., and Carere, A. (1987). Urinary and faecal mutagenicity in Sprague-Dawley rats dosed with the food mutagens quercetin and rutin. *Food Chem. Toxicol.* **25**, 9-15.
- Dardano, A., Ballardini, M., Ferdeghini, M., Lazzeri, E., Traino, C., Caraccio, N., Mariani, G., Barale, R., and Monzani, F. (2007). Anticlastogenic effect of *Ginkgo biloba* extract in Graves' disease patients receiving radioiodine therapy. *J. Clin. Endocrinol. Metab.* **92**, 4286-4289.
- De Feudis, F.V. (1998). *Ginkgo biloba* extract (EGb 761): *From Chemistry to the Clinic*. Ullstein Medical, Wiesbaden.
- De Feudis, F.V. (2003). A brief history of EGb 761 and its therapeutic uses. *Pharmacopsychiatry* **36** (Suppl. 1), S2-S7.
- De Feudis, F.V., and Drieu, K. (2000). *Ginkgo biloba* extract (EGb 761) and CNS functions: Basic studies and clinical applications. *Curr. Drug Targets* **1**, 25-58.
- DeKosky, S.T., Williamson, J.D., Fitzpatrick, A.L., Kronmal, R.A., Ives, D.G., Saxton, J.A., Lopez, O.L., Burke, G., Carlson, M.C., Fried, L.P., Kuller, L.H., Robbins, J.A., Tracy R.P., Woolard N.F., Dunn, L., Snitz, B.E., Nahin, R.L., Furberg, C.D., and Ginkgo Evaluation of Memory (GEM) Study Investigators (2008). *Ginkgo biloba* for prevention of dementia: A randomized controlled trial. *JAMA* **300**, 2253-2262, 2730.

- Del Tredici, P. (1991). Ginkgos and people: A thousand years of interaction. *Arnoldia* **51**, 2-15.
- Diamond, B.J., Shiflett, S.C., Feiwel, N., Matheis, R.J., Noskin, O., Richards, J.A., and Schoenberger, N.E. (2000). *Ginkgo biloba* extract: Mechanisms and clinical indications. *Arch. Phys. Med. Rehabil.* **81**, 668-678.
- Dias, M.C., Rodrigues, M.A., Reimberg, M.C., and Barbisan, L.F. (2008). Protective effects of *Ginkgo biloba* against rat liver carcinogenesis. *Chem. Biol. Interact.* **173**, 32-42.
- Diwan, B.A., Henneman, J.R., and Rice, J.M. (1995). Further evidence for promoter-dependent development of hepatoblastoma in the mouse. *Cancer Lett.* **89**, 29-35.
- Dixon, W.J., and Massey, F.J., Jr. (1957). *Introduction to Statistical Analysis*, 2nd ed., pp. 276-278, 412. McGraw-Hill Book Company, Inc., New York.
- Dunn, O.J. (1964). Multiple comparisons using rank sums. *Technometrics* **6**, 241-252.
- Dunnett, C.W. (1955). A multiple comparison procedure for comparing several treatments with a control. *J. Am. Stat. Assoc.* **50**, 1096-1121.
- Dunnick, J.K., and Hailey, J.R. (1992). Toxicity and carcinogenicity studies of quercetin, a natural component of foods. *Fundam. Appl. Toxicol.* **19**, 423-431.
- Duthie, S.J., Johnson, W., and Dobson, V.L. (1997). The effect of dietary flavonoids on DNA damage (strand breaks and oxidized pyrimidines) and growth in human cells. *Mutat. Res.* **390**, 141-151.
- Edenharder, R., and Grünhage, D. (2003). Free radical scavenging abilities of flavonoids as mechanism of protection against mutagenicity induced by tert-butyl hydroperoxide or cumene hydroperoxide in *Salmonella typhimurium* TA102. *Mutat. Res.* **540**, 1-18.
- Ehrlich, S.D. (2010). *Ginkgo biloba*. University of Maryland Medical Center. <<http://www.umm.edu/altmed/articles/ginkgo-biloba-000247.htm>>
- Emerit, I., Arutyunyan, R., Oganessian, N., Levy, A., Cernjavsky, L., Sarkisian, T., Pogossian, A., and Asrian, K. (1995). Radiation-induced clastogenic factors: Anticlastogenic effect of *Ginkgo biloba* extract. *Free Radic. Biol. Med.* **18**, 985-991.
- Etheridge, A.S., Black, S.R., Patel, P.R., So, J., and Mathews, J.M. (2007). An *in vitro* evaluation of cytochrome P450 inhibition and P-glycoprotein interaction with goldenseal, *Ginkgo biloba*, grape seed, milk thistle, and ginseng extracts and their constituents. *Planta Med.* **73**, 731-741.
- Evans, G.O., Ed. (2009). General enzymology. In *Animal Clinical Chemistry: A Practical Guide for Toxicologists and Biomedical Researchers*, pp. 17-30. Taylor and Francis Group. Boca Raton, FL.
- Fernandes, E.S., Pinto, R.M., de Paula Reis, J.E., de Oliveira Guerra, M., and Peters, V.M. (2010). Effects of *Ginkgo biloba* extract on the embryo-fetal development in Wistar rats. *Birth Defects Res. B. Dev. Reprod. Toxicol.* **89**, 133-138.
- Fransen, H.P., Pelgrom, S.M.G.J., Stewart-Knox, B., de Kaste, D., and Verhagen, H. (2010). Assessment of health claims, content, and safety of herbal supplements containing *Ginkgo biloba*. *Food Nutr. Res.* **54**, 5221-DOI: 10.3402/fnr.v54i0.5221
- Gart, J.J., Chu, K.C., and Tarone, R.E. (1979). Statistical issues in interpretation of chronic bioassay tests for carcinogenicity. *JNCI* **62**, 957-974.
- Gaspar, J., Rodrigues, A., Laires, A., Silva, F., Costa, S., Monteiro, M.J., Monteiro, C., and Rueff, J. (1994). On the mechanisms of genotoxicity and metabolism of quercetin. *Mutagenesis* **9**, 445-449.
- Gawron-Gzella, A., Marek, P., Chanaj, J., and Matławska, I. (2010). Comparative analysis of pharmaceuticals and dietary supplements containing extracts from the leaves of *Ginkgo biloba* L. *Acta Pol. Pharm.* **67**, 335-343.
- Girard, D.M., and Sager, D.B. (1987). The use of Markov chains to detect subtle variation in reproductive cycling. *Biometrics* **43**, 225-234.
- Granger, A.S. (2001). *Ginkgo biloba* precipitating epileptic seizures. *Age Ageing* **30**, 523-525.
- Gray, D.E., Messer, D., Porter, A., Ferguson, S., Harris, R.K., Clark, A.P., Algaier, J.W., Overstreet J.D., and Smith, C.S. (2005). Simultaneous quantification of terpenelactones and flavonol aglycones in hydrolyzed *Ginkgo biloba* extract by liquid chromatography with inline ultraviolet and evaporative light scattering detection. *J. AOAC Int.* **88**, 1613-1620.

- Gray, D.E., Messer, D., Porter, A., Hefner, B., Logan, D., Harris, R.K., Clark, A.P., Algaier, J.A., Overstreet, J.D., and Smith, C.S. (2007). Analysis of flavonol aglycones and terpenelactones in *Ginkgo biloba* extract: A comparison of high-performance thin-layer chromatography and column high-performance liquid chromatography. *J. AOAC Int.* **90**, 1203-1209.
- Guo, L., Mei, N., Liao, W., Chan, P.C., and Fu, P.P. (2010). *Ginkgo biloba* extract induces gene expression changes in xenobiotics metabolism and the Myc-centered network. *OMICS* **14**, 75-90.
- Hall, R.L. (2007). Clinical pathology of laboratory animals. In *Animal Models in Toxicology*, 2nd ed. (S.C. Gad, Ed.), pp. 787-830. Taylor and Francis Group, Boca Raton, FL.
- Hard, G.C., Seely, J.C., Betz, L.J., and Havashi, S.M. (2007). Re-evaluation of the kidney tumors and renal histopathology occurring in a 2-year rat carcinogenicity bioassay of quercetin. *Food Chem. Toxicol.* **45**, 600-608.
- Hardigree, A.A., and Epler, J.L. (1978). Comparative mutagenesis of plant flavonoids in microbial systems. *Mutat. Res.* **58**, 231-239.
- Harwood, M., Danielewska-Nikiel, B., Borzelleca, J.F., Flamm, G.W., Williams, G.M., and Lines, T.C. (2007). A critical review of the data related to the safety of quercetin and lack of evidence of in vivo toxicity, including lack of genotoxic/carcinogenic properties. *Food Chem. Toxicol.* **45**, 2179-2205.
- Hasler, A. (2000). Chemical constituents of *Ginkgo biloba*. In *Ginkgo Biloba* (T.A. van Beek, Ed.), pp. 124-164. Harwood Academic Publishers, Amsterdam.
- Hasler, A., Meier, B., and Sticher, O. (1992). Identification and determination of the flavonoids from *Ginkgo-biloba* by high-performance liquid-chromatography. *J. Chromatogr.* **605**, 41-48.
- Heads, J.A., Hawthorne, R.L., Lynagh, T., and Lynch, J.W. (2008). Structure-activity analysis of ginkgolide binding in the glycine receptor pore. *J. Neurochem.* **105**, 1418-1427.
- Heddle, J.A., Hite, M., Kirkhart, B., Mavournin, K., MacGregor, J.T., Newell, G.W., and Salamone, M.F. (1983). The induction of micronuclei as a measure of genotoxicity. A report of the U.S. Environmental Protection Agency Gene-Tox Program. *Mutat. Res.* **123**, 61-118.
- Hellum, B.H., Hu, Z., and Nilsen, O.G. (2007). The induction of CYP1A2, CYP2D6, and CYP3A4 by six trade herbal products in cultured human hepatocytes. *Basic Clin. Pharmacol. Toxicol.* **100**, 23-30.
- Hirono, I., Ueno, I., Hosaka, S., Takashi, H., Matsushima, T., Sugimura, T., and Natori, S. (1981). Carcinogenicity examination of quercetin and rutin in ACI rats. *Cancer Lett.* **13**, 15-21.
- Huh, H., Staba, E.J., and Singh, J. (1992). Supercritical fluid chromatographic analysis of polyphenols in *ginkgo-biloba*-L. *J. Chromatogr.* **600**, 364-369.
- Ivic, L., Sands T.T., Fishkin, N., Nakanishi, K., Kriegstein, A.R., and Strømgaard, K. (2003). Terpene trilactones from *Ginkgo biloba* are antagonists of cortical glycine and GABA (A) receptors. *J. Biol. Chem.* **278**, 49, 279-249, 285.
- Izzo, A.A., and Ernst, E. (2001). Interactions between herbal medicines and prescribed drugs: A systematic review. *Drugs* **61**, 2163-2175.
- Jiang, X.Y., Qian, L.P., Zheng, X.J., Xia, Y.Y., Jiang, Y.B., and Sun da, Y. (2009). Interventional effect of *Ginkgo biloba* extract on the progression of gastric precancerous lesions in rats. *J. Dig. Dis.* **10**, 293-299.
- Jonckheere, A.R. (1954). A distribution-free *k*-sample test against ordered alternatives. *Biometrika* **41**, 133-145.
- Kajiyama, Y., Fuji, K., Takeuchi, H., and Manabe, Y. (2002). *Ginkgo* seed poisoning. *Pediatrics* **109**, 325-327.
- Kaplan, E.L., and Meier, P. (1958). Nonparametric estimation from incomplete observations. *J. Am. Stat. Assoc.* **53**, 457-481.
- Kellermann, A.J., and Kloft, C. (2011). Is there a risk of bleeding associated with standardized *Ginkgo biloba* extract therapy? *Pharmacotherapy* **31**, 490-502.
- Kennedy, J. (2005). Herb and supplement use in the US adult population. *Clin. Ther.* **27**, 1847-1858.
- Kleijnen, J., and Knipschild, P. (1992). *Ginkgo biloba*. *Lancet* **340**, 1136-1139.
- Kobayashi, D., Yoshimura, T., Johno, A., Sasaki, K., and Wada, K. (2011). Toxicity of 4'-*O*-methylpyridoxine-5'-glucoside in *Ginkgo biloba* seeds. *Food Chem.* **126**, 1198-1202.

- Kondratskaya, E.L., Lishko, P.V., Chatterjee, S.S., and Krishtal, O.A. (2002). BN52021, a platelet activating factor antagonist, is a selective blocker of glycine-gated chloride channel. *Neurochem. Int.* **40**, 647-653.
- Kressmann, S., Müller, W.E., and Blume, H.H. (2002). Pharmaceutical quality of different *Ginkgo biloba* brands. *J. Pharm. Pharmacol.* **54**, 661-669.
- Krizková, L., Chovanová, Z., Duracková, Z., and Krajcovic, J. (2008). Antimutagenic in vitro activity of plant polyphenols: Pycnogenol and *Ginkgo biloba* extract (EGB 761). *Phytother. Res.* **22**, 384-388.
- Kubiak, R., and Rudek, Z. (1990). SCEs and chromosome aberrations in mammalian cells in vitro treated with quercetin. *Acta Biol. Hung.* **41**, 121-124.
- Kuller, L.H., Ives, D.G., Fitzpatrick, A.L., Carlson, M.C., Mercado, C., Lopez, O.L., Burke, G.L., Furberg, C.D., DeKosky, S.T., and Ginkgo Evaluation of Memory Study Investigators (2010). Does *Ginkgo biloba* reduce the risk of cardiovascular events? *Circ. Cardiovasc. Qual. Outcomes* **3**, 41-47.
- Lepoittevin, J.P., Benezra, C., and Asakawa, Y. (1989). Allergic contact dermatitis to *Ginkgo biloba* L.: Relationship with urushiol. *Arch. Dermatol. Res.* **281**, 227-230.
- Li, C.L., and Wong, Y.Y. (1997). The bioavailability of ginkgolides in *Ginkgo biloba* extracts. *Planta Med.* **63**, 563-565.
- Li, X.F., Ma, M., Scherban, K., and Tam, Y.K. (2002). Liquid chromatography-electrospray mass spectrometric studies of ginkgolides and bilobalide using simultaneous monitoring of proton, ammonium and sodium adducts. *Analyst* **127**, 641-646.
- McConnell, E.E., Solleveld, H.A., Swenberg, J.A., and Boorman, G.A. (1986). Guidelines for combining neoplasms for evaluation of rodent carcinogenesis studies. *JNCI* **76**, 283-289.
- MacGregor, J.T., and Jurd, L. (1978). Mutagenicity of plant flavonoids: Structural requirements for mutagenic activity in *Salmonella typhimurium*. *Mutat. Res.* **54**, 297-309.
- MacGregor, J.T., Wehr, C.M., Henika, P.R., and Shelby, M.D. (1990). The *in vivo* erythrocyte micronucleus test: Measurement at steady state increases assay efficiency and permits integration with toxicity studies. *Fundam. Appl. Toxicol.* **14**, 513-522.
- McKenna, D.J., Jones, K., and Hughes, K. (2001). Efficacy, safety, and use of *ginkgo biloba* in clinical and preclinical applications. *Altern. Ther. Health Med.* **75**, 70-86, 88-90.
- Mahadevan, S., and Park, Y. (2008). Multifaceted therapeutic benefits of *Ginkgo biloba* L.: Chemistry, efficacy, safety, and uses. *J. Food Sci.* **73**, R14-R19.
- Mahady, G.B. (2002). *Ginkgo biloba* for the prevention and treatment of cardiovascular disease: A review of the literature. *J. Cardiovasc. Nurs.* **16**, 21-32.
- Maronpot, R.R., and Boorman, G.A. (1982). Interpretation of rodent hepatocellular proliferative alterations and hepatocellular tumors in chemical safety assessment. *Toxicol. Pathol.* **10**, 71-80.
- Maronpot, R.R., Yoshizawa, K., Nyska, A., Harada, T., Flake, G., Mueller, G., Singh, B., and Ward, J.M. (2010). Hepatic enzyme induction. Histopathology. *Toxicol. Pathol.* **38**, 776-795.
- Maruta, A., Enaka, K., and Umeda, M. (1979). Mutagenicity of quercetin and kaempferol on cultured mammalian cells. *Gann* **70**, 273-276.
- Mauri, P., Simonetti, P., Gardana, C., Minoggio, M., Morazzoni, P., Bombardelli, E., and Pietta, P. (2001). Liquid chromatography/atmospheric pressure chemical ionization mass spectrometry of terpene lactones in plasma of volunteers dosed with *Ginkgo biloba* L. extracts. *Rapid Commun. Mass Spectrom.* **15**, 929-934.
- Meltz, M.L., and MacGregor, J.T. (1981). Activity of the plant flavanol quercetin in the mouse lymphoma L5178Y TK+/- mutation, DNA single-strand break, and Balb/c 3T3 chemical transformation assays. *Mutat. Res.* **88**, 317-324.
- Miller, J.A., and Miller, E.C. (1977). Ultimate chemical carcinogens as reactive mutagenic electrophiles. In *Origins of Human Cancer* (H.H. Hiatt, J.D. Watson, and J.A. Winsten, Eds.), pp. 605-627. Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.
- Moreau, J.P., Eck, C.R., McCabe, J., and Skinner, S. (1986). Absorption, distribution and elimination of a labelled extract of *Ginkgo biloba* leaves in the rat [in French, English summary]. *Presse Med.* **15**, 1458-1461.
- Nagao, M., Morita, N., Yahagi, T., Shimizu, M., Kuroyanagi, M., Fukuoka, M., Yoshihira, K., Natori, S., Fujino, T., and Sugimura, T. (1981). Mutagenicities of 61 flavonoids and 11 related compounds. *Environ. Mutagen.* **3**, 401-419.

- National Toxicology Program (NTP) (1992). Toxicology and Carcinogenesis Studies of Quercetin (CAS No. 117-39-5) in F344/N Rats (Feed Studies). Technical Report Series No. 409. NIH Publication No. 92-3140. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, Research Triangle Park, NC.
- National Toxicology Program (NTP) (2000). Toxicology and Carcinogenesis Studies of Primidone (CAS No. 125-33-7) in F344/N Rats and B6C3F1 Mice (Feed Studies). Technical Report Series No. 476. NIH Publication No. 00-3966. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, Research Triangle Park, NC.
- Ndjoko, K., Wolfender, J., and Hostettmann, K. (2000). Determination of trace amounts of ginkgolic acids in *Ginkgo biloba* L. leaf extracts and phytopharmaceuticals by liquid chromatography-electrospray mass spectrometry. *J. Chromatogr. B* **744**, 249-255.
- Pennisi, R.S. (2006). Acute generalized exanthematous pustulosis induced by the herbal remedy *Ginkgo biloba*. *Med. J. Aust.* **184**, 583-584.
- Piegorsch, W.W., and Bailer, A.J. (1997). *Statistics for Environmental Biology and Toxicology*, Section 6.3.2. Chapman and Hall, London.
- Pietta, P.G., Gardana, C., Mauri, P.L., Maffei-Fracino, R., and Carini, M. (1995). Identification of flavanoid metabolites after oral administration to rats of a *Ginkgo biloba* extract. *J. Chromatogr. B Biomed. Appl.* **673**, 75-80.
- Pietta, P.G., Gardana, C., and Mauri, P.L. (1997). Identification of *Ginkgo biloba* flavonol metabolites after oral administration to humans. *J. Chromatogr. B Biomed. Sci. Appl.* **693**, 249-255.
- Pinto, R.M., Fernandes, E.S., Reis, J.E., Peters, V.M., and Guerra Mde. O. (2007). Intra-uterine growth retardation after prenatal administration of *Ginkgo biloba* to rats. *Reprod. Toxicol.* **23**, 480-485.
- Portier, C.J., and Bailer, A.J. (1989). Testing for increased carcinogenicity using a survival-adjusted quantal response test. *Fundam. Appl. Toxicol.* **12**, 731-737.
- Portier, C.J., Hedges, J.C., and Hoel, D.G. (1986). Age-specific models of mortality and tumor onset for historical control animals in the National Toxicology Program's carcinogenicity experiments. *Cancer Res.* **46**, 4372-4378.
- Rajaraman, G., Yang, G., Chen, J., and Chang, T.K. (2009). Modulation of CYP1B1 and CYP1A1 gene expression and activation of aryl hydrocarbon receptor by *Ginkgo biloba* extract in MCF-10A human mammary epithelial cells. *Can. J. Physiol. Pharmacol.* **87**, 674-683.
- Rangel-Ordóñez, L., Nöldner, M., Schubert-Zsilavec, M., and Wurglics, M. (2010). Plasma levels and distribution of flavonoids in rat brain after single and repeated doses of standardized *Ginkgo biloba* extract EGb 761®. *Planta Med.* **76**, 1683-1690.
- Rao, G.N. (1996). New diet (NTP-2000) for rats in the National Toxicology Program toxicity and carcinogenicity studies. *Fundam. Appl. Toxicol.* **32**, 102-108.
- Rao, G.N. (1997). New nonpurified diet (NTP-2000) for rodents in the National Toxicology Program's toxicology and carcinogenesis studies. *J. Nutr.* **127**, 842s-846s.
- Reed, C.J. (1993). Drug metabolism in the nasal cavity: Relevance to toxicology. *Drug Metab. Rev.* **25**, 173-205.
- Robertson, S.M., Davey, R.T., Voell, J., Formentini, E., Alfaro, R.M., and Penzak, S.R. (2008). Effect of *Ginkgo biloba* extract on lopinavir, midazolam and fexofenadine pharmacokinetics in healthy subjects. *Curr. Med. Res. Opin.* **24**, 591-599.
- Salvador, R.L. (1995). Herbal medicine - ginkgo. *Can. Pharmacists J.* **52**, 39-41.
- Schmid, W. (1975). The micronucleus test. *Mutat. Res.* **31**, 9-15.
- Sells, D.M., Brix, A.E., Nyska, A., Jokinen, M.P., Orzech, D.P., and Walker, N.J. (2007). Respiratory tract lesions in noninhalation studies. *Toxicol. Pathol.* **35**, 170-177.

- Shelby, M.D., and Witt, K.L. (1995). Comparison of results from mouse bone marrow chromosome aberration and micronucleus tests. *Environ. Mol. Mutagen.* **25**, 302-313.
- Shelby, M.D., Erexson, G.L., Hook, G.J., and Tice, R.R. (1993). Evaluation of a three-exposure mouse bone marrow micronucleus protocol: Results with 49 chemicals. *Environ. Mol. Mutagen.* **21**, 160-179.
- Shi, C., Liu, J., Wu, F., and Yew, D.T. (2010a). *Ginkgo biloba* extract in Alzheimer's disease: From action mechanisms to medical practice. *Int. J. Mol. Sci.* **11**, 107-123.
- Shi, C., Fang, L., Yew, D.T., Yao, Z., and Xu, J. (2010b). *Ginkgo biloba* extract EGb761 protects against mitochondrial dysfunction in platelets and hippocampi in ovariectomized rats. *Platelets* **21**, 53-59.
- Shi, C., Xiao, S., Liu, J., Guo, K., Wu, F., Yew, D.T., and Xu, J. (2010c). *Ginkgo biloba* extract EGb761 protects against aging-associated mitochondrial dysfunction in platelets and hippocampi of SAMP8 mice. *Platelets* **21**, 373-379.
- Shinozuka, K., Umegaki, K., Kubota, Y., Tanaka, N., Mizuno, H., Yamauchi, J., Nakamura, K., and Kunitomo, M. (2002). Feeding of *Ginkgo biloba* extract (GBE) enhances gene expression of hepatic cytochrome P-450 and attenuates the hypotensive effect of nicardipine in rats. *Life Sci.* **70**, 2783-2792.
- Shirley, E. (1977). A non-parametric equivalent of Williams' test for contrasting increasing dose levels of a treatment. *Biometrics* **33**, 386-389.
- Silva, I.D., Rodrigues, A.S., Gaspar, J., Maia, R., Laires, A., and Rueff, J. (1997). Involvement of rat cytochrome 1A1 in the biotransformation of kaempferol to quercetin: Relevance to the genotoxicity of kaempferol. *Mutagenesis* **12**, 383-390.
- Sloley, B.D., Tawfik, S.R., Scherban K.A., and Tam, Y.K. (2003). Quality control analyses for ginkgo extracts require analysis of intact flavonol glycosides. *J. Food Drug Anal.* **11**, 102-107.
- Smith, J.V., and Luo, Y. (2004). Studies on molecular mechanisms of *Ginkgo biloba* extract. *Appl. Microbiol. Biotechnol.* **64**, 465-472.
- Smith, P.F., MacLennan, K., and Darlington, C.L. (1996). The neuroprotective properties of the *Ginkgo biloba* leaf: A review of the possible relationship to platelet-activating factor (PAF). *J. Ethnopharmacol.* **50**, 131-139.
- Snitz, B.E., O'Meara, E.S., Carlson, M.C., Arnold, A.M., Ives, D.G., Rapp, S.R., Saxton, J., Lopez, O.L., Dunn, L.O., Sink, K.M., DeKosky, S.T., and Ginkgo Evaluation of Memory (GEM) Study Investigators (2009). *Ginkgo biloba* for preventing cognitive decline in older adults: A randomized trial. *JAMA* **302**, 2663-2670.
- Sowers, W.F., Weary, P.E., Collins, O.D., and Cawley, E.P. (1965). Ginkgo-tree dermatitis. *Arch. Dermatol.* **91**, 452-456.
- Sparreboom, A., Cox, M.C., Acharya, M.R., and Figg, W.D. (2004). Herbal remedies in the United States: Potential adverse interactions with anticancer agents. *J. Clin. Oncol.* **22**, 2498-2503.
- Stoewsand, G.S., Anderson, J.L., Boyd, J.N., Hrazdina, G., Babish, J.G., Walsh, K.M., and Losco, P. (1984). Quercetin: A mutagen, not a carcinogen, in Fischer rats. *J. Toxicol. Environ. Health* **14**, 105-114.
- Straus, D.S. (1981). Somatic mutation, cellular differentiation, and cancer causation. *JNCI* **67**, 233-241.
- Stromberg, P.C., and Vogtsberger, L.M. (1983). Pathology of the mononuclear cell leukemia of Fischer rats. I. Morphologic studies. *Vet. Pathol.* **20**, 698-708.
- Strømgaard, K., and Nakanishi, K. (2004). Chemistry and biology of terpene trilactones from *Ginkgo biloba*. *Angew. Chem. Int. Ed. Engl.* **43**, 1640-1658.
- Sugimura, T., Nagao, M., Matsushima, T., Yahagi, T., Seino, Y., Shirai, A., Sawamura, M., Natori, S., Yoshihira, K., Fukuola, M., and Kuroyanagi, M. (1977). Mutagenicity of flavone derivatives. *Proc. Jpn. Acad. Ser. B* **53**, 194-197.
- Tarone, R.E. (1975). Tests for trend in life table analysis. *Biometrika* **62**, 679-682.
- Tennant, R.W., Margolin, B.H., Shelby, M.D., Zeiger, E., Haseman, J.K., Spalding, J., Caspary, W., Resnick, M., Stasiewicz, S., Anderson, B., and Minor, R. (1987). Prediction of chemical carcinogenicity in rodents from in vitro genetic toxicity assays. *Science* **236**, 933-941.



- Tolman, K.G., and Rej, R. (1999). Liver function. In *Tietz Textbook of Clinical Chemistry*, 3rd ed. (C.A. Burtis and E.R. Ashwood, Eds.), pp. 1125-1177. W.B. Saunders Company, Philadelphia, PA.
- Tomb, R.R., Fousseureau, J., and Sell, Y. (1988). Mini-epidemic of contact dermatitis from ginkgo tree fruit (*Ginkgo biloba* L.). *Contact Dermatitis* **19**, 281-283.
- Turusov, V.S., Torii, M., Sills, R.C., Willson, G.A., Herbert, R.A., Hailey, J.R., Haseman, J.K., and Boorman, G.A. (2002). Hepatoblastomas in mice in the U.S. National Toxicology Program (NTP) studies. *Toxicol. Pathol.* **30**, 580-591.
- Ude, C., Paulke, A., Nöldner, M., Schubert-Zsilavec, M., and Wurglics, M. (2011). Plasma and brain levels of terpene trilactones in rats after an oral single dose of standardized *Ginkgo biloba* extract Egb 761®. *Planta Med.* **77**, 259-264.
- van Beek, T.A., and Montoro, P. (2009). Chemical analysis and quality control of *Ginkgo biloba* leaves, extracts, and phytopharmaceuticals. *J. Chromatogr. A* **1216**, 2002-2032.
- Van der Hoeven, J.C., Bruggeman, I.M., and Debets, F.M. (1984). Genotoxicity of quercetin in cultured mammalian cells. *Mutat. Res.* **136**, 9-21.
- Vilar, J.B., Leite, K.R., and Chen Chen L. (2009). Antimutagenicity protection of *Ginkgo biloba* extract (Egb 761) against mitomycin C and cyclophosphamide in mouse bone marrow. *Genet. Mol. Res.* **24**, 328-333.
- Walsh, K.M., and Courtney, C.L. (1998). Nasal toxicity of CI-959, a novel anti-inflammatory drug, in Wistar rats and Beagle dogs. *Toxicol. Pathol.* **26**, 717-723.
- Wang, C.G., Dai, Y., Li, D.L., and Ma, K.Y. (2010). *Ginkgo biloba* leaf extract action in scavenging free radicals and reducing mutagenicity and toxicity of cigarette smoke in vivo. *J. Environ. Sci. Health A Tox. Hazard Subst. Environ. Eng.* **45**, 498-505.
- Watson, D.G., and Oliveira, E.J. (1999). Solid-phase extraction and gas chromatography-mass spectrometry determination of kaempferol and quercetin in human urine after consumption of *Ginkgo biloba* tablets. *J. Chromatogr. B Biomed. Sci. Appl.* **723**, 203-210.
- Watson, W.A. (1982). The mutagenic activity of quercetin and kaempferol in *Drosophila melanogaster*. *Mutat. Res.* **103**, 145-147.
- Westendorf, J., and Regan, J. (2000). Induction of DNA strand-breaks in primary rat hepatocytes by ginkgolic acids. *Pharmazie* **55**, 864-865.
- Williams, D.A. (1971). A test for differences between treatment means when several dose levels are compared with a zero dose control. *Biometrics* **27**, 103-117.
- Williams, D.A. (1972). The comparison of several dose levels with a zero dose control. *Biometrics* **28**, 519-531.
- Williams, D.A. (1986). A note on Shirley's nonparametric test for comparing several dose levels with a zero-dose control. *Biometrics* **42**, 183-186.
- Witt, K.L., Knapton, A., Wehr, C.M., Hook, G.J., Mirsalis, J., Shelby, M.D., and MacGregor, J.T. (2000). Micronucleated erythrocyte frequency in peripheral blood of B6C3F mice from short-term, prechronic, and chronic studies of the NTP Carcinogenesis Bioassay Program. *Environ. Mol. Mutagen.* **36**, 163-194.
- Woelkart, K., Feizlmayr, E., Dittrich, P., Beubler, E., Pinl, F., Suter, A., and Bauer, R. (2010). Pharmacokinetics of bilobalide, ginkgolide A and B after administration of three different *Ginkgo biloba* L. preparations in humans. *Phytother. Res.* **24**, 445-450.
- Woerdenbag, H.J., and De Smet, P.A.G.M. (2000). Adverse effects of and toxicity of Ginkgo extracts. In *Ginkgo biloba* (T.A. van Beek, Ed.), pp. 544-555. Harwood Academic Publishers, Amsterdam.
- Woerdenbag, H.J., and van Beek, T.A. (1997). *Ginkgo biloba*. In *Adverse Effects of Herbal Drugs* (P.A.G.M. De Smet, K. Keller, R. Hänsel, and R.F. Chandler, Eds.), Vol. 3, pp. 51-66. Springer-Verlag, Berlin.
- Xie, J., Ding, C., Ge, Q., Zhou, Z., and Zhi, X. (2008). Simultaneous determination of ginkgolides A, B, C and bilobalide in plasma by LC-MS/MS and its application to the pharmacokinetic study of *Ginkgo biloba* extract in rats. *J. Chromatogr. B Analyt. Technol. Biomed. Life Sci.* **864**, 87-94.
- Ye, B., Aponte, M., Dai, Y., Li, L., Ho, M.C., Vitonis, A., Edwards, D., Huang, T.N., and Cramer, D.W. (2007). *Ginkgo biloba* and ovarian cancer prevention: Epidemiological and biological evidence. *Cancer Lett.* **251**, 43-52.
- Yeh, K.Y., Pu, H.F., Kaphle, K., Lin, S.F., Wu, L.S., Lin, J.H., and Tsai, Y.F. (2008). *Ginkgo biloba* extract enhances male copulatory behavior and reduces serum prolactin levels in rats. *Horm. Behav.* **53**, 225-231.

Yoshida, M.A., Sasaki, M., Sugimura, K., and Kawachi, T. (1980). Cytogenetic effects of quercetin on cultured mammalian cells. *Proc. Jpn. Acad. Ser. B* **56**, 443-447.

Zeiger, E., Haseman, J.K., Shelby, M.D., Margolin, B.H., and Tennant, R.W. (1990). Evaluation of four in vitro genetic toxicity tests for predicting rodent carcinogenicity: Confirmation of earlier results with 41 additional chemicals. *Environ. Mol. Mutagen.* **16** (Suppl. 18), 1-14.

Zeiger, E., Anderson, B., Haworth, S., Lawlor, T., and Mortelmans, K. (1992). Salmonella mutagenicity tests: V. Results from the testing of 311 chemicals. *Environ. Mol. Mutagen.* **19** (Suppl. 21), 2-141.

Zhou, Z., and Zheng, S. (2003). The missing link in Ginkgo evolution. *Nature* **423**, 821-822.



**APPENDIX A**  
**SUMMARY OF LESIONS IN MALE RATS**  
**IN THE 2-YEAR GAVAGE STUDY**  
**OF *GINKGO BILOBA* EXTRACT**

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**TABLE A1**  
**Summary of the Incidence of Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Moribund	7	8	10	14
Natural deaths	5	5	9	20
Survivors				
Terminal kill	38	37	31	16
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Intestine large, cecum	(50)	(49)	(50)	(50)
Intestine large, colon	(50)	(50)	(50)	(50)
Intestine large, rectum	(50)	(50)	(50)	(50)
Intestine small, duodenum	(50)	(50)	(50)	(50)
Intestine small, ileum	(50)	(49)	(50)	(50)
Intestine small, jejunum	(50)	(50)	(50)	(50)
Leiomyoma	1 (2%)			
Schwannoma malignant		1 (2%)		
Liver	(50)	(50)	(50)	(50)
Hepatocellular adenoma		2 (4%)	3 (6%)	
Hepatocellular adenoma, multiple		1 (2%)		
Ito cell tumor benign		1 (2%)		
Osteosarcoma, metastatic, bone			1 (2%)	
Mesentery	(4)	(4)	(8)	(5)
Hemangioma		1 (25%)		
Hemangiosarcoma			1 (13%)	
Pancreas	(50)	(50)	(50)	(50)
Acinus, adenoma				1 (2%)
Salivary glands	(50)	(50)	(50)	(50)
Stomach, forestomach	(50)	(50)	(50)	(50)
Stomach, glandular	(50)	(50)	(50)	(50)
<b>Cardiovascular System</b>				
Blood vessel	(50)	(50)	(50)	(50)
Heart	(50)	(50)	(50)	(50)
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Adenoma			1 (2%)	1 (2%)
Adrenal medulla	(50)	(50)	(50)	(50)
Pheochromocytoma benign	11 (22%)	4 (8%)	4 (8%)	6 (12%)
Pheochromocytoma benign, multiple				1 (2%)
Pheochromocytoma complex				1 (2%)
Pheochromocytoma malignant	1 (2%)	1 (2%)		1 (2%)
Bilateral, pheochromocytoma benign		2 (4%)	1 (2%)	
Bilateral, pheochromocytoma malignant	1 (2%)			
Islets, pancreatic	(50)	(50)	(50)	(50)
Adenoma	4 (8%)	2 (4%)	1 (2%)	1 (2%)
Carcinoma			1 (2%)	1 (2%)
Parathyroid gland	(47)	(48)	(48)	(47)

**TABLE A1**  
**Summary of the Incidence of Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Endocrine System</b> (continued)				
Pituitary gland	(50)	(50)	(50)	(50)
Pars distalis, adenoma	38 (76%)	28 (56%)	25 (50%)	18 (36%)
Pars distalis, adenoma, multiple		2 (4%)		1 (2%)
Pars distalis, carcinoma				1 (2%)
Pars intermedia, adenoma	1 (2%)	1 (2%)		1 (2%)
Thyroid gland	(50)	(50)	(49)	(45)
C-cell, adenoma	10 (20%)	9 (18%)	10 (20%)	1 (2%)
C-cell, carcinoma	1 (2%)	2 (4%)	2 (4%)	
Follicle, adenoma	2 (4%)	1 (2%)	3 (6%)	5 (11%)
<b>General Body System</b>				
None				
<b>Genital System</b>				
Coagulating gland	(0)	(0)	(1)	(0)
Epididymis	(50)	(50)	(50)	(50)
Preputial gland	(50)	(50)	(50)	(50)
Adenoma	4 (8%)	3 (6%)		3 (6%)
Carcinoma			1 (2%)	2 (4%)
Prostate	(50)	(50)	(50)	(50)
Seminal vesicle	(50)	(50)	(50)	(50)
Testes	(50)	(50)	(50)	(50)
Bilateral, interstitial cell, adenoma	26 (52%)	29 (58%)	26 (52%)	27 (54%)
Interstitial cell, adenoma	11 (22%)	8 (16%)	13 (26%)	12 (24%)
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(48)	(50)
Lymph node	(2)	(2)	(9)	(10)
Mediastinal, carcinoma, metastatic, thyroid gland			1 (11%)	
Lymph node, mandibular	(0)	(0)	(1)	(0)
Lymph node, mesenteric	(50)	(50)	(50)	(50)
Spleen	(50)	(50)	(50)	(50)
Hemangiosarcoma			2 (4%)	
Osteosarcoma, metastatic, bone			1 (2%)	
Thymus	(47)	(50)	(47)	(47)
Thymoma benign	1 (2%)			1 (2%)
<b>Integumentary System</b>				
Mammary gland	(50)	(50)	(50)	(50)
Fibroadenoma	2 (4%)	1 (2%)	3 (6%)	1 (2%)
Skin	(50)	(50)	(50)	(50)
Basal cell adenoma	1 (2%)	1 (2%)	1 (2%)	
Keratoacanthoma	1 (2%)	3 (6%)	1 (2%)	3 (6%)
Keratoacanthoma, multiple	1 (2%)			1 (2%)
Subcutaneous tissue, fibroma	1 (2%)	1 (2%)	1 (2%)	1 (2%)
Subcutaneous tissue, fibrosarcoma				3 (6%)
Subcutaneous tissue, fibrous histiocytoma	1 (2%)			
Subcutaneous tissue, schwannoma malignant	1 (2%)		2 (4%)	
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Osteosarcoma			2 (4%)	

**TABLE A1**  
**Summary of the Incidence of Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Nervous System</b>				
Brain	(50)	(50)	(50)	(50)
Peripheral nerve	(0)	(0)	(0)	(1)
Spinal cord	(0)	(0)	(0)	(1)
<b>Respiratory System</b>				
Lung	(50)	(50)	(50)	(50)
Alveolar/bronchiolar adenoma	1 (2%)	1 (2%)	1 (2%)	2 (4%)
Alveolar/bronchiolar carcinoma			1 (2%)	1 (2%)
Carcinoma, metastatic, thyroid gland	1 (2%)	1 (2%)	1 (2%)	
Cystic keratinizing epithelioma			1 (2%)	
Osteosarcoma, metastatic, bone			1 (2%)	
Pheochromocytoma malignant, metastatic, adrenal medulla	1 (2%)	1 (2%)		
Nose	(50)	(49)	(49)	(50)
Pleura	(0)	(0)	(1)	(0)
Trachea	(50)	(50)	(50)	(50)
<b>Special Senses System</b>				
Eye	(50)	(50)	(50)	(50)
Harderian gland	(50)	(50)	(50)	(50)
Zymbal's gland	(1)	(0)	(0)	(1)
Carcinoma	1 (100%)			1 (100%)
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Lipoma	1 (2%)			
Renal tubule, adenoma			1 (2%)	1 (2%)
Transitional epithelium, carcinoma		1 (2%)		
Urinary bladder	(50)	(50)	(50)	(50)
<b>Systemic Lesions</b>				
Multiple organs <sup>b</sup>	(50)	(50)	(50)	(50)
Leukemia mononuclear	9 (18%)	12 (24%)	22 (44%)	21 (42%)
Mesothelioma malignant	3 (6%)	2 (4%)	1 (2%)	1 (2%)
<b>Neoplasm Summary</b>				
Total animals with primary neoplasms <sup>c</sup>	50	48	50	49
Total primary neoplasms	135	120	131	121
Total animals with benign neoplasms	50	48	49	48
Total benign neoplasms	117	101	96	88
Total animals with malignant neoplasms	13	17	30	29
Total malignant neoplasms	18	19	35	33
Total animals with metastatic neoplasms	3	3	2	
Total metastatic neoplasms	3	3	5	

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with neoplasm

<sup>b</sup> Number of animals with any tissue examined microscopically

<sup>c</sup> Primary neoplasms: all neoplasms except metastatic neoplasms

**TABLE A2**  
**Statistical Analysis of Primary Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Adrenal Medulla: Benign Pheochromocytoma</b>				
Overall rate <sup>a</sup>	11/50 (22%)	6/50 (12%)	5/50 (10%)	7/50 (14%)
Adjusted rate <sup>b</sup>	23.6%	13.0%	11.1%	16.4%
Terminal rate <sup>c</sup>	9/38 (24%)	4/37 (11%)	3/31 (10%)	2/16 (13%)
First incidence (days)	699	662	662	668
Poly-3 test <sup>d</sup>	P=0.423N	P=0.146N	P=0.095N	P=0.283N
<b>Adrenal Medulla: Benign, Complex, or Malignant Pheochromocytoma</b>				
Overall rate	12/50 (24%)	7/50 (14%)	5/50 (10%)	9/50 (18%)
Adjusted rate	25.7%	15.2%	11.1%	21.1%
Terminal rate	10/38 (26%)	5/37 (14%)	3/31 (10%)	3/16 (19%)
First incidence (days)	699	662	662	668
Poly-3 test	P=0.564	P=0.157N	P=0.060N	P=0.396N
<b>Liver: Hepatocellular Adenoma</b>				
Overall rate	0/50 (0%)	3/50 (6%)	3/50 (6%)	0/50 (0%)
Adjusted rate	0.0%	6.5%	6.7%	0.0%
Terminal rate	0/38 (0%)	2/37 (5%)	2/31 (7%)	0/16 (0%)
First incidence (days)	— <sup>e</sup>	714	692	—
Poly-3 test	P=0.325N	P=0.117	P=0.112	— <sup>f</sup>
<b>Mammary Gland: Fibroadenoma</b>				
Overall rate	2/50 (4%)	1/50 (2%)	3/50 (6%)	1/50 (2%)
Adjusted rate	4.3%	2.2%	6.7%	2.4%
Terminal rate	2/38 (5%)	0/37 (0%)	1/31 (3%)	0/16 (0%)
First incidence (days)	727 (T)	706	626	665
Poly-3 test	P=0.504N	P=0.504N	P=0.486	P=0.534N
<b>Pancreatic Islets: Adenoma</b>				
Overall rate	4/50 (8%)	2/50 (4%)	1/50 (2%)	1/50 (2%)
Adjusted rate	8.6%	4.4%	2.2%	2.4%
Terminal rate	3/38 (8%)	2/37 (5%)	1/31 (3%)	0/16 (0%)
First incidence (days)	626	727 (T)	727 (T)	689
Poly-3 test	P=0.211N	P=0.346N	P=0.194N	P=0.213N
<b>Pancreatic Islets: Adenoma or Carcinoma</b>				
Overall rate	4/50 (8%)	2/50 (4%)	2/50 (4%)	2/50 (4%)
Adjusted rate	8.6%	4.4%	4.5%	4.7%
Terminal rate	3/38 (8%)	2/37 (5%)	1/31 (5%)	0/16 (0%)
First incidence (days)	626	727 (T)	722	591
Poly-3 test	P=0.421N	P=0.346N	P=0.360N	P=0.383N
<b>Pituitary Gland (Pars Distalis): Adenoma</b>				
Overall rate	38/50 (76%)	30/50 (60%)	25/50 (50%)	19/50 (38%)
Adjusted rate	76.4%	61.8%	53.5%	41.9%
Terminal rate	28/38 (74%)	21/37 (57%)	18/31 (58%)	3/16 (19%)
First incidence (days)	505	449	534	568
Poly-3 test	P<0.001N	P=0.087N	P=0.013N	P<0.001N
<b>Pituitary Gland (Pars Distalis): Adenoma or Carcinoma</b>				
Overall rate	38/50 (76%)	30/50 (60%)	25/50 (50%)	20/50 (40%)
Adjusted rate	76.4%	61.8%	53.5%	43.5%
Terminal rate	28/38 (74%)	21/37 (57%)	18/31 (58%)	3/16 (19%)
First incidence (days)	505	449	534	510
Poly-3 test	P<0.001N	P=0.087N	P=0.013N	P<0.001N



**TABLE A2**  
**Statistical Analysis of Primary Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Preputial Gland: Adenoma</b>				
Overall rate	4/50 (8%)	3/50 (6%)	0/49 (0%)	3/50 (6%)
Adjusted rate	8.6%	6.5%	0.0%	7.0%
Terminal rate	4/38 (11%)	2/37 (5%)	0/30 (0%)	0/16 (0%)
First incidence (days)	727 (T)	662	—	600
Poly-3 test	P=0.573N	P=0.504N	P=0.069N	P=0.545N
<b>Preputial Gland: Adenoma or Carcinoma</b>				
Overall rate	4/50 (8%)	3/50 (6%)	1/49 (2%)	5/50 (10%)
Adjusted rate	8.6%	6.5%	2.3%	11.6%
Terminal rate	4/38 (11%)	2/37 (5%)	0/30 (0%)	1/16 (6%)
First incidence (days)	727 (T)	662	722	600
Poly-3 test	P=0.274	P=0.504N	P=0.198N	P=0.452
<b>Skin: Keratoacanthoma</b>				
Overall rate	2/50 (4%)	3/50 (6%)	1/50 (2%)	4/50 (8%)
Adjusted rate	4.3%	6.5%	2.2%	9.4%
Terminal rate	2/38 (5%)	3/37 (8%)	1/31 (3%)	2/16 (13%)
First incidence (days)	727 (T)	727 (T)	727 (T)	602
Poly-3 test	P=0.234	P=0.494	P=0.514N	P=0.296
<b>Skin: Keratoacanthoma or Basal Cell Adenoma</b>				
Overall rate	2/50 (4%)	4/50 (8%)	2/50 (4%)	4/50 (8%)
Adjusted rate	4.3%	8.7%	4.5%	9.4%
Terminal rate	2/38 (5%)	4/37 (11%)	2/31 (7%)	2/16 (13%)
First incidence (days)	727 (T)	727 (T)	727 (T)	602
Poly-3 test	P=0.320	P=0.332	P=0.679	P=0.296
<b>Skin (Subcutaneous Tissue): Fibrosarcoma</b>				
Overall rate	0/50 (0%)	0/50 (0%)	0/50 (0%)	3/50 (6%)
Adjusted rate	0.0%	0.0%	0.0%	7.0%
Terminal rate	0/38 (0%)	0/37 (0%)	0/31 (0%)	1/16 (6%)
First incidence (days)	—	—	—	505
Poly-3 test	P=0.007	—	—	P=0.106
<b>Skin (Subcutaneous Tissue): Fibrous Histiocytoma or Fibrosarcoma</b>				
Overall rate	1/50 (2%)	0/50 (0%)	0/50 (0%)	3/50 (6%)
Adjusted rate	2.2%	0.0%	0.0%	7.0%
Terminal rate	0/38 (0%)	0/37 (0%)	0/31 (0%)	1/16 (6%)
First incidence (days)	684	—	—	505
Poly-3 test	P=0.047	P=0.503N	P=0.509N	P=0.278
<b>Skin (Subcutaneous Tissue): Fibroma, Fibrous Histiocytoma, or Fibrosarcoma</b>				
Overall rate	2/50 (4%)	1/50 (2%)	1/50 (2%)	4/50 (8%)
Adjusted rate	4.3%	2.2%	2.2%	9.2%
Terminal rate	1/38 (3%)	1/37 (3%)	0/31 (0%)	1/16 (6%)
First incidence (days)	684	727 (T)	588	505
Poly-3 test	P=0.111	P=0.505N	P=0.512N	P=0.305
<b>Testes: Adenoma</b>				
Overall rate	37/50 (74%)	37/50 (74%)	39/50 (78%)	39/50 (78%)
Adjusted rate	79.1%	79.1%	81.6%	81.3%
Terminal rate	34/38 (90%)	31/37 (84%)	25/31 (81%)	15/16 (94%)
First incidence (days)	692	657	547	505
Poly-3 test	P=0.450	P=0.602N	P=0.482	P=0.498

**TABLE A2**  
**Statistical Analysis of Primary Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Thyroid Gland (C-Cell): Adenoma</b>				
Overall rate	10/50 (20%)	9/50 (18%)	10/49 (20%)	1/45 (2%)
Adjusted rate	21.3%	19.6%	22.8%	2.7%
Terminal rate	9/38 (24%)	9/37 (24%)	9/31 (29%)	0/16 (0%)
First incidence (days)	526	727 (T)	662	665
Poly-3 test	P=0.012N	P=0.525N	P=0.532	P=0.012N
<b>Thyroid Gland (C-Cell): Adenoma or Carcinoma</b>				
Overall rate	11/50 (22%)	11/50 (22%)	12/49 (24%)	1/45 (2%)
Adjusted rate	23.4%	24.0%	27.3%	2.7%
Terminal rate	10/38 (26%)	11/37 (30%)	10/31 (32%)	0/16 (0%)
First incidence (days)	526	727 (T)	662	665
Poly-3 test	P=0.006N	P=0.569	P=0.426	P=0.007N
<b>Thyroid Gland (Follicular Cell): Adenoma</b>				
Overall rate	2/50 (4%)	1/50 (2%)	3/49 (6%)	5/45 (11%)
Adjusted rate	4.3%	2.2%	6.7%	13.2%
Terminal rate	2/38 (5%)	0/37 (0%)	1/31 (3%)	2/16 (13%)
First incidence (days)	727 (T)	685	485	675
Poly-3 test	P=0.040	P=0.503N	P=0.482	P=0.142
<b>All Organs: Hemangiosarcoma</b>				
Overall rate	0/50 (0%)	0/50 (0%)	3/50 (6%)	0/50 (0%)
Adjusted rate	0.0%	0.0%	6.7%	0.0%
Terminal rate	0/38 (0%)	0/37 (0%)	2/31 (7%)	0/16 (0%)
First incidence (days)	—	—	664	—
Poly-3 test	P=0.663N	—	P=0.112	—
<b>All Organs: Hemangioma or Hemangiosarcoma</b>				
Overall rate	0/50 (0%)	1/50 (2%)	3/50 (6%)	0/50 (0%)
Adjusted rate	0.0%	2.2%	6.7%	0.0%
Terminal rate	0/38 (0%)	0/37 (0%)	2/31 (7%)	0/16 (0%)
First incidence (days)	—	657	664	—
Poly-3 test	P=0.524N	P=0.499	P=0.112	—
<b>All Organs: Mononuclear Cell Leukemia</b>				
Overall rate	9/50 (18%)	12/50 (24%)	22/50 (44%)	21/50 (42%)
Adjusted rate	19.2%	25.7%	45.7%	46.8%
Terminal rate	6/38 (16%)	7/37 (19%)	9/31 (29%)	7/16 (44%)
First incidence (days)	626	643	485	568
Poly-3 test	P=0.004	P=0.308	P=0.004	P=0.003
<b>All Organs: Malignant Mesothelioma</b>				
Overall rate	3/50 (6%)	2/50 (4%)	1/50 (2%)	1/50 (2%)
Adjusted rate	6.4%	4.4%	2.2%	2.4%
Terminal rate	2/38 (5%)	2/37 (5%)	1/31 (3%)	0/16 (0%)
First incidence (days)	684	727 (T)	727 (T)	675
Poly-3 test	P=0.303N	P=0.507N	P=0.321N	P=0.343N
<b>All Organs: Benign Neoplasms</b>				
Overall rate	50/50 (100%)	48/50 (96%)	49/50 (98%)	48/50 (96%)
Adjusted rate	100.0%	98.0%	98.3%	96.2%
Terminal rate	38/38 (100%)	36/37 (100%)	31/31 (100%)	15/16 (94%)
First incidence (days)	505	449	485	505
Poly-3 test	P=0.209N	P=0.496N	P=0.569N	P=0.249N

**TABLE A2**  
**Statistical Analysis of Primary Neoplasms in Male Rats in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>All Organs: Malignant Neoplasms</b>				
Overall rate	13/50 (26%)	17/50 (34%)	30/50 (60%)	29/50 (58%)
Adjusted rate	27.5%	36.2%	61.1%	61.5%
Terminal rate	8/38 (21%)	11/37 (30%)	14/31 (45%)	10/16 (63%)
First incidence (days)	626	643	485	505
Poly-3 test	P<0.001	P=0.248	P<0.001	P<0.001
<b>All Organs: Benign or Malignant Neoplasms</b>				
Overall rate	50/50 (100%)	48/50 (96%)	50/50 (100%)	49/50 (98%)
Adjusted rate	100.0%	98.0%	100.0%	98.2%
Terminal rate	38/38 (100%)	36/37 (100%)	31/31 (100%)	16/16 (100%)
First incidence (days)	505	449	485	505
Poly-3 test	P=0.509N	P=0.496N	—	P=0.542N

(T) Terminal kill

- <sup>a</sup> Number of neoplasm-bearing animals/number of animals examined. Denominator is number of animals examined microscopically for adrenal gland, liver, pancreatic islets, pituitary gland, preputial gland, testes, and thyroid gland; for other tissues, denominator is number of animals necropsied.
- <sup>b</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality
- <sup>c</sup> Observed incidence at terminal kill
- <sup>d</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for the differential mortality in animals that do not reach terminal kill. A negative trend or a lower incidence in a dose group is indicated by N.
- <sup>e</sup> Not applicable; no neoplasms in animal group
- <sup>f</sup> Value of statistic cannot be computed.

**TABLE A3a**  
**Historical Incidence of Thyroid Gland Follicular Cell Adenoma in Control Male F344/N Rats<sup>a</sup>**

Study (Study Start)	Incidence in Controls
<b>Historical Incidence: Corn Oil Gavage Studies</b>	
<i>Ginkgo biloba</i> extract (March 2005)	2/50
Isoeugenol (April 2002)	1/50
Kava kava extract (August 2004)	1/49
β-Myrcene (March 2002)	1/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	1/50
Pulegone (April 2003)	0/50
Total (%)	6/299 (2.0%)
Mean ± standard deviation	2.0% ± 1.3%
Range	0%-4%
<b>Overall Historical Incidence: All Routes</b>	
Total (%)	13/1,239 (1.1%)
Mean ± standard deviation	1.0% ± 1.7%
Range	0%-6%

<sup>a</sup> Data as of May 2011

**TABLE A3b**  
**Historical Incidence of Mononuclear Cell Leukemia in Control Male F344/N Rats<sup>a</sup>**

Study (Study Start)	Incidence in Controls
<b>Historical Incidence: Corn Oil Gavage Studies</b>	
<i>Ginkgo biloba</i> extract (March 2005)	9/50
Isoeugenol (April 2002)	10/50
Kava kava extract (August 2004)	7/49
β-Myrcene (March 2002)	9/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	14/50
Pulegone (April 2003)	4/50
Total (%)	53/299 (17.7%)
Mean ± standard deviation	17.7% ± 6.6%
Range	8%-28%
<b>Overall Historical Incidence: All Routes</b>	
Total (%)	450/1,249 (36.0%)
Mean ± standard deviation	36.0% ± 14.4%
Range	8%-58%

<sup>a</sup> Data as of May 2011; may include lymphocytic, monocytic, mononuclear, or undifferentiated leukemia.

**TABLE A4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Moribund	7	8	10	14
Natural deaths	5	5	9	20
Survivors				
Terminal kill	38	37	31	16
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Intestine large, cecum	(50)	(49)	(50)	(50)
Inflammation, chronic				1 (2%)
Thrombosis	1 (2%)			
Ulcer	1 (2%)			
Intestine large, colon	(50)	(50)	(50)	(50)
Parasite metazoan			2 (4%)	1 (2%)
Intestine large, rectum	(50)	(50)	(50)	(50)
Inflammation, acute				1 (2%)
Parasite metazoan	3 (6%)	8 (16%)	5 (10%)	5 (10%)
Intestine small, duodenum	(50)	(50)	(50)	(50)
Intestine small, ileum	(50)	(49)	(50)	(50)
Intestine small, jejunum	(50)	(50)	(50)	(50)
Liver	(50)	(50)	(50)	(50)
Angiectasis	2 (4%)	5 (10%)	2 (4%)	3 (6%)
Basophilic focus	30 (60%)	37 (74%)	23 (46%)	22 (44%)
Clear cell focus	31 (62%)	30 (60%)	18 (36%)	11 (22%)
Congestion	1 (2%)			
Degeneration, cystic	4 (8%)	14 (28%)	10 (20%)	14 (28%)
Eosinophilic focus	14 (28%)	21 (42%)	19 (38%)	21 (42%)
Fatty change, focal	3 (6%)			
Fibrosis		1 (2%)		
Hepatodiaphragmatic nodule	2 (4%)	3 (6%)	3 (6%)	
Inflammation, chronic	44 (88%)	41 (82%)	30 (60%)	32 (64%)
Mixed cell focus	19 (38%)	32 (64%)	24 (48%)	17 (34%)
Necrosis	1 (2%)	4 (8%)	6 (12%)	7 (14%)
Thrombosis				1 (2%)
Bile duct, hyperplasia	32 (64%)	43 (86%)	46 (92%)	46 (92%)
Hepatocyte, fatty change	27 (54%)	18 (36%)	23 (46%)	31 (62%)
Hepatocyte, hypertrophy	1 (2%)	17 (34%)	26 (52%)	27 (54%)
Oval cell, hyperplasia		1 (2%)	1 (2%)	10 (20%)
Mesentery	(4)	(4)	(8)	(5)
Thrombosis				1 (20%)
Fat, necrosis	2 (50%)	2 (50%)	5 (63%)	3 (60%)
Pancreas	(50)	(50)	(50)	(50)
Inflammation, chronic		1 (2%)	1 (2%)	
Mineralization	1 (2%)			
Necrosis				1 (2%)
Acinus, atrophy	22 (44%)	23 (46%)	14 (28%)	20 (40%)
Acinus, hyperplasia	11 (22%)	7 (14%)	5 (10%)	12 (24%)
Duct, cyst	3 (6%)	5 (10%)	10 (20%)	3 (6%)
Salivary glands	(50)	(50)	(50)	(50)

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with lesion

**TABLE A4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Alimentary System</b> (continued)				
Stomach, forestomach	(50)	(50)	(50)	(50)
Inflammation, chronic	4 (8%)	1 (2%)	6 (12%)	6 (12%)
Mineralization			1 (2%)	
Ulcer	2 (4%)		4 (8%)	4 (8%)
Stomach, glandular	(50)	(50)	(50)	(50)
Inflammation, suppurative		1 (2%)		
Inflammation, chronic		1 (2%)	1 (2%)	
Mineralization	1 (2%)	1 (2%)	1 (2%)	6 (12%)
Ulcer	2 (4%)			2 (4%)
Epithelium, hyperplasia	1 (2%)			
Glands, ectasia	17 (34%)	30 (60%)	19 (38%)	12 (24%)
Glands, hyperplasia		2 (4%)		1 (2%)
<b>Cardiovascular System</b>				
Blood vessel	(50)	(50)	(50)	(50)
Thrombosis				1 (2%)
Aorta, mineralization	1 (2%)			2 (4%)
Pulmonary vein, mineralization	1 (2%)			
Heart	(50)	(50)	(50)	(50)
Cardiomyopathy	50 (100%)	48 (96%)	49 (98%)	50 (100%)
Atrium, thrombosis	3 (6%)		1 (2%)	3 (6%)
Myocardium, mineralization	1 (2%)			2 (4%)
Valve, inflammation, chronic			1 (2%)	
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Cytoplasmic alteration		1 (2%)		
Degeneration, cystic	2 (4%)	4 (8%)		
Hyperplasia, focal	12 (24%)	9 (18%)	9 (18%)	8 (16%)
Hypertrophy, focal	7 (14%)	10 (20%)	9 (18%)	3 (6%)
Hypertrophy, diffuse	3 (6%)	3 (6%)	5 (10%)	11 (22%)
Infiltration cellular, mononuclear cell		1 (2%)		
Inflammation, chronic				1 (2%)
Necrosis		1 (2%)	2 (4%)	1 (2%)
Vacuolization cytoplasmic, focal	17 (34%)	17 (34%)	16 (32%)	13 (26%)
Vacuolization cytoplasmic, diffuse	18 (36%)	25 (50%)	33 (66%)	34 (68%)
Adrenal medulla	(50)	(50)	(50)	(50)
Hyperplasia	15 (30%)	16 (32%)	8 (16%)	10 (20%)
Necrosis			1 (2%)	
Islets, pancreatic	(50)	(50)	(50)	(50)
Hyperplasia	3 (6%)	2 (4%)	5 (10%)	2 (4%)
Parathyroid gland	(47)	(48)	(48)	(47)
Hyperplasia	1 (2%)	3 (6%)	2 (4%)	7 (15%)
Pituitary gland	(50)	(50)	(50)	(50)
Angiectasis			1 (2%)	1 (2%)
Cyst	5 (10%)	4 (8%)	7 (14%)	8 (16%)
Pars distalis, hyperplasia	19 (38%)	18 (36%)	18 (36%)	16 (32%)
Pars intermedia, hyperplasia	1 (2%)			1 (2%)
Thyroid gland	(50)	(50)	(49)	(45)
C-cell, hyperplasia	35 (70%)	29 (58%)	27 (55%)	24 (53%)
Follicle, hyperplasia		7 (14%)	9 (18%)	5 (11%)
Follicular cell, hypertrophy	13 (26%)	37 (74%)	41 (84%)	41 (91%)
<b>General Body System</b>				
None				

**TABLE A4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Genital System</b>				
Coagulating gland	(0)	(0)	(1)	(0)
Inflammation, chronic			1 (100%)	
Epididymis	(50)	(50)	(50)	(50)
Granuloma sperm		1 (2%)	3 (6%)	
Inflammation, chronic				1 (2%)
Mineralization		1 (2%)		
Preputial gland	(50)	(50)	(50)	(50)
Cyst	2 (4%)			
Hyperplasia	2 (4%)	1 (2%)		
Inflammation, chronic	49 (98%)	48 (96%)	47 (94%)	49 (98%)
Metaplasia, cartilagenous			1 (2%)	
Prostate	(50)	(50)	(50)	(50)
Hyperplasia	6 (12%)	3 (6%)	3 (6%)	4 (8%)
Inflammation	36 (72%)	27 (54%)	25 (50%)	32 (64%)
Necrosis	1 (2%)			
Seminal vesicle	(50)	(50)	(50)	(50)
Inflammation	2 (4%)	3 (6%)	2 (4%)	4 (8%)
Testes	(50)	(50)	(50)	(50)
Germinal epithelium, atrophy	1 (2%)		1 (2%)	1 (2%)
Germinal epithelium, necrosis			1 (2%)	
Interstitial cell, hyperplasia				1 (2%)
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(48)	(50)
Hyperplasia	14 (28%)	15 (30%)	21 (44%)	26 (52%)
Necrosis			1 (2%)	
Lymph node	(2)	(2)	(9)	(10)
Deep cervical, hyperplasia, plasma cell				1 (10%)
Mediastinal, ectasia			1 (11%)	1 (10%)
Mediastinal, hyperplasia, lymphoid		1 (50%)	1 (11%)	3 (30%)
Mediastinal, hyperplasia, plasma cell				1 (10%)
Mediastinal, infiltration cellular, histiocyte		1 (50%)		
Mediastinal, inflammation, suppurative	1 (50%)			
Pancreatic, necrosis				1 (10%)
Renal, hyperplasia, lymphoid				1 (10%)
Lymph node, mandibular	(0)	(0)	(1)	(0)
Ectasia			1 (100%)	
Lymph node, mesenteric	(50)	(50)	(50)	(50)
Ectasia			1 (2%)	
Hyperplasia, lymphoid		1 (2%)		
Infiltration cellular, histiocyte	1 (2%)	1 (2%)		
Necrosis		1 (2%)	1 (2%)	1 (2%)
Spleen	(50)	(50)	(50)	(50)
Fibrosis	1 (2%)	1 (2%)		
Hematopoietic cell proliferation	3 (6%)	8 (16%)	4 (8%)	6 (12%)
Hemorrhage		1 (2%)		
Necrosis		1 (2%)	1 (2%)	1 (2%)
Lymphoid follicle, atrophy	2 (4%)	1 (2%)	4 (8%)	14 (28%)
Thymus	(47)	(50)	(47)	(47)
Atrophy	47 (100%)	48 (96%)	46 (98%)	48 (98%)
Epithelial cell, hyperplasia	1 (2%)	1 (2%)		1 (2%)
<b>Integumentary System</b>				
Mammary gland	(50)	(50)	(50)	(50)
Hyperplasia				1 (2%)
Inflammation, chronic		1 (2%)		
Duct, cyst	12 (24%)	19 (38%)	13 (26%)	12 (24%)

**TABLE A4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Integumentary System</b> (continued)				
Skin	(50)	(50)	(50)	(50)
Cyst epithelial inclusion		1 (2%)		
Lymphatic, subcutaneous tissue, cyst	1 (2%)	1 (2%)		
Sebaceous gland, cyst	1 (2%)			
Subcutaneous tissue, hemorrhage				1 (2%)
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Hyperostosis		1 (2%)	1 (2%)	1 (2%)
<b>Nervous System</b>				
Brain	(50)	(50)	(50)	(50)
Necrosis		1 (2%)		
Hippocampus, necrosis				1 (2%)
Peripheral nerve	(0)	(0)	(0)	(1)
Axon, degeneration				1 (100%)
Spinal cord	(0)	(0)	(0)	(1)
<b>Respiratory System</b>				
Lung	(50)	(50)	(50)	(50)
Inflammation, acute				1 (2%)
Inflammation, chronic	19 (38%)	14 (28%)	12 (24%)	8 (16%)
Metaplasia, osseous	1 (2%)	1 (2%)	2 (4%)	
Thrombosis			1 (2%)	2 (4%)
Alveolar epithelium, hyperplasia	8 (16%)	4 (8%)	2 (4%)	5 (10%)
Bronchiole, hyperplasia	1 (2%)			
Bronchus, hyperplasia	1 (2%)			
Nose	(50)	(49)	(49)	(50)
Foreign body	11 (22%)	5 (10%)	9 (18%)	5 (10%)
Hemorrhage			1 (2%)	
Inflammation, chronic active	33 (66%)	32 (65%)	38 (78%)	46 (92%)
Respiratory metaplasia	1 (2%)			
Synechia, focal	1 (2%)		1 (2%)	
Thrombosis			1 (2%)	
Glands, hyperplasia	1 (2%)			
Goblet cell, respiratory epithelium, hyperplasia	20 (40%)	18 (37%)	41 (84%)	34 (68%)
Goblet cell, transitional epithelium, hyperplasia			1 (2%)	
Nasolacrimal duct, inflammation, chronic active	1 (2%)			
Nerve, olfactory epithelium, atrophy		17 (35%)	14 (29%)	23 (46%)
Olfactory epithelium, accumulation, hyaline droplet	45 (90%)	43 (88%)	14 (29%)	
Olfactory epithelium, atrophy	1 (2%)	26 (53%)	37 (76%)	31 (62%)
Olfactory epithelium, foreign body			1 (2%)	
Olfactory epithelium, hyperplasia				1 (2%)
Olfactory epithelium, pigmentation		39 (80%)	42 (86%)	30 (60%)
Olfactory epithelium, respiratory metaplasia	9 (18%)	30 (61%)	40 (82%)	32 (64%)
Respiratory epithelium, hyperplasia	14 (28%)	28 (57%)	45 (92%)	35 (70%)
Respiratory epithelium, inflammation, chronic	1 (2%)			
Submucosa, fibrosis				8 (16%)
Transitional epithelium, hyperplasia	2 (4%)	18 (37%)	43 (88%)	31 (62%)



**TABLE A4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Respiratory System (continued)</b>				
Pleura	(0)	(0)	(1)	(0)
Trachea	(50)	(50)	(50)	(50)
Inflammation, chronic	1 (2%)			2 (4%)
<b>Special Senses System</b>				
Eye	(50)	(50)	(50)	(50)
Cataract	1 (2%)	4 (8%)		
Degeneration		1 (2%)		
Anterior chamber, inflammation, suppurative				2 (4%)
Retina, atrophy		1 (2%)		
Harderian gland	(50)	(50)	(50)	(50)
Atrophy		1 (2%)		
Inflammation		2 (4%)		
Zymbal's gland	(1)	(0)	(0)	(1)
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Hydropnephrosis	1 (2%)			1 (2%)
Infarct			1 (2%)	
Nephropathy	49 (98%)	49 (98%)	49 (98%)	50 (100%)
Papilla, necrosis	3 (6%)	1 (2%)		1 (2%)
Pelvis, inflammation, acute				1 (2%)
Renal tubule, cyst	1 (2%)	1 (2%)	1 (2%)	1 (2%)
Renal tubule, hyperplasia	1 (2%)			
Urinary bladder	(50)	(50)	(50)	(50)
Inflammation, acute				2 (4%)
Inflammation, chronic	2 (4%)	1 (2%)		2 (4%)
Mineralization				1 (2%)
Necrosis	1 (2%)			
Ulcer				2 (4%)

**APPENDIX B**  
**SUMMARY OF LESIONS IN FEMALE RATS**  
**IN THE 2-YEAR GAVAGE STUDY**  
**OF *GINKGO BILOBA* EXTRACT**

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**TABLE B1**  
**Summary of the Incidence of Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Accidental death				1
Moribund	9	13	7	4
Natural deaths	4	10	6	13
Survivors				
Died last week of study			1	
Terminal kill	37	27	36	32
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Carcinoma, metastatic, uterus			1 (2%)	
Intestine large, cecum	(50)	(50)	(50)	(49)
Intestine large, colon	(50)	(50)	(50)	(49)
Intestine large, rectum	(50)	(50)	(50)	(50)
Intestine small, duodenum	(50)	(50)	(50)	(49)
Schwannoma, malignant	1 (2%)			
Intestine small, ileum	(50)	(50)	(50)	(49)
Carcinoma, metastatic, uterus			1 (2%)	
Intestine small, jejunum	(50)	(50)	(50)	(49)
Liver	(50)	(50)	(50)	(50)
Carcinoma, metastatic, uterus			1 (2%)	
Mesentery	(10)	(2)	(8)	(11)
Oral mucosa	(0)	(0)	(1)	(0)
Squamous cell papilloma			1 (100%)	
Pancreas	(50)	(50)	(50)	(48)
Carcinoma, metastatic, uterus			1 (2%)	
Salivary glands	(50)	(50)	(50)	(50)
Stomach, forestomach	(50)	(50)	(50)	(50)
Stomach, glandular	(50)	(50)	(50)	(50)
<b>Cardiovascular System</b>				
Blood vessel	(50)	(50)	(50)	(50)
Heart	(50)	(50)	(50)	(50)
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Adenoma			1 (2%)	
Carcinoma		1 (2%)		
Carcinoma, metastatic, uterus			1 (2%)	
Adrenal medulla	(50)	(50)	(50)	(50)
Pheochromocytoma benign	2 (4%)	2 (4%)		2 (4%)
Pheochromocytoma malignant				1 (2%)
Islets, pancreatic	(50)	(50)	(50)	(50)
Adenoma	1 (2%)			1 (2%)
Parathyroid gland	(38)	(47)	(43)	(35)
Adenoma	1 (3%)			
Pituitary gland	(50)	(50)	(50)	(50)
Pars distalis, adenoma	33 (66%)	27 (54%)	22 (44%)	16 (32%)
Pars distalis, adenoma, multiple	1 (2%)	1 (2%)		
Pars distalis, carcinoma	2 (4%)			2 (4%)
Pars intermedia, adenoma	1 (2%)			

**TABLE B1**  
**Summary of the Incidence of Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Endocrine System</b> (continued)				
Thyroid gland	(49)	(50)	(49)	(49)
Bilateral, C-cell, adenoma	1 (2%)			
C-cell, adenoma	10 (20%)	8 (16%)	8 (16%)	5 (10%)
C-cell, carcinoma		1 (2%)	1 (2%)	1 (2%)
Follicle, adenoma	1 (2%)		3 (6%)	1 (2%)
Follicle, carcinoma			1 (2%)	1 (2%)
<b>General Body System</b>				
None				
<b>Genital System</b>				
Clitoral gland	(50)	(50)	(50)	(50)
Adenoma	5 (10%)	5 (10%)	4 (8%)	7 (14%)
Carcinoma			1 (2%)	
Bilateral, adenoma		3 (6%)		1 (2%)
Ovary	(50)	(50)	(50)	(50)
Carcinoma, metastatic, uterus			1 (2%)	
Granulosa cell tumor benign		1 (2%)	1 (2%)	
Schwannoma malignant, metastatic, intestine small, duodenum	1 (2%)			
Tubulostromal adenoma	1 (2%)			
Uterus	(50)	(50)	(50)	(50)
Carcinoma			1 (2%)	
Polyp stromal	3 (6%)	8 (16%)	8 (16%)	9 (18%)
Schwannoma malignant	1 (2%)			
Endometrium adenoma				1 (2%)
Vagina	(0)	(2)	(0)	(0)
Schwannoma malignant		2 (100%)		
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(50)	(50)
Lymph node	(3)	(3)	(3)	(4)
Mediastinal, carcinoma, metastatic, thyroid gland		1 (33%)		
Lymph node, mesenteric	(50)	(50)	(50)	(50)
Carcinoma, metastatic, uterus			1 (2%)	
Spleen	(50)	(50)	(50)	(50)
Thymus	(50)	(48)	(49)	(48)
Thymoma benign	1 (2%)			
<b>Integumentary System</b>				
Mammary gland	(50)	(50)	(50)	(50)
Fibroadenoma	13 (26%)	22 (44%)	21 (42%)	10 (20%)
Fibroadenoma, multiple	10 (20%)	9 (18%)	10 (20%)	4 (8%)
Skin	(50)	(50)	(50)	(50)
Keratoacanthoma				1 (2%)
Squamous cell carcinoma	1 (2%)			
Subcutaneous tissue, fibroma	1 (2%)	1 (2%)	2 (4%)	1 (2%)
Subcutaneous tissue, fibrosarcoma			1 (2%)	1 (2%)
Subcutaneous tissue, schwannoma malignant		1 (2%)	1 (2%)	1 (2%)

**TABLE B1**  
**Summary of the Incidence of Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Skeletal muscle	(0)	(0)	(1)	(0)
Carcinoma, metastatic, uterus			1 (100%)	
<b>Nervous System</b>				
Brain	(50)	(50)	(50)	(50)
Astrocytoma malignant		1 (2%)		
Granular cell tumor malignant				1 (2%)
Peripheral nerve	(1)	(0)	(0)	(0)
Spinal cord	(1)	(0)	(0)	(0)
<b>Respiratory System</b>				
Larynx	(0)	(0)	(0)	(1)
Lung	(50)	(50)	(50)	(50)
Alveolar/bronchiolar adenoma	4 (8%)		3 (6%)	
Astrocytoma malignant, metastatic, brain		1 (2%)		
Carcinoma, metastatic, adrenal cortex		1 (2%)		
Carcinoma, metastatic, uterus			1 (2%)	
Granular cell tumor malignant, metastatic, brain				1 (2%)
Nose	(49)	(49)	(50)	(46)
Respiratory epithelium, adenoma			2 (4%)	
Trachea	(50)	(50)	(50)	(50)
<b>Special Senses System</b>				
Eye	(50)	(50)	(50)	(50)
Harderian gland	(50)	(50)	(50)	(50)
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Carcinoma, metastatic, uterus			1 (2%)	
Mesenchymal tumor malignant				1 (2%)
Renal tubule, adenoma				1 (2%)
Urinary bladder	(50)	(50)	(50)	(49)
Carcinoma, metastatic, uterus			1 (2%)	
<b>Systemic Lesions</b>				
Multiple organs <sup>b</sup>	(50)	(50)	(50)	(50)
Histiocytic sarcoma				1 (2%)
Leukemia mononuclear	8 (16%)	8 (16%)	7 (14%)	5 (10%)

**TABLE B1**  
**Summary of the Incidence of Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of *Ginkgo biloba* Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Neoplasm Summary</b>				
Total animals with primary neoplasms <sup>c</sup>	49	47	48	42
Total primary neoplasms	102	101	99	75
Total animals with benign neoplasms	47	43	46	37
Total benign neoplasms	89	87	86	60
Total animals with malignant neoplasms	12	14	12	13
Total malignant neoplasms	13	14	13	15
Total animals with metastatic neoplasms	1	3	1	1
Total metastatic neoplasms	1	3	11	1

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with neoplasm

<sup>b</sup> Number of animals with any tissue examined microscopically

<sup>c</sup> Primary neoplasms: all neoplasms except metastatic neoplasms

**TABLE B2**  
**Statistical Analysis of Primary Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Adrenal Medulla: Benign or Malignant Pheochromocytoma</b>				
Overall rate <sup>a</sup>	2/50 (4%)	2/50 (4%)	0/50 (0%)	3/50 (6%)
Adjusted rate <sup>b</sup>	4.4%	4.9%	0.0%	7.2%
Terminal rate <sup>c</sup>	1/37 (3%)	2/27 (7%)	0/37 (0%)	2/32 (6%)
First incidence (days)	653	728 (T)	— <sup>e</sup>	618
Poly-3 test <sup>d</sup>	P=0.329	P=0.652	P=0.237N	P=0.458
<b>Clitoral Gland: Adenoma</b>				
Overall rate	5/50 (10%)	8/50 (16%)	4/50 (8%)	8/50 (16%)
Adjusted rate	11.0%	19.2%	8.8%	19.0%
Terminal rate	4/37 (11%)	7/27 (26%)	4/37 (11%)	4/32 (13%)
First incidence (days)	698	380	728 (T)	587
Poly-3 test	P=0.269	P=0.218	P=0.498N	P=0.226
<b>Clitoral Gland: Adenoma or Carcinoma</b>				
Overall rate	5/50 (10%)	8/50 (16%)	5/50 (10%)	8/50 (16%)
Adjusted rate	11.1%	19.2%	10.8%	19.0%
Terminal rate	4/37 (11%)	7/27 (26%)	4/37 (11%)	4/32 (13%)
First incidence (days)	698	380	533	587
Poly-3 test	P=0.279	P=0.218	P=0.620N	P=0.226
<b>Lung: Alveolar/bronchiolar Adenoma</b>				
Overall rate	4/50 (8%)	0/50 (0%)	3/50 (6%)	0/50 (0%)
Adjusted rate	8.8%	0.0%	6.6%	0.0%
Terminal rate	4/37 (11%)	0/27 (0%)	2/37 (5%)	0/32 (0%)
First incidence (days)	728 (T)	—	710	—
Poly-3 test	P=0.117N	P=0.075N	P=0.496N	P=0.073N
<b>Mammary Gland: Fibroadenoma</b>				
Overall rate	23/50 (46%)	31/50 (62%)	31/50 (62%)	14/50 (28%)
Adjusted rate	49.7%	70.4%	64.8%	33.4%
Terminal rate	20/37 (54%)	19/27 (70%)	24/37 (65%)	10/32 (31%)
First incidence (days)	596	559	474	639
Poly-3 test	P=0.004N	P=0.031	P=0.097	P=0.086N
<b>Pituitary Gland (Pars Distalis): Adenoma</b>				
Overall rate	34/50 (68%)	28/50 (56%)	22/50 (44%)	16/50 (32%)
Adjusted rate	70.7%	62.2%	47.0%	37.8%
Terminal rate	24/37 (65%)	16/27 (59%)	17/37 (46%)	13/32 (41%)
First incidence (days)	551	433	609	533
Poly-3 test	P<0.001N	P=0.255N	P=0.013N	P<0.001N
<b>Pituitary Gland (Pars Distalis): Adenoma or Carcinoma</b>				
Overall rate	36/50 (72%)	28/50 (56%)	22/50 (44%)	18/50 (36%)
Adjusted rate	74.1%	62.2%	47.0%	42.6%
Terminal rate	25/37 (68%)	16/27 (59%)	17/37 (46%)	14/32 (44%)
First incidence (days)	551	433	609	533
Poly-3 test	P=0.002N	P=0.149N	P=0.004N	P<0.001N
<b>Skin (Subcutaneous Tissue): Fibroma or Fibrosarcoma</b>				
Overall rate	1/50 (2%)	1/50 (2%)	3/50 (6%)	2/50 (4%)
Adjusted rate	2.2%	2.5%	6.5%	4.8%
Terminal rate	1/37 (3%)	1/27 (4%)	2/37 (5%)	1/32 (3%)
First incidence (days)	728 (T)	728 (T)	656	533
Poly-3 test	P=0.401	P=0.736	P=0.309	P=0.472

**TABLE B2**  
**Statistical Analysis of Primary Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Thyroid Gland (C-Cell): Adenoma</b>				
Overall rate	11/49 (22%)	8/50 (16%)	8/49 (16%)	5/49 (10%)
Adjusted rate	24.0%	19.6%	17.5%	12.1%
Terminal rate	7/37 (19%)	7/27 (26%)	6/37 (16%)	3/32 (9%)
First incidence (days)	498	705	656	618
Poly-3 test	P=0.116N	P=0.408N	P=0.307N	P=0.124N
<b>Thyroid Gland (C-Cell): Adenoma or Carcinoma</b>				
Overall rate	11/49 (22%)	9/50 (18%)	9/49 (18%)	6/49 (12%)
Adjusted rate	24.0%	22.0%	19.7%	14.4%
Terminal rate	7/37 (19%)	7/27 (26%)	7/37 (19%)	3/32 (9%)
First incidence (days)	498	692	656	618
Poly-3 test	P=0.166N	P=0.513N	P=0.404N	P=0.196N
<b>Thyroid Gland (Follicular Cell): Adenoma</b>				
Overall rate	1/49 (2%)	0/50 (0%)	3/49 (6%)	1/49 (2%)
Adjusted rate	2.2%	0.0%	6.6%	2.4%
Terminal rate	1/37 (3%)	0/27 (0%)	3/37 (8%)	0/32 (0%)
First incidence (days)	728 (T)	—	728 (T)	637
Poly-3 test	P=0.573	P=0.519N	P=0.310	P=0.741
<b>Thyroid Gland (Follicular Cell): Adenoma or Carcinoma</b>				
Overall rate	1/49 (2%)	0/50 (0%)	4/49 (8%)	2/49 (4%)
Adjusted rate	2.2%	0.0%	8.8%	4.9%
Terminal rate	1/37 (3%)	0/27 (0%)	4/37 (11%)	1/32 (3%)
First incidence (days)	728 (T)	—	728 (T)	637
Poly-3 test	P=0.324	P=0.519N	P=0.183	P=0.469
<b>Uterus: Stromal Polyp</b>				
Overall rate	3/50 (6%)	8/50 (16%)	8/50 (16%)	9/50 (18%)
Adjusted rate	6.6%	18.8%	17.3%	20.7%
Terminal rate	2/37 (5%)	4/27 (15%)	7/27 (19%)	4/32 (13%)
First incidence (days)	653	433	533	521
Poly-3 test	P=0.120	P=0.077	P=0.102	P=0.048
<b>All Organs: Mononuclear Cell Leukemia</b>				
Overall rate	8/50 (16%)	8/50 (16%)	7/50 (14%)	5/50 (10%)
Adjusted rate	17.5%	19.1%	14.9%	12.1%
Terminal rate	6/37 (16%)	4/27 (15%)	4/37 (11%)	5/32 (16%)
First incidence (days)	653	629	580	728 (T)
Poly-3 test	P=0.258N	P=0.530	P=0.480N	P=0.344N
<b>All Organs: Benign Neoplasms</b>				
Overall rate	47/50 (94%)	43/50 (86%)	46/50 (92%)	37/50 (74%)
Adjusted rate	95.5%	90.5%	93.1%	81.2%
Terminal rate	35/37 (95%)	25/27 (93%)	35/37 (95%)	25/32 (78%)
First incidence (days)	498	380	474	521
Poly-3 test	P=0.014N	P=0.279N	P=0.474N	P=0.025N
<b>All Organs: Malignant Neoplasms</b>				
Overall rate	12/50 (24%)	14/50 (28%)	12/50 (24%)	13/50 (26%)
Adjusted rate	25.4%	32.0%	25.1%	30.4%
Terminal rate	7/37 (19%)	5/27 (19%)	6/37 (16%)	9/32 (28%)
First incidence (days)	454	327	533	533
Poly-3 test	P=0.430	P=0.320	P=0.580N	P=0.383



**TABLE B2**  
**Statistical Analysis of Primary Neoplasms in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>All Organs: Benign or Malignant Neoplasms</b>				
Overall rate	49/50 (98%)	47/50 (94%)	48/50 (96%)	42/50 (84%)
Adjusted rate	98.0%	95.6%	96.0%	91.1%
Terminal rate	36/37 (97%)	25/27 (93%)	35/37 (100%)	29/32 (91%)
First incidence (days)	454	327	474	521
Poly-3 test	P=0.100N	P=0.460N	P=0.500N	P=0.137N

(T) Terminal kill

- <sup>a</sup> Number of neoplasm-bearing animals/number of animals examined. Denominator is number of animals examined microscopically for adrenal gland, clitoral gland, lung, pituitary gland, and thyroid gland; for other tissues, denominator is number of animals necropsied.
- <sup>b</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality
- <sup>c</sup> Observed incidence at terminal kill
- <sup>d</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for the differential mortality in animals that do not reach terminal kill. A negative trend or a lower incidence in a dose group is indicated by **N**.
- <sup>e</sup> Not applicable; no neoplasms in animal group

**TABLE B3a**  
**Historical Incidence of Neoplasms of the Thyroid Gland in Control Female F344/N Rats<sup>a</sup>**

Study (Study Start)	Follicular Cell Adenoma	Follicular Cell Carcinoma	Follicular Cell Adenoma or Carcinoma
<b>Historical Incidence: Corn Oil Gavage Studies</b>			
<i>Ginkgo biloba</i> extract (March 2005)	1/49	0/49	1/49
Isoeugenol (April 2002)	0/50	1/50	1/50
Kava kava extract (August 2004)	1/50	0/50	1/50
β-Myrcene (March 2002)	0/50	0/50	0/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	1/49	0/49	1/49
Pulegone (April 2003)	0/50	0/50	0/50
Total (%)	3/298 (1.0%)	1/298 (0.3%)	4/298 (1.3%)
Mean ± standard deviation	1.0% ± 1.1%	0.3% ± 0.8%	1.4% ± 1.0%
Range	0%-2%	0%-2%	0%-2%
<b>Overall Historical Incidence: All Routes</b>			
Total (%)	8/1,186 (0.7%)	5/1,186 (0.4%)	12/1,186 (1.0%)
Mean ± standard deviation	0.7% ± 1.0%	0.4% ± 1.0%	1.0% ± 1.3%
Range	0%-2%	0%-4%	0%-4%

<sup>a</sup> Data as of May 2011

**TABLE B3b**  
**Historical Incidence of Adenoma of the Nose in Control Female F344/N Rats<sup>a</sup>**

Study (Study Start)	Incidence in Controls
<b>Historical Incidence: Corn Oil Gavage Studies</b>	
<i>Ginkgo biloba</i> extract (March 2005)	0/49
Isoeugenol (April 2002)	0/50
Kava kava extract (August 2004)	0/50
β-Myrcene (March 2002)	0/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	0/50
Pulegone (April 2003)	0/50
Total	0/299
<b>Overall Historical Incidence: All Routes</b>	
Total (%)	1/1,196 (0.1%)
Mean ± standard deviation	0.1% ± 0.4%
Range	0%-2%

<sup>a</sup> Data as of May 2011

**TABLE B3c**  
**Historical Incidence of Stromal Polyp of the Uterus in Control Female F344/N Rats<sup>a</sup>**

Study (Study Start)	Incidence in Controls
<b>Historical Incidence: Corn Oil Gavage Studies</b>	
<i>Ginkgo biloba</i> extract (March 2005)	3/50
Isoeugenol (April 2002)	8/50
Kava kava extract (August 2004)	7/50
β-Myrcene (March 2002)	8/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	3/50
Pulegone (April 2003)	5/50
Total (%)	34/300 (11.3%)
Mean ± standard deviation	11.3% ± 4.7%
Range	6%-16%
<b>Overall Historical Incidence: All Routes</b>	
Total (%)	189/1,200 (15.8%)
Mean ± standard deviation	15.8% ± 6.6%
Range	4%-34%

<sup>a</sup> Data as of May 2011

**TABLE B4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Accidental death				1
Moribund	9	13	7	4
Natural deaths	4	10	6	13
Survivors				
Died last week of study			1	
Terminal kill	37	27	36	32
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Intestine large, cecum	(50)	(50)	(50)	(49)
Inflammation, chronic			2 (4%)	
Intestine large, colon	(50)	(50)	(50)	(49)
Parasite metazoan	3 (6%)	2 (4%)	2 (4%)	
Intestine large, rectum	(50)	(50)	(50)	(50)
Parasite metazoan	8 (16%)	4 (8%)	3 (6%)	6 (12%)
Intestine small, duodenum	(50)	(50)	(50)	(49)
Intestine small, ileum	(50)	(50)	(50)	(49)
Intestine small, jejunum	(50)	(50)	(50)	(49)
Liver	(50)	(50)	(50)	(50)
Angiectasis	7 (14%)	2 (4%)	4 (8%)	4 (8%)
Basophilic focus	48 (96%)	43 (86%)	44 (88%)	40 (80%)
Clear cell focus	20 (40%)	7 (14%)	17 (34%)	11 (22%)
Degeneration, cystic	1 (2%)		2 (4%)	
Eosinophilic focus	24 (48%)	30 (60%)	38 (76%)	30 (60%)
Fatty change, focal	11 (22%)	25 (50%)	30 (60%)	25 (50%)
Hepatodiaphragmatic nodule	6 (12%)	7 (14%)	1 (2%)	3 (6%)
Inflammation, chronic	45 (90%)	41 (82%)	41 (82%)	42 (84%)
Mixed cell focus	24 (48%)	12 (24%)	17 (34%)	10 (20%)
Necrosis	5 (10%)	2 (4%)	3 (6%)	3 (6%)
Bile duct, hyperplasia	11 (22%)	31 (62%)	31 (62%)	33 (66%)
Hepatocyte, fatty change	14 (28%)	7 (14%)	7 (14%)	9 (18%)
Hepatocyte, hypertrophy	7 (14%)	15 (30%)	27 (54%)	33 (66%)
Ito cell, hyperplasia		1 (2%)		
Mesentery	(10)	(2)	(8)	(11)
Fat, necrosis	10 (100%)	2 (100%)	8 (100%)	11 (100%)
Oral mucosa	(0)	(0)	(1)	(0)
Pancreas	(50)	(50)	(50)	(48)
Hemorrhage				1 (2%)
Acinus, atrophy	17 (34%)	13 (26%)	12 (24%)	20 (42%)
Acinus, hyperplasia	5 (10%)		2 (4%)	
Duct, cyst	3 (6%)		1 (2%)	4 (8%)
Duct, hyperplasia		1 (2%)		
Salivary glands	(50)	(50)	(50)	(50)
Stomach, forestomach	(50)	(50)	(50)	(50)
Inflammation, chronic	1 (2%)	1 (2%)	1 (2%)	1 (2%)
Ulcer	1 (2%)	1 (2%)	2 (4%)	2 (4%)
Stomach, glandular	(50)	(50)	(50)	(50)
Inflammation, chronic		2 (4%)		
Mineralization	1 (2%)	2 (4%)		1 (2%)
Ulcer		2 (4%)	3 (6%)	
Glands, ectasia	35 (70%)	37 (74%)	37 (74%)	36 (72%)
Glands, hyperplasia	1 (2%)		1 (2%)	

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with lesion

**TABLE B4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Cardiovascular System</b>				
Blood vessel	(50)	(50)	(50)	(50)
Aorta, mineralization		1 (2%)		
Heart	(50)	(50)	(50)	(50)
Cardiomyopathy	49 (98%)	46 (92%)	46 (92%)	48 (96%)
Atrium, thrombosis		1 (2%)		1 (2%)
Myocardium, mineralization				1 (2%)
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Degeneration, cystic	12 (24%)	5 (10%)	7 (14%)	7 (14%)
Hyperplasia, focal	12 (24%)	10 (20%)	13 (26%)	15 (30%)
Hyperplasia, diffuse				1 (2%)
Hypertrophy, focal	6 (12%)	2 (4%)	2 (4%)	5 (10%)
Hypertrophy, diffuse	3 (6%)	10 (20%)	7 (14%)	9 (18%)
Vacuolization cytoplasmic, focal	23 (46%)	14 (28%)	22 (44%)	21 (42%)
Vacuolization cytoplasmic, diffuse	4 (8%)	5 (10%)	6 (12%)	4 (8%)
Capsule, fibrosis	1 (2%)			
Adrenal medulla	(50)	(50)	(50)	(50)
Hyperplasia	3 (6%)	3 (6%)	5 (10%)	2 (4%)
Islets, pancreatic	(50)	(50)	(50)	(50)
Hyperplasia	1 (2%)			
Parathyroid gland	(38)	(47)	(43)	(35)
Hyperplasia	1 (3%)			
Pituitary gland	(50)	(50)	(50)	(50)
Angiectasis		2 (4%)		
Cyst	26 (52%)	24 (48%)	29 (58%)	31 (62%)
Pars distalis, cyst	1 (2%)			
Pars distalis, hyperplasia	11 (22%)	13 (26%)	18 (36%)	23 (46%)
Thyroid gland	(49)	(50)	(49)	(49)
C-cell, hyperplasia	40 (82%)	38 (76%)	36 (73%)	21 (43%)
Follicle, hyperplasia	3 (6%)	3 (6%)	1 (2%)	5 (10%)
Follicular cell, hypertrophy	15 (31%)	41 (82%)	45 (92%)	48 (98%)
<b>General Body System</b>				
None				
<b>Genital System</b>				
Clitoral gland	(50)	(50)	(50)	(50)
Atrophy			1 (2%)	
Cyst			1 (2%)	
Hyperplasia	3 (6%)	4 (8%)	3 (6%)	2 (4%)
Inflammation, chronic	36 (72%)	39 (78%)	40 (80%)	38 (76%)
Mineralization		1 (2%)		
Ovary	(50)	(50)	(50)	(50)
Cyst	3 (6%)	2 (4%)	2 (4%)	3 (6%)
Uterus	(50)	(50)	(50)	(50)
Cyst	4 (8%)			4 (8%)
Decidual reaction			1 (2%)	
Inflammation, suppurative	2 (4%)	2 (4%)		5 (10%)
Necrosis		1 (2%)		
Endometrium, hyperplasia, cystic	3 (6%)	13 (26%)	11 (22%)	7 (14%)
Vagina	(0)	(2)	(0)	(0)

**TABLE B4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(50)	(50)
Hemorrhage	1 (2%)			
Hyperplasia	7 (14%)	11 (22%)	9 (18%)	12 (24%)
Necrosis			1 (2%)	
Lymph node	(3)	(3)	(3)	(4)
Ectasia				1 (25%)
Deep cervical, hyperplasia, lymphoid		1 (33%)		
Mediastinal, ectasia				1 (25%)
Mediastinal, hemorrhage		1 (33%)		
Mediastinal, hyperplasia, lymphoid			1 (33%)	3 (75%)
Pancreatic, congestion	1 (33%)			
Lymph node, mesenteric	(50)	(50)	(50)	(49)
Pigmentation, hemosiderin				1 (2%)
Spleen	(50)	(50)	(50)	(50)
Hematopoietic cell proliferation	14 (28%)	18 (36%)	13 (26%)	13 (26%)
Hyperplasia, histiocytic	1 (2%)	1 (2%)	1 (2%)	2 (4%)
Infarct		1 (2%)		
Necrosis			1 (2%)	
Thrombosis		1 (2%)		
Lymphoid follicle, atrophy	9 (18%)	6 (12%)	9 (18%)	5 (10%)
Thymus	(50)	(48)	(49)	(48)
Atrophy	48 (96%)	47 (98%)	46 (94%)	47 (98%)
Ectopic parathyroid gland		1 (2%)		
Ectopic thyroid		1 (2%)		1 (2%)
<b>Integumentary System</b>				
Mammary gland	(50)	(50)	(50)	(50)
Duct, cyst	14 (28%)	10 (20%)	8 (16%)	6 (12%)
Skin	(50)	(50)	(50)	(50)
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Hyperostosis				1 (2%)
Skeletal muscle	(0)	(0)	(1)	(0)
<b>Nervous System</b>				
Brain	(50)	(50)	(50)	(50)
Congestion				1 (2%)
Hydrocephalus	1 (2%)			
Artery, meninges, inflammation, chronic		1 (2%)		
Hippocampus, necrosis				1 (2%)
Hypothalamus, congestion		1 (2%)		
Peripheral nerve	(1)	(0)	(0)	(0)
Spinal cord	(1)	(0)	(0)	(0)
Congestion	1 (100%)			
<b>Respiratory System</b>				
Larynx	(0)	(0)	(0)	(1)
Foreign body				1 (100%)

**TABLE B4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Rats in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Respiratory System (continued)</b>				
Lung	(50)	(50)	(50)	(50)
Cyst	1 (2%)			
Inflammation, suppurative			1 (2%)	
Inflammation, chronic	7 (14%)	3 (6%)	11 (22%)	6 (12%)
Inflammation, chronic active				1 (2%)
Metaplasia, osseous	2 (4%)	1 (2%)		1 (2%)
Thrombosis			1 (2%)	
Alveolar epithelium, hyperplasia	3 (6%)		3 (6%)	2 (4%)
Nose	(49)	(49)	(50)	(46)
Foreign body	1 (2%)	1 (2%)	1 (2%)	7 (15%)
Inflammation, chronic active	22 (45%)	16 (33%)	26 (52%)	38 (83%)
Goblet cell, olfactory epithelium, hyperplasia		1 (2%)		
Goblet cell, respiratory epithelium, hyperplasia	6 (12%)	2 (4%)	18 (36%)	35 (76%)
Nerve, olfactory epithelium, atrophy		15 (31%)	22 (44%)	33 (72%)
Olfactory epithelium, accumulation, hyaline droplet	44 (90%)	39 (80%)	25 (50%)	
Olfactory epithelium, atrophy		18 (37%)	25 (50%)	37 (80%)
Olfactory epithelium, degeneration		1 (2%)		
Olfactory epithelium, hemorrhage	1 (2%)			
Olfactory epithelium, hyperplasia				1 (2%)
Olfactory epithelium, pigmentation		37 (76%)	43 (86%)	40 (87%)
Olfactory epithelium, regeneration			1 (2%)	2 (4%)
Olfactory epithelium, respiratory metaplasia	8 (16%)	4 (8%)	32 (64%)	37 (80%)
Respiratory epithelium, hyperplasia	9 (18%)	9 (18%)	19 (38%)	34 (74%)
Transitional epithelium, hyperplasia		6 (12%)	32 (64%)	36 (78%)
Trachea	(50)	(50)	(50)	(50)
Inflammation, chronic			1 (2%)	1 (2%)
<b>Special Senses System</b>				
Eye	(50)	(50)	(50)	(50)
Cataract		2 (4%)	3 (6%)	2 (4%)
Degeneration			1 (2%)	
Retinal detachment				1 (2%)
Retina, atrophy		2 (4%)	1 (2%)	
Retina, hemorrhage				1 (2%)
Retrolbulbar, inflammation, chronic			1 (2%)	
Harderian gland	(50)	(50)	(50)	(50)
Hyperplasia				1 (2%)
Inflammation, chronic	4 (8%)	6 (12%)	8 (16%)	7 (14%)
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Hydropnephrosis			1 (2%)	
Infarct	2 (4%)	2 (4%)	1 (2%)	6 (12%)
Inflammation, chronic	2 (4%)		1 (2%)	
Nephropathy	41 (82%)	42 (84%)	43 (86%)	42 (84%)
Renal tubule, cyst			1 (2%)	
Renal tubule, hyperplasia	3 (6%)	1 (2%)	3 (6%)	
Renal tubule, mineralization	1 (2%)	1 (2%)		1 (2%)
Renal tubule, pigmentation, lipofuscin	1 (2%)			
Urinary bladder	(50)	(50)	(50)	(49)
Inflammation, acute	1 (2%)			

**APPENDIX C**  
**SUMMARY OF LESIONS IN MALE MICE**  
**IN THE 2-YEAR GAVAGE STUDY**  
**OF *GINKGO BILOBA* EXTRACT**

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**TABLE C1**  
**Summary of the Incidence of Neoplasms in Male Mice in the 2-Year Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Accidental death			1	
Moribund	8	16	23	13
Natural deaths	8	7	5	14
Survivors				
Terminal kill	34	27	21	23
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Gallbladder	(46)	(48)	(44)	(46)
Intestine large, cecum	(50)	(50)	(50)	(50)
Intestine large, colon	(50)	(50)	(50)	(50)
Intestine large, rectum	(50)	(50)	(50)	(50)
Intestine small, duodenum	(50)	(50)	(50)	(50)
Carcinoma			1 (2%)	
Intestine small, ileum	(50)	(50)	(50)	(50)
Intestine small, jejunum	(50)	(50)	(50)	(50)
Carcinoma	1 (2%)		1 (2%)	2 (4%)
Serosa, hepatoblastoma		1 (2%)		
Liver	(50)	(50)	(50)	(50)
Hemangiosarcoma	9 (18%)	2 (4%)		3 (6%)
Hemangiosarcoma, multiple		1 (2%)		
Hepatoblastoma	2 (4%)	16 (32%)	10 (20%)	17 (34%)
Hepatoblastoma, metastatic, liver				1 (2%)
Hepatoblastoma, multiple	1 (2%)	12 (24%)	26 (52%)	21 (42%)
Hepatocellular adenoma	13 (26%)	6 (12%)	7 (14%)	6 (12%)
Hepatocellular adenoma, multiple	18 (36%)	40 (80%)	26 (52%)	27 (54%)
Hepatocellular carcinoma	11 (22%)	8 (16%)	9 (18%)	4 (8%)
Hepatocellular carcinoma, multiple	11 (22%)	23 (46%)	32 (64%)	43 (86%)
Hepatocholangiocarcinoma		1 (2%)		
Hepatocholangiocarcinoma, multiple		1 (2%)		1 (2%)
Ito cell tumor benign		1 (2%)		
Ito cell tumor benign, multiple	1 (2%)			
Mesentery	(5)	(6)	(3)	(4)
Hepatoblastoma, metastatic, liver		2 (33%)	1 (33%)	1 (25%)
Hepatocholangiocarcinoma, metastatic, liver				1 (25%)
Pancreas	(50)	(50)	(50)	(50)
Hepatoblastoma, metastatic, liver		1 (2%)	1 (2%)	
Salivary glands	(50)	(50)	(50)	(50)
Hemangiosarcoma		1 (2%)		
Stomach, forestomach	(50)	(50)	(50)	(50)
Squamous cell papilloma		2 (4%)	1 (2%)	
Squamous cell papilloma, multiple				1 (2%)
Stomach, glandular	(50)	(50)	(50)	(50)
Tooth	(50)	(50)	(50)	(50)
<b>Cardiovascular System</b>				
Blood vessel	(50)	(50)	(50)	(50)
Heart	(50)	(50)	(50)	(50)
Hemangiosarcoma, metastatic, liver	1 (2%)	1 (2%)		
Hepatoblastoma, metastatic, liver		1 (2%)		
Hepatocholangiocarcinoma, metastatic, liver				1 (2%)

**TABLE C1**  
**Summary of the Incidence of Neoplasms in Male Mice in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Hepatoblastoma, metastatic, liver			1 (2%)	
Subcapsular, adenoma	1 (2%)	3 (6%)	1 (2%)	
Adrenal medulla	(50)	(50)	(50)	(49)
Islets, pancreatic	(50)	(50)	(50)	(50)
Adenoma	1 (2%)			
Parathyroid gland	(36)	(46)	(46)	(44)
Pituitary gland	(49)	(50)	(50)	(49)
Thyroid gland	(49)	(49)	(50)	(50)
C-cell, carcinoma			1 (2%)	1 (2%)
Follicular cell, adenoma			2 (4%)	2 (4%)
<b>General Body System</b>				
Peritoneum	(0)	(1)	(2)	(2)
<b>Genital System</b>				
Epididymis	(50)	(50)	(50)	(50)
Hepatoblastoma, metastatic, liver		1 (2%)		
Bilateral, hepatoblastoma, metastatic, liver				1 (2%)
Preputial gland	(50)	(50)	(50)	(50)
Hemangiosarcoma				1 (2%)
Prostate	(50)	(50)	(49)	(50)
Adenoma				1 (2%)
Carcinoma		1 (2%)		
Hemangiosarcoma		1 (2%)		
Seminal vesicle	(50)	(50)	(50)	(50)
Hepatoblastoma, metastatic, liver			1 (2%)	
Testes	(50)	(50)	(50)	(50)
Interstitial cell, adenoma	1 (2%)		1 (2%)	1 (2%)
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(50)	(50)
Hemangioma			1 (2%)	
Lymph node	(11)	(15)	(18)	(14)
Bronchial, alveolar/bronchiolar carcinoma, metastatic, lung		1 (7%)		
Bronchial, hepatoblastoma, metastatic, liver		1 (7%)		
Bronchial, hepatocholangiocarcinoma, metastatic, liver				1 (7%)
Lymph node, mandibular	(50)	(50)	(50)	(50)
Carcinoma, metastatic, Harderian gland			1 (2%)	
Lymph node, mesenteric	(50)	(49)	(49)	(50)
Hepatoblastoma, metastatic, liver			1 (2%)	1 (2%)
Spleen	(50)	(50)	(50)	(50)
Hemangiosarcoma		1 (2%)		1 (2%)
Thymus	(50)	(47)	(50)	(45)
Thymoma malignant		1 (2%)		
<b>Integumentary System</b>				
Skin	(50)	(50)	(50)	(50)
Hepatoblastoma, metastatic, liver				1 (2%)
Pinna, amelanotic melanoma, malignant				1 (2%)
Pinna, melanoma malignant	1 (2%)			
Tail, schwannoma NOS				1 (2%)

**TABLE C1**  
**Summary of the Incidence of Neoplasms in Male Mice in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Turbinate, carcinoma, metastatic, Harderian gland			1 (2%)	
Skeletal muscle	(1)	(1)	(1)	(1)
Hepatoblastoma, metastatic, liver		1 (100%)		
<b>Nervous System</b>				
Brain	(50)	(50)	(50)	(50)
Neuroblastoma			1 (2%)	
Peripheral nerve	(0)	(0)	(1)	(0)
<b>Respiratory System</b>				
Lung	(50)	(50)	(50)	(50)
Alveolar/bronchiolar adenoma	8 (16%)	6 (12%)	5 (10%)	1 (2%)
Alveolar/bronchiolar carcinoma	11 (22%)	7 (14%)	4 (8%)	3 (6%)
Alveolar/bronchiolar carcinoma, metastatic, lung	2 (4%)			
Alveolar/bronchiolar carcinoma, multiple Carcinoma, metastatic, Harderian gland		1 (2%)	1 (2%)	
Hemangiosarcoma	1 (2%)		1 (2%)	
Hepatoblastoma, metastatic, liver		7 (14%)	14 (28%)	14 (28%)
Hepatocellular carcinoma, metastatic, liver	10 (20%)	8 (16%)	8 (16%)	18 (36%)
Hepatocholangiocarcinoma, metastatic, liver		1 (2%)		1 (2%)
Nose	(50)	(50)	(50)	(50)
Trachea	(50)	(50)	(50)	(50)
<b>Special Senses System</b>				
Ear	(1)	(0)	(0)	(1)
Neural crest tumor				1 (100%)
Eye	(50)	(50)	(50)	(50)
Harderian gland	(50)	(50)	(50)	(50)
Adenoma	4 (8%)	3 (6%)	2 (4%)	3 (6%)
Carcinoma	3 (6%)	5 (10%)	4 (8%)	2 (4%)
Hepatoblastoma, metastatic, liver			1 (2%)	
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Hepatoblastoma, metastatic, liver		1 (2%)		1 (2%)
Urethra	(0)	(1)	(0)	(0)
Urinary bladder	(50)	(50)	(50)	(50)
Hemangiosarcoma		1 (2%)		
<b>Systemic Lesions</b>				
Multiple organs <sup>b</sup>	(50)	(50)	(50)	(50)
Lymphoma malignant	1 (2%)	3 (6%)	1 (2%)	

**TABLE C1**  
**Summary of the Incidence of Neoplasms in Male Mice in the 2-Year Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Neoplasm Summary</b>				
Total animals with primary neoplasms <sup>c</sup>	44	48	48	49
Total primary neoplasms	99	148	137	144
Total animals with benign neoplasms	38	47	36	35
Total benign neoplasms	47	61	46	42
Total animals with malignant neoplasms	35	46	46	48
Total malignant neoplasms	52	87	91	100
Total animals with metastatic neoplasms	13	17	23	26
Total metastatic neoplasms	13	26	31	42
Total animals with uncertain neoplasms benign or malignant				2
Total uncertain neoplasms				2

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with neoplasm

<sup>b</sup> Number of animals with any tissue examined microscopically

<sup>c</sup> Primary neoplasms: all neoplasms except metastatic neoplasms

**TABLE C2**  
**Statistical Analysis of Primary Neoplasms in Male Mice in the 2-Year Gavage Study**  
**of *Ginkgo biloba* Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Adrenal Cortex: Adenoma</b>				
Overall rate <sup>a</sup>	1/50 (2%)	3/50 (6%)	1/50 (2%)	0/50 (0%)
Adjusted rate <sup>b</sup>	2.3%	7.3%	2.6%	0.0%
Terminal rate <sup>c</sup>	0/34 (0%)	2/27 (7%)	0/21 (0%)	0/23 (0%)
First incidence (days)	660	565	681	— <sup>e</sup>
Poly-3 test <sup>d</sup>	P=0.196N	P=0.277	P=0.727	P=.519N
<b>Harderian Gland: Adenoma</b>				
Overall rate	4/50 (8%)	3/50 (6%)	2/50 (4%)	3/50 (6%)
Adjusted rate	9.1%	7.4%	5.1%	7.4%
Terminal rate	4/34 (12%)	3/27 (11%)	1/21 (5%)	2/23 (9%)
First incidence (days)	726 (T)	726 (T)	308	641
Poly-3 test	P=0.532N	P=0.547N	P=0.394N	P=545N
<b>Harderian Gland: Carcinoma</b>				
Overall rate	3/50 (6%)	5/50 (10%)	4/50 (8%)	2/50 (4%)
Adjusted rate	6.8%	11.9%	10.1%	4.9%
Terminal rate	3/34 (9%)	1/27 (4%)	0/21 (0%)	1/23 (4%)
First incidence (days)	726 (T)	520	490	620
Poly-3 test	P=0.309N	P=0.333	P=0.446	P=537N
<b>Harderian Gland: Adenoma or Carcinoma</b>				
Overall rate	7/50 (14%)	8/50 (16%)	6/50 (12%)	5/50 (10%)
Adjusted rate	15.9%	19.0%	14.7%	12.2%
Terminal rate	7/34 (21%)	4/27 (15%)	1/21 (5%)	3/23 (13%)
First incidence (days)	726 (T)	520	308	620
Poly-3 test	P=0.305N	P=0.464	P=0.559N	P=0.431N
<b>Liver: Hemangiosarcoma</b>				
Overall rate	9/50 (18%)	3/50 (6%)	0/50 (0%)	3/50 (6%)
Adjusted rate	20.1%	7.4%	0.0%	7.4%
Terminal rate	6/34 (18%)	1/27 (4%)	0/21 (0%)	2/23 (9%)
First incidence (days)	594	674	—	641
Poly-3 test	P=0.126N	P=0.083N	P=0.004N	P=0.083N
<b>Liver: Hepatocellular Adenoma</b>				
Overall rate	31/50 (62%)	46/50 (92%)	33/50 (66%)	33/50 (66%)
Adjusted rate	66.2%	96.0%	74.3%	71.0%
Terminal rate	22/34 (65%)	27/27 (100%)	16/21 (76%)	16/23 (70%)
First incidence (days)	482	400	308	443
Poly-3 test	P=0.171N	P<0.001	P=0.260	P=0.388
<b>Liver: Hepatocellular Carcinoma</b>				
Overall rate	22/50 (44%)	31/50 (62%)	41/50 (82%)	47/50 (94%)
Adjusted rate	47.0%	70.6%	92.5%	98.8%
Terminal rate	13/34 (38%)	20/27 (74%)	20/21 (95%)	23/23 (100%)
First incidence (days)	442	555	490	553
Poly-3 test	P<0.001	P=0.015	P<0.001	P<0.001
<b>Liver: Hepatocellular Adenoma or Carcinoma</b>				
Overall rate	39/50 (78%)	46/50 (92%)	46/50 (92%)	49/50 (98%)
Adjusted rate	79.4%	96.0%	98.5%	100.0%
Terminal rate	25/34 (74%)	27/27 (100%)	21/21 (100%)	23/23 (100%)
First incidence (days)	442	400	308	443
Poly-3 test	P<0.001	P=0.011	P=0.002	P<0.001

**TABLE C2**  
**Statistical Analysis of Primary Neoplasms in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Liver: Hepatoblastoma</b>				
Overall rate	3/50 (6%)	28/50 (56%)	36/50 (72%)	38/50 (76%)
Adjusted rate	6.8%	61.0%	80.6%	79.6%
Terminal rate	3/34 (9%)	13/27 (48%)	14/21 (67%)	16/23 (70%)
First incidence (days)	726 (T)	400	477	516
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
<b>Liver: Hepatocellular Carcinoma or Hepatoblastoma</b>				
Overall rate	24/50 (48%)	42/50 (84%)	45/50 (90%)	48/50 (96%)
Adjusted rate	51.3%	88.3%	97.1%	99.5%
Terminal rate	15/34 (44%)	23/27 (85%)	20/21 (95%)	23/23 (100%)
First incidence (days)	442	400	477	516
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
<b>Liver: Hepatocellular Adenoma, Hepatocellular Carcinoma, or Hepatoblastoma</b>				
Overall rate	39/50 (78%)	48/50 (96%)	48/50 (96%)	49/50 (98%)
Adjusted rate	79.4%	98.5%	100.0%	100.0%
Terminal rate	25/34 (74%)	27/27 (100%)	21/21 (100%)	23/23 (100%)
First incidence (days)	442	400	308	443
Poly-3 test	P<0.001	P=0.002	P<0.001	P<0.001
<b>Lung: Alveolar/bronchiolar Adenoma</b>				
Overall rate	8/50 (16%)	6/50 (12%)	5/50 (10%)	1/50 (2%)
Adjusted rate	17.9%	14.4%	13.0%	2.5%
Terminal rate	5/34 (15%)	2/27 (7%)	3/21 (14%)	1/23 (4%)
First incidence (days)	592	555	611	726 (T)
Poly-3 test	P=0.020N	P=0.444N	P=0.377N	P=0.024N
<b>Lung: Alveolar/bronchiolar Carcinoma</b>				
Overall rate	11/50 (22%)	8/50 (16%)	5/50 (10%)	3/50 (6%)
Adjusted rate	24.4%	19.7%	13.2%	7.3%
Terminal rate	8/34 (24%)	7/27 (26%)	5/21 (24%)	0/23 (0%)
First incidence (days)	482	674	726 (T)	553
Poly-3 test	P=0.022N	P=0.399N	P=0.155N	P=0.029N
<b>Lung: Alveolar/bronchiolar Adenoma or Carcinoma</b>				
Overall rate	17/50 (34%)	14/50 (28%)	10/50 (20%)	4/50 (8%)
Adjusted rate	37.1%	33.5%	25.9%	9.7%
Terminal rate	12/34 (35%)	9/27 (33%)	8/21 (38%)	1/23 (4%)
First incidence (days)	482	555	611	553
Poly-3 test	P<0.001N	P=0.450N	P=0.193N	P=0.002N
<b>All Organs: Hemangiosarcoma</b>				
Overall rate	9/50 (18%)	5/50 (10%)	0/50 (0%)	4/50 (8%)
Adjusted rate	20.1%	12.3%	0.0%	9.9%
Terminal rate	6/34 (18%)	3/27 (11%)	0/21 (0%)	3/23 (13%)
First incidence (days)	594	674	—	641
Poly-3 test	P=0.178N	P=0.249N	P=0.004N	P=0.156N
<b>All Organs: Hemangioma or Hemangiosarcoma</b>				
Overall rate	9/50 (18%)	5/50 (10%)	1/50 (2%)	4/50 (8%)
Adjusted rate	20.1%	12.3%	2.6%	9.9%
Terminal rate	6/34 (18%)	3/27 (11%)	1/21 (5%)	3/23 (13%)
First incidence (days)	594	674	726 (T)	641
Poly-3 test	P=0.180N	P=0.249N	P=0.016N	P=0.156N

**TABLE C2**  
**Statistical Analysis of Primary Neoplasms in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>All Organs: Malignant Lymphoma</b>				
Overall rate	1/50 (2%)	3/50 (6%)	1/50 (2%)	0/50 (0%)
Adjusted rate	2.3%	7.4%	2.6%	0.0%
Terminal rate	1/34 (3%)	2/27 (7%)	1/21 (5%)	0/23 (0%)
First incidence (days)	726 (T)	687	726 (T)	—
Poly-3 test	P=0.195N	P=0.276	P=0.727	P=0.518N
<b>All Organs: Benign Neoplasms</b>				
Overall rate	38/50 (76%)	47/50 (94%)	36/50 (72%)	35/50 (70%)
Adjusted rate	79.8%	97.7%	80.3%	75.2%
Terminal rate	26/34 (77%)	27/27 (100%)	18/21 (86%)	17/23 (74%)
First incidence (days)	482	400	308	443
Poly-3 test	P=0.040N	P=0.003	P=0.581	P=0.383N
<b>All Organs: Malignant Neoplasms</b>				
Overall rate	35/50 (70%)	46/50 (92%)	46/50 (92%)	48/50 (96%)
Adjusted rate	71.9%	94.4%	97.7%	99.5%
Terminal rate	22/34 (65%)	25/27 (93%)	20/21 (95%)	23/23 (100%)
First incidence (days)	442	400	453	516
Poly-3 test	P<0.001	P=0.002	P<0.001	P<0.001
<b>All Organs: Benign or Malignant Neoplasms</b>				
Overall rate	44/50 (88%)	48/50 (96%)	48/50 (96%)	49/50 (98%)
Adjusted rate	89.5%	98.5%	100.0%	100.0%
Terminal rate	29/34 (85%)	27/27 (100%)	21/21 (100%)	23/23 (100%)
First incidence (days)	442	400	308	443
Poly-3 test	P=0.030	P=0.066	P=0.028	P=0.026

(T) Terminal kill

<sup>a</sup> Number of neoplasm-bearing animals/number of animals examined. Denominator is number of animals examined microscopically for adrenal gland, liver, and lung; for other tissues, denominator is number of animals necropsied.

<sup>b</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>c</sup> Observed incidence at terminal kill

<sup>d</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for the differential mortality in animals that do not reach terminal kill. A negative trend or a lower incidence in a dose group is indicated by **N**.

<sup>e</sup> Not applicable; no neoplasms in animal group

**TABLE C3a**  
**Historical Incidence of Liver Neoplasms in Control Male B6C3F1/N Mice<sup>a</sup>**

Study (Study Start)	Hepatocellular Adenoma	Hepatocellular Carcinoma	Hepatocellular Adenoma or Hepatocellular Carcinoma
<b>Historical Incidence: Corn Oil Gavage Studies</b>			
<i>Ginkgo biloba</i> extract (March 2005)	31/50	22/50	39/50
Isoeugenol (April 2002)	24/50	8/50	28/50
Kava kava extract (August 2004)	27/50	20/50	38/50
β-Myrcene (March 2002)	26/50	14/50	33/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	29/50	22/50	38/50
Pulegone (April 2003)	22/50	13/50	29/50
3,3',4,4'-Tetrachloroazobenzene (February 2003)	22/50	17/50	34/50
Total (%)	181/350 (51.7%)	116/350 (33.1%)	239/350 (68.3%)
Mean ± standard deviation	51.7% ± 6.9%	33.1% ± 10.5%	68.3% ± 8.9%
Range	44%-62%	16%-44%	56%-78%
<b>Overall Historical Incidence: All Routes</b>			
Total (%)	658/1,149 (57.3%)	399/1,149 (34.7%)	844/1,149 (73.5%)
Mean ± standard deviation	57.3% ± 12.6%	34.7% ± 10.8%	73.5% ± 11.3%
Range	24%-78%	16%-56%	52%-90%
	<b>Hepatoblastoma</b>	<b>Hepatocellular Carcinoma or Hepatoblastoma</b>	<b>Hepatocellular Adenoma, Hepatocellular Carcinoma, or Hepatoblastoma</b>
<b>Historical Incidence: Corn Oil Gavage Studies</b>			
<i>Ginkgo biloba</i> extract (March 2005)	3/50	24/50	39/50
Isoeugenol (April 2002)	3/50	11/50	30/50
Kava kava extract (August 2004)	0/50	20/50	38/50
β-Myrcene (March 2002)	4/50	16/50	34/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	1/50	22/50	38/50
Pulegone (April 2003)	1/50	13/50	29/50
3,3',4,4'-Tetrachloroazobenzene (February 2003)	2/50	19/50	34/50
Total (%)	14/350 (4.0%)	125/350 (35.7%)	242/350 (69.1%)
Mean ± standard deviation	4.0% ± 2.8%	35.7% ± 9.5%	69.1% ± 8.0%
Range	2%-8%	22%-48%	58%-78%
<b>Overall Historical Incidence: All Routes</b>			
Total (%)	61/1,149 (5.3%)	433/1,149 (37.7%)	852/1,149 (74.2%)
Mean ± standard deviation	5.3% ± 7.1%	37.7% ± 11.1%	74.2% ± 11.5%
Range	0%-34%	18%-58%	52%-92%

<sup>a</sup> Data as of May 2011



**TABLE C3b**  
**Historical Incidence of Thyroid Gland Follicular Cell Adenoma in Control Male B6C3F1/N mice<sup>a</sup>**

Study (Study Start)	Incidence in Controls
<b>Historical Incidence: Corn Oil Gavage Studies</b>	
<i>Ginkgo biloba</i> extract (March 2005)	0/49
Isoeugenol (April 2002)	0/50
Kava kava extract (August 2004)	0/50
β-Myrcene (March 2002)	0/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	1/50
Pulegone (April 2003)	0/50
3,3',4,4'-Tetrachloroazobenzene (February 2003)	0/50
Total (%)	1/349 (0.3%)
Mean ± standard deviation	0.3% ± 0.8%
Range	0%-2%
<b>Overall Historical Incidence: All Routes</b>	
Total (%)	7/1,143 (0.6%)
Mean ± standard deviation	0.6% ± 1.0%
Range	0%-2%

<sup>a</sup> Data as of May 2011

**TABLE C3c**  
**Historical Incidence of Alveolar/bronchiolar Neoplasms in Control Male B6C3F1/N Mice<sup>a</sup>**

Study (Study Start)	Adenoma	Carcinoma	Adenoma or Carcinoma
<b>Historical Incidence: Corn Oil Gavage Studies</b>			
<i>Ginkgo biloba</i> extract (March 2005)	8/50	11/50	17/50
Isoeugenol (April 2002)	6/50	2/50	7/50
Kava kava extract (August 2004)	9/50	2/50	11/50
β-Myrcene (March 2002)	8/50	5/50	13/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	11/50	2/50	13/50
Pulegone (April 2003)	6/50	3/50	9/50
3,3',4,4'-Tetrachloroazobenzene (February 2003)	5/50	3/50	7/50
Total (%)	53/530 (15.1%)	28/350 (8.0%)	77/350 (22.0%)
Mean ± standard deviation	15.1% ± 4.1%	8.0% ± 6.5%	22.0% ± 7.3%
Range	10%-22%	4%-22%	14%-34%
<b>Overall Historical Incidence: All Routes</b>			
Total (%)	172/1,150 (15.0%)	144/1,150 (12.5%)	301/1,150 (26.2%)
Mean ± standard deviation	15.0% ± 6.9%	12.5% ± 7.1%	26.2% ± 6.3%
Range	2%-30%	4%-24%	14%-40%

<sup>a</sup> Data as of May 2011

**TABLE C4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Accidental death			1	
Moribund	8	16	23	13
Natural deaths	8	7	5	14
Survivors				
Terminal kill	34	27	21	23
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Gallbladder	(46)	(48)	(44)	(46)
Hyperplasia, cystic				1 (2%)
Inflammation	2 (4%)			
Intestine large, cecum	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid	3 (6%)		2 (4%)	1 (2%)
Epithelium, hyperplasia	1 (2%)			
Intestine large, colon	(50)	(50)	(50)	(50)
Epithelium, hyperplasia		1 (2%)		
Intestine large, rectum	(50)	(50)	(50)	(50)
Intestine small, duodenum	(50)	(50)	(50)	(50)
Ectopic tissue	1 (2%)			1 (2%)
Intestine small, ileum	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid				1 (2%)
Inflammation	3 (6%)		1 (2%)	
Epithelium, hyperplasia	3 (6%)		1 (2%)	
Intestine small, jejunum	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid	7 (14%)	1 (2%)	6 (12%)	2 (4%)
Inflammation	3 (6%)		1 (2%)	
Mineralization	1 (2%)			
Epithelium, hyperplasia	1 (2%)			
Liver	(50)	(50)	(50)	(50)
Angiectasis	2 (4%)			
Basophilic focus	15 (30%)	14 (28%)	5 (10%)	4 (8%)
Clear cell focus	21 (42%)	22 (44%)	14 (28%)	12 (24%)
Eosinophilic focus	34 (68%)	41 (82%)	36 (72%)	39 (78%)
Erythrophagocytosis		4 (8%)	11 (22%)	7 (14%)
Fatty change, focal	4 (8%)	3 (6%)		
Hematopoietic cell proliferation	4 (8%)	9 (18%)	12 (24%)	14 (28%)
Hepatodiaphragmatic nodule	1 (2%)			
Hypertrophy	3 (6%)	19 (38%)	35 (70%)	23 (46%)
Infiltration cellular, lymphoid	1 (2%)			
Inflammation	28 (56%)	35 (70%)	42 (84%)	39 (78%)
Mixed cell focus	15 (30%)	13 (26%)	12 (24%)	9 (18%)
Necrosis	9 (18%)	15 (30%)	17 (34%)	19 (38%)
Tension lipidosis	6 (12%)	1 (2%)		1 (2%)
Vacuolization cytoplasmic	16 (32%)	13 (26%)	14 (28%)	14 (28%)
Bile duct, hyperplasia		2 (4%)	1 (2%)	2 (4%)
Hepatocyte, hyperplasia			1 (2%)	
Vein, thrombosis			1 (2%)	
Mesentery	(5)	(6)	(3)	(4)
Inflammation		2 (33%)	2 (67%)	2 (50%)
Fat, necrosis	5 (100%)	4 (67%)		

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with lesion

**TABLE C4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Alimentary System (continued)</b>				
Pancreas	(50)	(50)	(50)	(50)
Atrophy	1 (2%)		1 (2%)	
Cyst			1 (2%)	
Infiltration cellular, lymphoid				2 (4%)
Inflammation		1 (2%)		2 (4%)
Salivary glands	(50)	(50)	(50)	(50)
Infiltration cellular, lymphoid	5 (10%)	4 (8%)	5 (10%)	1 (2%)
Stomach, forestomach	(50)	(50)	(50)	(50)
Cyst		1 (2%)		
Infiltration cellular, mast cell			1 (2%)	
Inflammation	11 (22%)	24 (48%)	21 (42%)	45 (90%)
Mineralization		2 (4%)	1 (2%)	
Epithelium, erosion		2 (4%)	1 (2%)	3 (6%)
Epithelium, hyperkeratosis	11 (22%)	24 (48%)	24 (48%)	46 (92%)
Epithelium, hyperplasia	14 (28%)	27 (54%)	27 (54%)	45 (90%)
Epithelium, ulcer	7 (14%)	10 (20%)	12 (24%)	24 (48%)
Stomach, glandular	(50)	(50)	(50)	(50)
Cyst	1 (2%)			1 (2%)
Inflammation	2 (4%)		1 (2%)	1 (2%)
Mineralization		2 (4%)	1 (2%)	
Epithelium, hyperplasia	4 (8%)	5 (10%)	7 (14%)	4 (8%)
Tooth	(50)	(50)	(50)	(50)
Dysplasia	46 (92%)	46 (92%)	40 (80%)	33 (66%)
<b>Cardiovascular System</b>				
Blood vessel	(50)	(50)	(50)	(50)
Inflammation		1 (2%)		
Heart	(50)	(50)	(50)	(50)
Cardiomyopathy	38 (76%)	22 (44%)	27 (54%)	25 (50%)
Inflammation	1 (2%)	3 (6%)		
Mineralization	1 (2%)		2 (4%)	
Thrombosis	1 (2%)	1 (2%)		1 (2%)
Artery, inflammation		1 (2%)		
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Hematopoietic cell proliferation	1 (2%)			
Hyperplasia	1 (2%)			
Hypertrophy	9 (18%)		3 (6%)	1 (2%)
Subcapsular, hyperplasia	41 (82%)	39 (78%)	42 (84%)	43 (86%)
Adrenal medulla	(50)	(50)	(50)	(49)
Hyperplasia	2 (4%)	1 (2%)		2 (4%)
Islets, pancreatic	(50)	(50)	(50)	(50)
Hyperplasia	39 (78%)	38 (76%)	44 (88%)	35 (70%)
Parathyroid gland	(36)	(46)	(46)	(44)
Pituitary gland	(49)	(50)	(50)	(49)
Cyst				1 (2%)
Inflammation	1 (2%)			
Pars distalis, hyperplasia	2 (4%)		1 (2%)	

**TABLE C4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Endocrine System</b> (continued)				
Thyroid gland	(49)	(49)	(50)	(50)
Cyst			1 (2%)	
Ultimobranchial, cyst	8 (16%)	3 (6%)	1 (2%)	
C-cell, hyperplasia	2 (4%)	5 (10%)		
Follicle, cyst	2 (4%)	1 (2%)		
Follicle, hyperplasia	2 (4%)	1 (2%)	7 (14%)	25 (50%)
Follicle, ultimobranchial cyst	2 (4%)			
Follicular cell, degeneration		1 (2%)		
Follicular cell, hypertrophy	2 (4%)		2 (4%)	38 (76%)
<b>General Body System</b>				
Peritoneum	(0)	(1)	(2)	(2)
Inflammation		1 (100%)	2 (100%)	2 (100%)
<b>Genital System</b>				
Epididymis	(50)	(50)	(50)	(50)
Hemorrhage	1 (2%)			
Infiltration cellular, lymphoid	3 (6%)	4 (8%)	3 (6%)	2 (4%)
Inflammation	1 (2%)	3 (6%)	2 (4%)	3 (6%)
Preputial gland	(50)	(50)	(50)	(50)
Cyst		1 (2%)		
Ectasia	4 (8%)	3 (6%)	5 (10%)	8 (16%)
Fibrosis				1 (2%)
Infiltration cellular, lymphoid	1 (2%)			
Inflammation	30 (60%)	42 (84%)	49 (98%)	46 (92%)
Prostate	(50)	(50)	(49)	(50)
Hyperplasia	7 (14%)	3 (6%)	1 (2%)	1 (2%)
Infiltration cellular, lymphoid		3 (6%)	1 (2%)	
Inflammation	3 (6%)	5 (10%)	4 (8%)	4 (8%)
Seminal vesicle	(50)	(50)	(50)	(50)
Dilatation	2 (4%)		1 (2%)	
Hyperplasia	1 (2%)		1 (2%)	
Inflammation	2 (4%)	2 (4%)		1 (2%)
Testes	(50)	(50)	(50)	(50)
Inflammation		1 (2%)		2 (4%)
Mineralization		3 (6%)		2 (4%)
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(50)	(50)
Atrophy			1 (2%)	
Hyperplasia	48 (96%)	49 (98%)	49 (98%)	50 (100%)
Lymph node	(11)	(15)	(18)	(14)
Bronchial, hyperplasia, lymphoid	6 (55%)	2 (13%)	1 (6%)	4 (29%)
Bronchial, infiltration cellular, histiocyte				1 (7%)
Inguinal, hyperplasia, lymphoid	6 (55%)	10 (67%)	16 (89%)	11 (79%)
Mediastinal, hyperplasia, lymphoid		1 (7%)		
Mediastinal, infiltration cellular, histiocyte			1 (6%)	
Lymph node, mandibular	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid	17 (34%)	14 (28%)	16 (32%)	5 (10%)
Infiltration cellular, histiocyte			1 (2%)	1 (2%)
Lymph node, mesenteric	(50)	(49)	(49)	(50)
Hyperplasia, lymphoid	6 (12%)	5 (10%)	10 (20%)	1 (2%)
Inflammation		1 (2%)	1 (2%)	

**TABLE C4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Hematopoietic System (continued)</b>				
Spleen	(50)	(50)	(50)	(50)
Angiectasis		1 (2%)		
Hematopoietic cell proliferation	49 (98%)	47 (94%)	50 (100%)	50 (100%)
Hyperplasia				1 (2%)
Hyperplasia, lymphoid	9 (18%)	12 (24%)	6 (12%)	8 (16%)
Lymphoid follicle, atrophy		1 (2%)		
Thymus	(50)	(47)	(50)	(45)
Atrophy	1 (2%)			
Hyperplasia, lymphoid	10 (20%)	10 (21%)	19 (38%)	10 (22%)
Necrosis		1 (2%)		
<b>Integumentary System</b>				
Skin	(50)	(50)	(50)	(50)
Cyst epithelial inclusion		1 (2%)		
Dermis, fibrosis	2 (4%)		1 (2%)	
Dermis, inflammation	2 (4%)	2 (4%)	1 (2%)	
Dermis, subcutaneous tissue, inflammation		1 (2%)		
Epidermis, hyperkeratosis	1 (2%)	1 (2%)		
Epidermis, hyperplasia	2 (4%)	1 (2%)	1 (2%)	
Epidermis, ulcer	2 (4%)	2 (4%)	1 (2%)	
Subcutaneous tissue, inflammation		2 (4%)		
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Hyperplasia			1 (2%)	
Vertebra, fracture			1 (2%)	
Skeletal muscle	(1)	(1)	(1)	(1)
Cyst				1 (100%)
Hemorrhage			1 (100%)	
Inflammation	1 (100%)			1 (100%)
<b>Nervous System</b>				
Brain	(50)	(50)	(50)	(50)
Hemorrhage		1 (2%)		
Infiltration cellular, lymphoid	2 (4%)			1 (2%)
Peripheral nerve	(0)	(0)	(1)	(0)
Spinal, hemorrhage			1 (100%)	
<b>Respiratory System</b>				
Lung	(50)	(50)	(50)	(50)
Infiltration cellular, histiocyte	1 (2%)			
Inflammation	5 (10%)	1 (2%)	6 (12%)	3 (6%)
Metaplasia, osseous				1 (2%)
Mineralization	2 (4%)	1 (2%)		1 (2%)
Pigmentation			1 (2%)	
Alveolar epithelium, hyperplasia	4 (8%)	3 (6%)	1 (2%)	1 (2%)
Alveolus, infiltration cellular, histiocyte	10 (20%)	7 (14%)	11 (22%)	5 (10%)

**TABLE C4**  
**Summary of the Incidence of Nonneoplastic Lesions in Male Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Respiratory System (continued)</b>				
Nose	(50)	(50)	(50)	(50)
Inflammation	7 (14%)	16 (32%)	5 (10%)	9 (18%)
Glands, metaplasia	1 (2%)			
Glands, metaplasia, respiratory	3 (6%)	3 (6%)	2 (4%)	1 (2%)
Olfactory epithelium, accumulation, hyaline droplet	18 (36%)	16 (32%)	15 (30%)	28 (56%)
Olfactory epithelium, atrophy		3 (6%)		
Olfactory epithelium, degeneration	1 (2%)			
Olfactory epithelium, hyperplasia	2 (4%)			1 (2%)
Olfactory epithelium, metaplasia	1 (2%)			
Olfactory epithelium, metaplasia, respiratory	3 (6%)	3 (6%)		
Olfactory epithelium, pigmentation		1 (2%)	3 (6%)	13 (26%)
Respiratory epithelium, hyperplasia	40 (80%)	38 (76%)	37 (74%)	33 (66%)
Trachea	(50)	(50)	(50)	(50)
<b>Special Senses System</b>				
Ear	(1)	(0)	(0)	(1)
Eye	(50)	(50)	(50)	(50)
Atrophy			1 (2%)	
Cataract			1 (2%)	
Inflammation	1 (2%)			
Cornea, hyperplasia, squamous	1 (2%)	1 (2%)	3 (6%)	
Cornea, inflammation	1 (2%)	1 (2%)	3 (6%)	1 (2%)
Harderian gland	(50)	(50)	(50)	(50)
Atrophy		1 (2%)		
Cyst				1 (2%)
Fibrosis		1 (2%)		
Hyperplasia	3 (6%)	5 (10%)	3 (6%)	2 (4%)
Infiltration cellular, lymphoid		1 (2%)	1 (2%)	
Mineralization		1 (2%)		
Pigmentation	1 (2%)			
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Accumulation, hyaline droplet		1 (2%)		
Cyst	6 (12%)	6 (12%)	8 (16%)	5 (10%)
Infarct	2 (4%)	2 (4%)		
Infiltration cellular, lymphoid	2 (4%)	1 (2%)	1 (2%)	
Inflammation	2 (4%)	4 (8%)	1 (2%)	1 (2%)
Metaplasia, osseous	3 (6%)	4 (8%)	4 (8%)	
Mineralization	40 (80%)	40 (80%)	38 (76%)	21 (42%)
Nephropathy	49 (98%)	45 (90%)	44 (88%)	39 (78%)
Pigmentation	3 (6%)	15 (30%)	26 (52%)	19 (38%)
Pelvis, dilatation			1 (2%)	
Renal tubule, hyperplasia	1 (2%)	1 (2%)		
Renal tubule, necrosis		1 (2%)		
Urethra	(0)	(1)	(0)	(0)
Bulbourethral gland, inflammation		1 (100%)		
Urinary bladder	(50)	(50)	(50)	(50)
Hemorrhage		1 (2%)		
Inflammation	2 (4%)	2 (4%)		1 (2%)



**APPENDIX D**  
**SUMMARY OF LESIONS IN FEMALE MICE**  
**IN THE 2-YEAR GAVAGE STUDY**  
**OF *GINKGO BILOBA* EXTRACT**

<b>TABLE D1</b>	<b>Summary of the Incidence of Neoplasms in Female Mice in the 2-Year Gavage Study of <i>Ginkgo biloba</i> Extract .....</b>	<b>130</b>
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**TABLE D1**  
**Summary of the Incidence of Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of *Ginkgo biloba* Extract<sup>a</sup>**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Accidental death	5	2	1	
Moribund	8	8	3	3
Natural death	6	4	3	11
Survivors				
Terminal kill	31	36	43	36
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Gallbladder	(50)	(50)	(48)	(48)
Intestine large, cecum	(50)	(50)	(50)	(50)
Intestine large, colon	(50)	(50)	(50)	(50)
Intestine large, rectum	(50)	(50)	(50)	(50)
Intestine small, duodenum	(50)	(50)	(50)	(50)
Intestine small, ileum	(50)	(50)	(50)	(50)
Intestine small, jejunum	(50)	(50)	(50)	(50)
Liver	(50)	(50)	(50)	(50)
Fibrous histiocytoma				1 (2%)
Hemangiosarcoma		1 (2%)	1 (2%)	
Hepatoblastoma	1 (2%)	1 (2%)	7 (14%)	7 (14%)
Hepatoblastoma, multiple			1 (2%)	4 (8%)
Hepatocellular adenoma	7 (14%)	7 (14%)	4 (8%)	5 (10%)
Hepatocellular adenoma, multiple	10 (20%)	30 (60%)	37 (74%)	43 (86%)
Hepatocellular carcinoma	7 (14%)	8 (16%)	10 (20%)	13 (26%)
Hepatocellular carcinoma, multiple	2 (4%)	2 (4%)	5 (10%)	31 (62%)
Osteosarcoma, metastatic, bone				1 (2%)
Mesentery	(3)	(5)	(3)	(4)
Oral mucosa	(1)	(0)	(0)	(0)
Gingival, squamous cell carcinoma	1 (100%)			
Pancreas	(50)	(49)	(50)	(50)
Fibrous histiocytoma				1 (2%)
Salivary glands	(50)	(50)	(49)	(50)
Sarcoma, metastatic, skin		1 (2%)		
Stomach, forestomach	(50)	(50)	(50)	(50)
Squamous cell papilloma	2 (4%)	1 (2%)		
Stomach, glandular	(50)	(50)	(50)	(50)
Adenoma			1 (2%)	
Tooth	(50)	(50)	(50)	(50)
<b>Cardiovascular System</b>				
Blood vessel	(50)	(49)	(50)	(50)
Heart	(50)	(50)	(50)	(50)

**TABLE D1**  
**Summary of the Incidence of Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Fibrous histiocytoma				1 (2%)
Adrenal medulla	(50)	(50)	(50)	(50)
Pheochromocytoma benign		1 (2%)		
Pheochromocytoma malignant		1 (2%)		
Islets, pancreatic	(50)	(50)	(50)	(50)
Parathyroid gland	(47)	(46)	(45)	(45)
Pituitary gland	(50)	(50)	(49)	(50)
Pars distalis, adenoma	4 (8%)	2 (4%)	1 (2%)	
Pars intermedia, adenoma	1 (2%)			1 (2%)
Thyroid gland	(49)	(48)	(49)	(48)
<b>General Body System</b>				
None				
<b>Genital System</b>				
Clitoral gland	(50)	(50)	(50)	(49)
Ovary	(50)	(50)	(49)	(50)
Choriocarcinoma	1 (2%)			
Cystadenoma	2 (4%)	3 (6%)	1 (2%)	1 (2%)
Fibrous histiocytoma				1 (2%)
Hemangioma				1 (2%)
Hemangiosarcoma	1 (2%)			
Teratoma benign			1 (2%)	
Uterus	(50)	(50)	(50)	(50)
Polyp stromal	1 (2%)			
Sarcoma stromal	1 (2%)			
Endometrium, polyp stromal			1 (2%)	
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(50)	(50)
Lymph node	(16)	(11)	(11)	(6)
Lymph node, bronchial	(0)	(0)	(0)	(1)
Lymph node, mandibular	(49)	(50)	(49)	(50)
Lymph node, mesenteric	(50)	(50)	(50)	(50)
Spleen	(50)	(50)	(50)	(50)
Hemangiosarcoma	1 (2%)			
Thymus	(50)	(49)	(49)	(50)
<b>Integumentary System</b>				
Mammary gland	(50)	(50)	(50)	(50)
Carcinoma		1 (2%)	1 (2%)	
Skin	(50)	(50)	(50)	(50)
Basal cell carcinoma	1 (2%)			
Keratoacanthoma				1 (2%)
Melanoma malignant	1 (2%)			
Sarcoma	1 (2%)	1 (2%)		
Subcutaneous tissue, sarcoma	2 (4%)	2 (4%)		
Tail, fibrous histiocytoma			1 (2%)	
Tail, melanoma malignant		1 (2%)		

**TABLE D1**  
**Summary of the Incidence of Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Osteosarcoma				1 (2%)
Skeletal muscle	(1)	(1)	(0)	(0)
Hemangiosarcoma	1 (100%)			
Sarcoma		1 (100%)		
<b>Nervous System</b>				
Brain	(50)	(50)	(49)	(50)
Peripheral nerve	(1)	(1)	(1)	(0)
Spinal cord	(0)	(1)	(1)	(0)
<b>Respiratory System</b>				
Lung	(50)	(50)	(50)	(50)
Alveolar/bronchiolar adenoma				1 (2%)
Alveolar/bronchiolar carcinoma	1 (2%)	2 (4%)	2 (4%)	3 (6%)
Hepatoblastoma, metastatic, liver			1 (2%)	
Hepatocellular carcinoma, metastatic, liver	3 (6%)	3 (6%)	2 (4%)	5 (10%)
Osteosarcoma, metastatic, bone				1 (2%)
Pheochromocytoma malignant, metastatic, adrenal medulla		1 (2%)		
Sarcoma, metastatic, skin	1 (2%)			
Nose	(50)	(50)	(50)	(50)
Adenoma		1 (2%)		
Trachea	(50)	(50)	(50)	(50)
<b>Special Senses System</b>				
Ear	(1)	(0)	(0)	(0)
Eye	(50)	(50)	(49)	(50)
Harderian gland	(50)	(50)	(49)	(50)
Adenoma	5 (10%)	3 (6%)	2 (4%)	10 (20%)
Carcinoma	1 (2%)		4 (8%)	1 (2%)
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Fibrous histiocytoma				1 (2%)
Urinary bladder	(50)	(50)	(50)	(50)
Fibrous histiocytoma				1 (2%)
<b>Systemic Lesions</b>				
Multiple organs <sup>b</sup>	(50)	(50)	(50)	(50)
Histiocytic sarcoma	1 (2%)	1 (2%)	3 (6%)	3 (6%)
Leukemia myeloid				1 (2%)
Lymphoma malignant	11 (22%)	9 (18%)	7 (14%)	2 (4%)

**TABLE D1**  
**Summary of the Incidence of Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of *Ginkgo biloba* Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Neoplasm Summary</b>				
Total animals with primary neoplasms <sup>c</sup>	35	46	46	49
Total primary neoplasms	67	79	90	135
Total animals with benign neoplasms	25	39	41	48
Total benign neoplasms	32	48	48	63
Total animals with malignant neoplasms	28	26	30	47
Total malignant neoplasms	35	31	42	72
Total animals with metastatic neoplasms	4	5	3	6
Total metastatic neoplasms	4	5	3	7

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with neoplasm

<sup>b</sup> Number of animals with any tissue examined microscopically

<sup>c</sup> Primary neoplasms: all neoplasms except metastatic neoplasms

**TABLE D2**  
**Statistical Analysis of Primary Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Harderian Gland: Adenoma</b>				
Overall rate <sup>a</sup>	5/50 (10%)	3/50 (6%)	2/50 (4%)	10/50 (20%)
Adjusted rate <sup>b</sup>	12.2%	6.6%	4.3%	21.6%
Terminal rate <sup>c</sup>	4/31 (13%)	2/36 (6%)	2/43 (5%)	8/36 (22%)
First incidence (days)	653	704	727 (T)	609
Poly-3 test <sup>d</sup>	P=0.018	P=0.299N	P=0.166N	P=0.192
<b>Harderian Gland: Carcinoma</b>				
Overall rate	1/50 (2%)	0/50 (0%)	4/50 (8%)	1/50 (2%)
Adjusted rate	2.5%	0.0%	8.5%	2.2%
Terminal rate	1/31 (3%)	0/36 (0%)	3/43 (7%)	1/36 (3%)
First incidence (days)	727 (T)	— <sup>e</sup>	587	727 (T)
Poly-3 test	P=0.641	P=0.478N	P=0.228	P=0.734N
<b>Harderian Gland: Adenoma or Carcinoma</b>				
Overall rate	6/50 (12%)	3/50 (6%)	6/50 (12%)	10/50 (20%)
Adjusted rate	14.7%	6.6%	12.7%	21.6%
Terminal rate	5/31 (16%)	2/36 (6%)	5/43 (12%)	8/36 (22%)
First incidence (days)	653	704	587	609
Poly-3 test	P=0.061	P=0.191N	P=0.517N	P=0.290
<b>Liver: Hepatocellular Adenoma</b>				
Overall rate	17/50 (34%)	37/50 (74%)	41/50 (82%)	48/50 (96%)
Adjusted rate	41.0%	78.3%	86.9%	96.0%
Terminal rate	14/31 (45%)	29/36 (81%)	38/43 (88%)	34/36 (94%)
First incidence (days)	589	596	628	497
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
<b>Liver: Hepatocellular Carcinoma</b>				
Overall rate	9/50 (18%)	10/50 (20%)	15/50 (30%)	44/50 (88%)
Adjusted rate	21.7%	21.8%	32.1%	91.7%
Terminal rate	5/31 (16%)	8/36 (22%)	14/43 (33%)	34/36 (94%)
First incidence (days)	653	656	718	593
Poly-3 test	P<0.001	P=0.596	P=0.197	P<0.001
<b>Liver: Hepatocellular Adenoma or Carcinoma</b>				
Overall rate	20/50 (40%)	39/50 (78%)	41/50 (82%)	49/50 (98%)
Adjusted rate	47.7%	82.1%	86.9%	98.0%
Terminal rate	15/31 (48%)	30/36 (83%)	38/43 (88%)	35/36 (97%)
First incidence (days)	589	596	628	497
Poly-3 test	P<0.001	P<0.001	P<0.001	P<0.001
<b>Liver: Hepatoblastoma</b>				
Overall rate	1/50 (2%)	1/50 (2%)	8/50 (16%)	11/50 (22%)
Adjusted rate	2.5%	2.2%	17.1%	23.8%
Terminal rate	1/31 (3%)	1/36 (3%)	8/43 (19%)	8/36 (22%)
First incidence (days)	727 (T)	727 (T)	727 (T)	609
Poly-3 test	P<0.001	P=0.735N	P=0.028	P=0.004
<b>Liver: Hepatocellular Carcinoma or Hepatoblastoma</b>				
Overall rate	10/50 (20%)	11/50 (22%)	18/50 (36%)	44/50 (88%)
Adjusted rate	24.1%	24.0%	38.5%	91.7%
Terminal rate	6/31 (19%)	9/36 (25%)	17/43 (40%)	34/36 (94%)
First incidence (days)	653	656	718	593
Poly-3 test	P<0.001	P=0.594N	P=0.110	P<0.001

**TABLE D2**  
**Statistical Analysis of Primary Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Lung: Alveolar/bronchiolar Adenoma or Carcinoma</b>				
Overall rate	1/50 (2%)	2/50 (4%)	2/50 (4%)	4/50 (8%)
Adjusted rate	2.5%	4.4%	4.3%	8.7%
Terminal rate	0/31 (0%)	1/36 (3%)	2/43 (5%)	3/36 (8%)
First incidence (days)	659	685	727 (T)	609
Poly-3 test	P=0.149	P=0.538	P=0.547	P=0.217
<b>Ovary: Cystadenoma</b>				
Overall rate	2/50 (4%)	3/50 (6%)	1/49 (2%)	1/50 (2%)
Adjusted rate	4.9%	6.5%	2.2%	2.2%
Terminal rate	1/31 (3%)	1/36 (3%)	1/43 (2%)	1/36 (3%)
First incidence (days)	531	659	727 (T)	727(T)
Poly-3 test	P=0.294N	P=0.548	P=0.464N	P=0.465N
<b>Pituitary Gland (Pars Distalis): Adenoma</b>				
Overall rate	4/50 (8%)	2/50 (4%)	1/49 (2%)	0/50 (0%)
Adjusted rate	9.9%	4.4%	2.2%	0.0%
Terminal rate	4/31 (13%)	2/36 (6%)	1/43 (2%)	0/36 (0%)
First incidence (days)	727 (T)	727 (T)	727 (T)	—
Poly-3 test	P=0.056N	P=0.287N	P=0.145N	P=0.047N
<b>Skin: Sarcoma</b>				
Overall rate	3/50 (6%)	3/50 (6%)	0/50 (0%)	0/50 (0%)
Adjusted rate	7.3%	6.5%	0.0%	0.0%
Terminal rate	1/31 (3%)	1/36 (3%)	0/43 (0%)	0/36 (0%)
First incidence (days)	659	447	—	—
Poly-3 test	P=0.058N	P=0.604N	P=0.097N	P=0.101N
<b>Skin: Fibrous Histiocytoma or Sarcoma</b>				
Overall rate	3/50 (6%)	3/50 (6%)	1/50 (2%)	0/50 (0%)
Adjusted rate	7.3%	6.5%	2.1%	0.0%
Terminal rate	1/31 (3%)	1/36 (3%)	1/43 (2%)	0/36 (0%)
First incidence (days)	659	447	727 (T)	—
Poly-3 test	P=0.065N	P=0.604N	P=0.260N	P=0.101N
<b>All Organs: Histiocytic Sarcoma</b>				
Overall rate	1/50 (2%)	1/50 (2%)	3/50 (6%)	3/50 (6%)
Adjusted rate	2.5%	2.2%	6.3%	6.5%
Terminal rate	0/31 (0%)	1/36 (3%)	2/43 (5%)	1/36 (3%)
First incidence (days)	700	727 (T)	414	589
Poly-3 test	P=0.250	P=0.736N	P=0.363	P=0.353
<b>All Organs: Malignant Lymphoma</b>				
Overall rate	11/50 (22%)	9/50 (18%)	7/50 (14%)	2/50 (4%)
Adjusted rate	26.6%	19.5%	15.0%	4.4%
Terminal rate	8/31 (26%)	7/36 (19%)	6/43 (14%)	1/36 (3%)
First incidence (days)	547	596	718	672
Poly-3 test	P=0.004N	P=0.297N	P=0.138N	P=0.003N
<b>All Organs: Benign Neoplasms</b>				
Overall rate	25/50 (50%)	39/50 (78%)	41/50 (82%)	48/50 (96%)
Adjusted rate	58.8%	82.1%	86.9%	96.0%
Terminal rate	18/31 (58%)	30/36 (83%)	38/43 (88%)	34/36 (94%)
First incidence (days)	531	596	628	497
Poly-3 test	P<0.001	P=0.010	P=0.002	P<0.001

**TABLE D2**  
**Statistical Analysis of Primary Neoplasms in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>All Organs: Malignant Neoplasms</b>				
Overall rate	28/50 (56%)	26/50 (52%)	30/50 (60%)	47/50 (94%)
Adjusted rate	64.9%	53.8%	62.4%	95.3%
Terminal rate	18/31 (58%)	17/36 (47%)	26/43 (61%)	34/36 (94%)
First incidence (days)	476	447	414	497
Poly-3 test	P<0.001	P=0.191N	P=0.487N	P<0.001
<b>All Organs: Benign or Malignant Neoplasms</b>				
Overall rate	35/50 (70%)	46/50 (92%)	46/50 (92%)	49/50 (98%)
Adjusted rate	79.2%	93.3%	94.9%	98.0%
Terminal rate	23/31 (74%)	33/36 (92%)	41/43 (95%)	35/36 (97%)
First incidence (days)	476	447	414	497
Poly-3 test	P=0.012	P=0.041	P=0.021	P=0.003

(T) Terminal kill

<sup>a</sup> Number of neoplasm-bearing animals/number of animals examined. Denominator is number of animals examined microscopically for liver, lung, ovary, and pituitary gland; for other tissues, denominator is number of animals necropsied.

<sup>b</sup> Poly-3 estimated neoplasm incidence after adjustment for intercurrent mortality

<sup>c</sup> Observed incidence at terminal kill

<sup>d</sup> Beneath the vehicle control incidence is the P value associated with the trend test. Beneath the dosed group incidence are the P values corresponding to pairwise comparisons between the vehicle controls and that dosed group. The Poly-3 test accounts for the differential mortality in animals that do not reach terminal kill. A negative trend or a lower incidence in a dose group is indicated by **N**.

<sup>e</sup> Not applicable; no neoplasms in animal group

**TABLE D3**  
**Historical Incidence of Liver Neoplasms in Control Female B6C3F1/N Mice<sup>a</sup>**

Study (Study Start)	Hepatocellular Adenoma	Hepatocellular Carcinoma	Hepatocellular Adenoma or Hepatocellular Carcinoma
<b>Historical Incidence: Corn Oil Gavage Studies</b>			
<i>Ginkgo biloba</i> extract (March 2005)	17/50	9/50	20/50
Isoeugenol (April 2002)	11/49	3/49	13/49
Kava kava extract (August 2004)	8/50	3/50	10/50
β-Myrcene (March 2002)	6/50	1/50	7/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	17/50	6/50	20/50
Pulegone (April 2003)	13/49	5/49	17/49
3,3',4,4'-Tetrachloroazobenzene (February 2003)	3/49	2/49	4/49
Total (%)	75/347 (21.6%)	29/347 (8.4%)	91/347 (26.2%)
Mean ± standard deviation	21.6% ± 10.8%	8.4% ± 5.5%	26.2% ± 12.7%
Range	6%-34%	2%-18%	8%-40%
<b>Overall Historical Incidence: All Routes</b>			
Total (%)	380/1,195 (31.8%)	144/1,195 (12.1%)	444/1,195 (37.2%)
Mean ± standard deviation	31.8% ± 21.4%	12.1% ± 10.8%	37.2% ± 22.9%
Range	2%-78%	0%-46%	6%-82%
	<b>Hepatoblastoma</b>	<b>Hepatocellular Carcinoma or Hepatoblastoma</b>	<b>Hepatocellular Adenoma, Hepatocellular Carcinoma, or Hepatoblastoma</b>
<b>Historical Incidence: Corn Oil Gavage Studies</b>			
<i>Ginkgo biloba</i> extract (March 2005)	1/50	10/50	20/50
Isoeugenol (April 2002)	0/49	3/49	13/49
Kava kava extract (August 2004)	0/50	3/50	10/50
β-Myrcene (March 2002)	0/50	1/50	7/50
<i>N,N</i> -Dimethyl- <i>p</i> -toluidine (October 2004)	0/50	6/50	20/50
Pulegone (April 2003)	0/49	5/49	17/49
3,3',4,4'-Tetrachloroazobenzene (February 2003)	0/49	2/49	4/49
Total (%)	1/347 (0.3%)	30/347 (8.6%)	91/347 (26.2%)
Mean ± standard deviation	0.3% ± 0.8%	8.6% ± 6.1%	26.2% ± 12.7%
Range	0%-2%	2%-20%	8%-40%
<b>Overall Historical Incidence: All Routes</b>			
Total (%)	4/1,195 (0.3%)	148/1,195 (12.4%)	444/1,195 (37.2%)
Mean ± standard deviation	0.3% ± 0.8%	12.4% ± 11.2%	37.2% ± 22.9%
Range	0%-2%	0%-46%	6%-82%

<sup>a</sup> Data as of May 2011



**TABLE D4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Disposition Summary</b>				
Animals initially in study	50	50	50	50
Early deaths				
Accidental death	5	2	1	
Moribund	8	8	3	3
Natural death	6	4	3	11
Survivors				
Terminal kill	31	36	43	36
Animals examined microscopically	50	50	50	50
<b>Alimentary System</b>				
Esophagus	(50)	(50)	(50)	(50)
Inflammation	5 (10%)		1 (2%)	
Perforation	4 (8%)			
Gallbladder	(50)	(50)	(48)	(48)
Cyst		3 (6%)		
Intestine large, cecum	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid				1 (2%)
Inflammation			1 (2%)	
Necrosis		1 (2%)		
Intestine large, colon	(50)	(50)	(50)	(50)
Inflammation				1 (2%)
Intestine large, rectum	(50)	(50)	(50)	(50)
Intestine small, duodenum	(50)	(50)	(50)	(50)
Epithelium, hyperplasia	1 (2%)			
Intestine small, ileum	(50)	(50)	(50)	(50)
Inflammation	1 (2%)			
Epithelium, hyperplasia	1 (2%)			
Intestine small, jejunum	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid			1 (2%)	
Liver	(50)	(50)	(50)	(50)
Basophilic focus	7 (14%)	8 (16%)	9 (18%)	9 (18%)
Clear cell focus	1 (2%)	3 (6%)	2 (4%)	6 (12%)
Eosinophilic focus	26 (52%)	39 (78%)	43 (86%)	45 (90%)
Erythrophagocytosis		3 (6%)	7 (14%)	16 (32%)
Fatty change, focal	1 (2%)	1 (2%)	2 (4%)	3 (6%)
Hematopoietic cell proliferation	14 (28%)	12 (24%)	9 (18%)	4 (8%)
Hypertrophy		18 (36%)	37 (74%)	37 (74%)
Inflammation	38 (76%)	45 (90%)	46 (92%)	41 (82%)
Mineralization				1 (2%)
Mixed cell focus	7 (14%)	27 (54%)	31 (62%)	31 (62%)
Necrosis	4 (8%)	2 (4%)	6 (12%)	11 (22%)
Tension lipidosis	5 (10%)	11 (22%)	10 (20%)	3 (6%)
Vacuolization, cytoplasmic	18 (36%)	38 (76%)	44 (88%)	35 (70%)
Bile duct, cyst		2 (4%)	1 (2%)	
Mesentery	(3)	(5)	(3)	(4)
Inflammation			1 (33%)	1 (25%)
Fat, necrosis	2 (67%)	5 (100%)	3 (100%)	2 (50%)
Oral mucosa	(1)	(0)	(0)	(0)
Pancreas	(50)	(49)	(50)	(50)
Atrophy	1 (2%)	4 (8%)	4 (8%)	1 (2%)
Cyst	1 (2%)			
Infiltration cellular, lymphoid		3 (6%)	1 (2%)	
Inflammation			1 (2%)	2 (4%)
Acinus, hyperplasia			1 (2%)	
Acinus, hypertrophy	1 (2%)			
Duct, cyst		1 (2%)	3 (6%)	1 (2%)

<sup>a</sup> Number of animals examined microscopically at the site and the number of animals with lesion

**TABLE D4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Alimentary System (continued)</b>				
Salivary glands	(50)	(50)	(49)	(50)
Infiltration cellular, lymphoid	3 (6%)	2 (4%)	2 (4%)	1 (2%)
Stomach, forestomach	(50)	(50)	(50)	(50)
Inflammation	4 (8%)	6 (12%)	5 (10%)	19 (38%)
Mineralization		1 (2%)		
Epithelium, erosion		1 (2%)		
Epithelium, hyperkeratosis	3 (6%)	11 (22%)	5 (10%)	20 (40%)
Epithelium, hyperplasia	8 (16%)	18 (36%)	11 (22%)	20 (40%)
Epithelium, ulcer	1 (2%)	1 (2%)	1 (2%)	11 (22%)
Stomach, glandular	(50)	(50)	(50)	(50)
Cyst		1 (2%)	2 (4%)	1 (2%)
Inflammation		2 (4%)	1 (2%)	3 (6%)
Mineralization	1 (2%)			
Epithelium, hyperplasia	2 (4%)	2 (4%)	1 (2%)	5 (10%)
Tooth	(50)	(50)	(50)	(50)
Dysplasia		4 (8%)	3 (6%)	
<b>Cardiovascular System</b>				
Blood vessel	(50)	(49)	(50)	(50)
Mineralization	1 (2%)	1 (2%)		
Aorta, inflammation	1 (2%)			
Heart	(50)	(50)	(50)	(50)
Cardiomyopathy	7 (14%)	5 (10%)	5 (10%)	7 (14%)
Inflammation	2 (4%)	1 (2%)		
Mineralization	2 (4%)	2 (4%)	3 (6%)	
Necrosis		1 (2%)		
Epicardium, inflammation	2 (4%)		1 (2%)	
<b>Endocrine System</b>				
Adrenal cortex	(50)	(50)	(50)	(50)
Angiectasis	1 (2%)			
Hematopoietic cell proliferation	5 (10%)	1 (2%)	3 (6%)	3 (6%)
Hypertrophy	1 (2%)			
Infiltration cellular, lymphoid			1 (2%)	1 (2%)
Subcapsular, hyperplasia	46 (92%)	50 (100%)	49 (98%)	50 (100%)
Adrenal medulla	(50)	(50)	(50)	(50)
Hyperplasia		1 (2%)		
Hypertrophy				1 (2%)
Islets, pancreatic	(50)	(50)	(50)	(50)
Atrophy			1 (2%)	
Hyperplasia	7 (14%)	11 (22%)	11 (22%)	9 (18%)
Parathyroid gland	(47)	(46)	(45)	(45)
Hyperplasia	1 (2%)	1 (2%)	1 (2%)	
Infiltration cellular, lymphoid			2 (4%)	
Pituitary gland	(50)	(50)	(49)	(50)
Angiectasis		1 (2%)		
Pars distalis, hyperplasia	14 (28%)	20 (40%)	22 (45%)	10 (20%)
Thyroid gland	(49)	(48)	(49)	(48)
Ultimobranchial cyst	14 (29%)	7 (15%)	9 (18%)	3 (6%)
C-cell, hyperplasia	3 (6%)	6 (13%)	5 (10%)	1 (2%)
Follicle, cyst	3 (6%)	1 (2%)	2 (4%)	1 (2%)
Follicle, hyperplasia			4 (8%)	
Follicular cell, degeneration			1 (2%)	
Follicular cell, hypertrophy	1 (2%)	5 (10%)	9 (18%)	39 (81%)

**TABLE D4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>General Body System</b>				
None				
<b>Genital System</b>				
Clitoral gland	(50)	(50)	(50)	(49)
Inflammation	4 (8%)	2 (4%)	1 (2%)	
Ovary	(50)	(50)	(49)	(50)
Angiectasis	2 (4%)			2 (4%)
Cyst	8 (16%)	10 (20%)	17 (35%)	11 (22%)
Hemorrhage, chronic		1 (2%)		
Mineralization	1 (2%)		1 (2%)	
Thrombosis	1 (2%)		1 (2%)	
Germinal epithelium, hyperplasia			1 (2%)	
Uterus	(50)	(50)	(50)	(50)
Angiectasis			1 (2%)	1 (2%)
Dysplasia				1 (2%)
Fibrosis	1 (2%)			
Hemorrhage			1 (2%)	
Inflammation	7 (14%)	10 (20%)	3 (6%)	2 (4%)
Malformation		1 (2%)		
Artery, dysplasia			1 (2%)	
Endometrium, decidual reaction	1 (2%)			
Endometrium, hyperplasia	1 (2%)			
Endometrium, hyperplasia, cystic	35 (70%)	37 (74%)	35 (70%)	30 (60%)
<b>Hematopoietic System</b>				
Bone marrow	(50)	(50)	(50)	(50)
Hyperplasia	38 (76%)	43 (86%)	42 (84%)	36 (72%)
Necrosis		1 (2%)		
Lymph node	(16)	(11)	(11)	(6)
Bronchial, hyperplasia, lymphoid	3 (19%)	3 (27%)	2 (18%)	1 (17%)
Inguinal, hyperplasia, lymphoid	7 (44%)	2 (18%)	2 (18%)	3 (50%)
Mediastinal, hyperplasia, lymphoid		2 (18%)		1 (17%)
Pancreatic, angiectasis	1 (6%)			
Pancreatic, hyperplasia, lymphoid	1 (6%)		1 (9%)	
Renal, angiectasis	1 (6%)			
Renal, ectasia			1 (9%)	
Renal, hemorrhage, chronic			1 (9%)	
Renal, sinus, ectasia			1 (9%)	
Lymph node, bronchial	(0)	(0)	(0)	(1)
Lymph node, mandibular	(49)	(50)	(49)	(50)
Angiectasis			1 (2%)	
Hyperplasia, lymphoid	6 (12%)	15 (30%)	10 (20%)	7 (14%)
Inflammation	1 (2%)			
Lymph node, mesenteric	(50)	(50)	(50)	(50)
Hyperplasia, lymphoid	6 (12%)	5 (10%)	2 (4%)	
Inflammation			1 (2%)	
Spleen	(50)	(50)	(50)	(50)
Hematopoietic cell proliferation	48 (96%)	48 (96%)	50 (100%)	50 (100%)
Hyperplasia, lymphoid	20 (40%)	33 (66%)	25 (50%)	29 (58%)
Mineralization		1 (2%)		
Necrosis			1 (2%)	
Pigmentation	4 (8%)			
Lymphoid follicle, atrophy			1 (2%)	1 (2%)

**TABLE D4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Hematopoietic System (continued)</b>				
Thymus	(50)	(49)	(49)	(50)
Angiectasis				1 (2%)
Hyperplasia, lymphoid	18 (36%)	16 (33%)	23 (47%)	13 (26%)
Inflammation			1 (2%)	
Necrosis	3 (6%)			
<b>Integumentary System</b>				
Mammary gland	(50)	(50)	(50)	(50)
Hyperplasia	3 (6%)			
Inflammation			1 (2%)	
Skin	(50)	(50)	(50)	(50)
Dermis, inflammation	1 (2%)		1 (2%)	
Epidermis, hyperplasia	1 (2%)			
Epidermis, ulcer	1 (2%)			
Sebaceous gland, hyperplasia	1 (2%)			
<b>Musculoskeletal System</b>				
Bone	(50)	(50)	(50)	(50)
Fracture		2 (4%)		
Osteopetrosis			1 (2%)	
Osteoporosis	7 (14%)	16 (32%)	17 (34%)	6 (12%)
Synovial tissue, inflammation		1 (2%)		
Skeletal muscle	(1)	(1)	(0)	(0)
<b>Nervous System</b>				
Brain	(50)	(50)	(49)	(50)
Gliosis	1 (2%)	1 (2%)		
Hemorrhage		1 (2%)		
Peripheral nerve	(1)	(1)	(1)	(0)
Sciatic, demyelination	1 (100%)			
Spinal, demyelination	1 (100%)			
Spinal cord	(0)	(1)	(1)	(0)
<b>Respiratory System</b>				
Lung	(50)	(50)	(50)	(50)
Cyst			1 (2%)	
Hemorrhage		2 (4%)		
Infiltration cellular, histiocyte		3 (6%)	2 (4%)	3 (6%)
Inflammation		5 (10%)	3 (6%)	7 (14%)
Metaplasia, osseous	1 (2%)			1 (2%)
Mineralization		1 (2%)		
Thrombosis	1 (2%)			
Vacuolization, cytoplasmic				1 (2%)
Alveolar epithelium, hyperplasia	1 (2%)	1 (2%)		
Alveolar epithelium, inflammation	1 (2%)			
Arteriole, hyperplasia				3 (6%)
Bronchiole, hyperplasia		1 (2%)		
Pleura, inflammation	5 (10%)		1 (2%)	
Smooth muscle, proliferation				1 (2%)

**TABLE D4**  
**Summary of the Incidence of Nonneoplastic Lesions in Female Mice in the 2-Year Gavage Study**  
**of Ginkgo biloba Extract**

	Vehicle Control	200 mg/kg	600 mg/kg	2,000 mg/kg
<b>Respiratory System (continued)</b>				
Nose	(50)	(50)	(50)	(50)
Inflammation,	4 (8%)	5 (10%)	4 (8%)	6 (12%)
Glands, metaplasia	3 (6%)	4 (8%)	5 (10%)	2 (4%)
Olfactory epithelium, accumulation, hyaline droplet	5 (10%)	3 (6%)	12 (24%)	17 (34%)
Olfactory epithelium, atrophy			1 (2%)	1 (2%)
Olfactory epithelium, degeneration	3 (6%)			
Olfactory epithelium, hyperplasia	1 (2%)			
Olfactory epithelium, metaplasia	1 (2%)			
Olfactory epithelium, pigmentation		1 (2%)	6 (12%)	13 (26%)
Respiratory epithelium, hyperplasia	15 (30%)	15 (30%)	18 (36%)	15 (30%)
Trachea	(50)	(50)	(50)	(50)
<b>Special Senses System</b>				
Ear	(1)	(0)	(0)	(0)
Eye	(50)	(50)	(49)	(50)
Cataract		1 (2%)	1 (2%)	
Phthisis bulbi		1 (2%)		
Anterior chamber, inflammation	1 (2%)			1 (2%)
Cornea, inflammation	1 (2%)	1 (2%)	1 (2%)	1 (2%)
Harderian gland	(50)	(50)	(49)	(50)
Fibrosis			1 (2%)	
Hyperplasia	2 (4%)	1 (2%)	2 (4%)	4 (8%)
Infiltration cellular, lymphoid	1 (2%)			1 (2%)
Inflammation			1 (2%)	1 (2%)
<b>Urinary System</b>				
Kidney	(50)	(50)	(50)	(50)
Accumulation, hyaline droplet			1 (2%)	
Cyst	1 (2%)		3 (6%)	3 (6%)
Dilatation		1 (2%)		
Glomerulopathy				1 (2%)
Infarct	1 (2%)		1 (2%)	
Infiltration cellular, lymphoid				1 (2%)
Inflammation	1 (2%)		2 (4%)	
Metaplasia, osseous	1 (2%)	1 (2%)	1 (2%)	
Mineralization	11 (22%)	8 (16%)	3 (6%)	10 (20%)
Nephropathy	24 (48%)	17 (34%)	15 (30%)	14 (28%)
Pigmentation			2 (4%)	1 (2%)
Glomerulus, amyloid deposition	1 (2%)			
Pelvis, dilatation				1 (2%)
Urinary bladder	(50)	(50)	(50)	(50)
Infiltration cellular, lymphoid	6 (12%)	2 (4%)	2 (4%)	8 (16%)
Inflammation			1 (2%)	

## APPENDIX E

### GENETIC TOXICOLOGY

<b>BACTERIAL MUTAGENICITY TEST PROTOCOL .....</b>	<b>144</b>
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## GENETIC TOXICOLOGY

### BACTERIAL MUTAGENICITY TEST PROTOCOL

Testing procedures were modified from those reported by Zeiger *et al.* (1992). *Ginkgo biloba* extract (lot 020703; the same chemical lot that was used in the 3-month and 2-year studies) was sent to the laboratory as a coded aliquot. It was incubated with the *Salmonella typhimurium* tester strains TA98 and TA100 and *Escherichia coli* (WP2 *uvrA*/pKM101) either in buffer or S9 mix (metabolic activation enzymes and cofactors from Aroclor 1254-induced male Sprague-Dawley rat liver) for 20 minutes at 37° C. Top agar supplemented with L-histidine and d-biotin was added, and the contents of the tubes were mixed and poured onto the surfaces of minimal glucose agar plates. Histidine-independent mutant colonies arising on these plates were counted following incubation for 2 days at 37° C.

Each trial consisted of triplicate plates of concurrent positive and negative controls and five doses of *Ginkgo biloba* extract. The high dose was limited by experimental design to 10,000 µg/plate. All trials were repeated.

In this assay, a positive response is defined as a reproducible, dose-related increase in histidine-independent (revertant) colonies in any one strain/activation combination. An equivocal response is defined as an increase in revertants that is not dose related, is not reproducible, or is not of sufficient magnitude to support a determination of mutagenicity. A negative response is obtained when no increase in revertant colonies is observed following chemical treatment. There is no minimum percentage or fold increase required for a chemical to be judged positive or weakly positive, although positive calls are typically reserved for increases in mutant colonies that are at least twofold over background.

### MOUSE PERIPHERAL BLOOD MICRONUCLEUS TEST PROTOCOL

A detailed discussion of this assay is presented by MacGregor *et al.* (1990). At the end of the 3-month toxicity study, peripheral blood samples were obtained from male and female mice. Smears were immediately prepared and fixed in absolute methanol. The methanol-fixed slides were stained with acridine orange and coded. Slides were scanned to determine the frequency of micronuclei in 2,000 normochromatic erythrocytes (NCEs; mature erythrocytes) in each of nine or 10 animals per dose group. In addition, the percentage of polychromatic erythrocytes (PCEs; reticulocytes) in 1,000 total erythrocytes per animal in the peripheral blood was scored for each dose group as a measure of bone marrow toxicity.

The results were tabulated as the mean of the pooled results from all animals within a treatment group plus or minus the standard error of the mean. The frequency of micronucleated cells among NCEs was analyzed by a statistical software package that tested for increasing trend over dose groups with a one-tailed Cochran-Armitage trend test, followed by pairwise comparisons between each dosed group and the vehicle control group. In the presence of excess binomial variation, as detected by a binomial dispersion test, the binomial variance of the Cochran-Armitage test was adjusted upward in proportion to the excess variation. In the micronucleus test, an individual trial is considered positive if the trend test P value is less than or equal to 0.025 or if the P value for any single dosed group is less than or equal to 0.025 divided by the number of dosed groups. A final call of positive for micronucleus induction is preferably based on reproducibly positive trials (as noted above). Results of the 3-month studies were accepted without repeat tests, because additional test data could not be obtained. Ultimately, the final call is determined by the scientific staff after considering the results of statistical analyses, the reproducibility of any effects observed, and the magnitudes of those effects. In addition to the analysis of micronucleus frequencies, the percent PCE data were analyzed using linear regression.

### EVALUATION PROTOCOL

These are the basic guidelines for arriving at an overall assay result for assays performed by the National Toxicology Program. Statistical as well as biological factors are considered. For an individual assay, the statistical procedures for data analysis have been described in the preceding protocols. There have been instances, however, in which multiple samples of a chemical were tested in the same assay, and different results were obtained among these samples and/or among laboratories. Results from more than one aliquot or from more than one laboratory are not

simply combined into an overall result. Rather, all the data are critically evaluated, particularly with regard to pertinent protocol variations, in determining the weight of evidence for an overall conclusion of chemical activity in an assay. In addition to multiple aliquots, the *in vitro* assays have another variable that must be considered in arriving at an overall test result. *In vitro* assays are conducted with and without exogenous metabolic activation. Results obtained in the absence of activation are not combined with results obtained in the presence of activation; each testing condition is evaluated separately. The summary table in the Abstract of this Technical Report presents a result that represents a scientific judgment of the overall evidence for activity of the chemical in an assay.

## RESULTS

*Ginkgo biloba* extract (1,000 to 10,000 µg/plate) was mutagenic in *S. typhimurium* strains TA98 and TA100 and in *E. coli* strain WP2 *uvrA*/pKM101, with and without 10% induced rat liver S9 mix (Table E1). No increase in the frequency of micronucleated erythrocytes was observed in peripheral blood of male B6C3F1/N mice administered *Ginkgo biloba* extract (125 to 2,000 mg/kg per day) for 3 months by gavage (Table E2). In female mice administered these doses, the results of the micronucleus test were judged to be equivocal based on a significant trend test and no individual dose groups being significantly elevated over the vehicle control group (Table E2). A significant ( $P < 0.001$ ) dose-related decrease in the percentages of circulating PCEs were observed in male mice, suggesting that increasing doses of *Ginkgo biloba* extract induced bone marrow toxicity. In female mice, a significant ( $P = 0.001$ ) decrease in the percentage of circulating PCEs was also observed, although the response was less well-correlated with dose than in males.



**TABLE E1**  
**Mutagenicity of *Ginkgo biloba* Extract in Bacterial Tester Strains<sup>a</sup>**

Strain	Dose ( $\mu\text{g}/\text{plate}$ )	Without S9	Without S9	With 10% rat S9	With 10% rat S9
<b>TA100</b>	0	59 $\pm$ 2	67 $\pm$ 7	69 $\pm$ 2	78 $\pm$ 2
	1,000	81 $\pm$ 3	55 $\pm$ 5	104 $\pm$ 4	114 $\pm$ 7
	2,500	93 $\pm$ 8	55 $\pm$ 9	106 $\pm$ 5	125 $\pm$ 9
	5,000	101 $\pm$ 3	67 $\pm$ 4	126 $\pm$ 6	131 $\pm$ 10
	7,500	103 $\pm$ 4	116 $\pm$ 1	132 $\pm$ 9	142 $\pm$ 6
	10,000	159 $\pm$ 10	130 $\pm$ 5	139 $\pm$ 17	172 $\pm$ 4
	Trial summary Positive control <sup>b</sup>		Positive 421 $\pm$ 20	Positive 769 $\pm$ 63	Positive 827 $\pm$ 18
<b>TA98</b>	0	20 $\pm$ 2	21 $\pm$ 0	28 $\pm$ 2	33 $\pm$ 4
	1,000	34 $\pm$ 5	32 $\pm$ 5	94 $\pm$ 8	94 $\pm$ 5
	2,500	49 $\pm$ 4	39 $\pm$ 3	131 $\pm$ 27	146 $\pm$ 14
	5,000	58 $\pm$ 4	53 $\pm$ 3	145 $\pm$ 9	193 $\pm$ 16
	7,500	72 $\pm$ 5	64 $\pm$ 5	221 $\pm$ 11	239 $\pm$ 3
	10,000	66 $\pm$ 9	46 $\pm$ 4	243 $\pm$ 9	285 $\pm$ 23
	Trial summary Positive control		Positive 629 $\pm$ 16	Positive 649 $\pm$ 13	Positive 1,112 $\pm$ 65
<b><i>Escherichia coli</i> WP2 <i>uvrA</i>/pKM101</b>					
	0	125 $\pm$ 3	149 $\pm$ 7	199 $\pm$ 17	207 $\pm$ 7
	1,000	144 $\pm$ 8	203 $\pm$ 15	241 $\pm$ 15	222 $\pm$ 8
	2,500	169 $\pm$ 2	260 $\pm$ 19	262 $\pm$ 11	303 $\pm$ 20
	5,000	165 $\pm$ 8	249 $\pm$ 16	259 $\pm$ 23	253 $\pm$ 13
	7,500	171 $\pm$ 10	258 $\pm$ 16	302 $\pm$ 2	262 $\pm$ 19
	10,000	230 $\pm$ 11	268 $\pm$ 7	306 $\pm$ 8	327 $\pm$ 43
Trial summary Positive control		Positive 2,161 $\pm$ 37	Positive 859 $\pm$ 52	Positive 1,250 $\pm$ 39	Positive 1,015 $\pm$ 12

<sup>a</sup> The detailed protocol is presented by Zeiger *et al.* (1992); SITEK Research Laboratories used a modification of this protocol and the same lot (020703) that was used in the 3-month and 2-year studies. 0  $\mu\text{g}/\text{plate}$  was the solvent control. Data are presented as revertants/plate (mean  $\pm$  standard error) from three plates.

<sup>b</sup> The positive controls in the absence of metabolic activation were sodium azide (TA100), 4-nitro-*o*-phenylenediamine (TA98), and methyl methanesulfonate (*E. coli*). The positive control for metabolic activation with all strains was 2-aminoanthracene.

**TABLE E2**  
**Frequency of Micronuclei in Peripheral Blood Erythrocytes of Mice Following Administration of *Ginkgo biloba* Extract by Gavage for 3 Months<sup>a</sup>**

	Dose (mg/kg)	Number of Mice with Erythrocytes Scored	Micronucleated NCEs/1,000 NCEs <sup>b</sup>	P Value <sup>c</sup>	PCEs <sup>b</sup> (%)
<b>Male</b>					
Corn oil <sup>d</sup>	0	10	2.25 ± 0.25		3.970 ± 0.21
<i>Ginkgo biloba</i> extract	125	10	2.40 ± 0.31	0.3777	3.720 ± 0.24
	250	10	3.00 ± 0.36	0.0714	3.370 ± 0.22
	500	10	2.90 ± 0.36	0.0998	3.020 ± 0.14
	1,000	10	2.00 ± 0.20	0.7064	2.570 ± 0.09
	2,000	10	2.60 ± 0.34	0.2384	2.160 ± 0.17
			P=0.556 <sup>e</sup>		P<0.001 <sup>f</sup>
<b>Female</b>					
Corn oil	0	10	1.05 ± 0.19		3.170 ± 0.17
<i>Ginkgo biloba</i> extract	125	10	1.25 ± 0.20	0.2776	3.940 ± 0.30
	250	10	1.25 ± 0.37	0.2776	3.330 ± 0.30
	500	10	1.75 ± 0.37	0.0306	3.010 ± 0.24
	1,000	9	1.89 ± 0.31	0.0159	2.567 ± 0.19
	2,000	10	2.05 ± 0.36	0.0055	2.600 ± 0.18
			P=0.002		P=0.001

<sup>a</sup> Study was performed at ILS, Inc. The detailed protocol is presented by MacGregor *et al.* (1990). NCE=normochromatic erythrocyte; PCE=polychromatic erythrocyte

<sup>b</sup> Mean ± standard error

<sup>c</sup> Pairwise comparison with the vehicle control group; dosed group values are significant at P≤0.005

<sup>d</sup> Vehicle control

<sup>e</sup> Significance of micronucleated NCEs/1,000 NCEs tested by the one-tailed trend test; significant at P≤0.025

<sup>f</sup> Significance of % PCEs tested by linear regression trend test; significant at P≤0.025



## APPENDIX F

### CLINICAL PATHOLOGY RESULTS

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**TABLE F1**  
**Hematology and Clinical Chemistry Data for Rats in the 3-Month Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Male</b>						
Hematology						
n						
Day 4	10	10	10	9	10	9
Day 23	10	9	10	10	10	9
Week 14	10	10	10	10	9	10
Hematocrit (%)						
Day 4	44.1 ± 0.6	43.6 ± 0.6	43.5 ± 0.5	43.7 ± 0.9	43.0 ± 0.8	42.9 ± 0.6
Day 23	45.3 ± 0.5	45.7 ± 0.5	47.5 ± 0.7*	45.2 ± 0.9	45.1 ± 0.6	46.0 ± 0.4
Week 14	49.2 ± 0.5	47.6 ± 0.5	47.9 ± 0.4	47.6 ± 0.5	47.4 ± 0.6	47.8 ± 0.5
Hemoglobin (g/dL)						
Day 4	13.3 ± 0.2	13.4 ± 0.2	13.2 ± 0.2	13.3 ± 0.2	13.1 ± 0.3	13.0 ± 0.2
Day 23	15.0 ± 0.1	15.4 ± 0.2	15.8 ± 0.2*	15.1 ± 0.2	15.0 ± 0.2	15.4 ± 0.2
Week 14	15.6 ± 0.1	15.2 ± 0.2	15.0 ± 0.2*	15.1 ± 0.2	15.0 ± 0.1*	15.1 ± 0.2
Erythrocytes (10 <sup>6</sup> /μL)						
Day 4	7.23 ± 0.11	7.24 ± 0.09	7.20 ± 0.10	7.14 ± 0.12	7.09 ± 0.16	7.08 ± 0.09
Day 23	7.65 ± 0.08	7.70 ± 0.07	7.98 ± 0.11	7.63 ± 0.12	7.61 ± 0.12	7.75 ± 0.09
Week 14	9.28 ± 0.10	9.02 ± 0.13	8.95 ± 0.09	9.08 ± 0.11	8.99 ± 0.09	9.11 ± 0.10
Reticulocytes (10 <sup>6</sup> /μL)						
Day 4	0.62 ± 0.02	0.60 ± 0.02	0.62 ± 0.03	0.59 ± 0.04	0.60 ± 0.03	0.58 ± 0.03
Day 23	0.32 ± 0.01	0.31 ± 0.01	0.31 ± 0.02	0.32 ± 0.02	0.32 ± 0.02	0.32 ± 0.01
Week 14	0.19 ± 0.01	0.19 ± 0.01	0.21 ± 0.01	0.23 ± 0.01**	0.22 ± 0.01**	0.21 ± 0.01**
Mean cell volume (fL)						
Day 4	61.0 ± 0.3	60.3 ± 0.3	60.4 ± 0.3	61.1 ± 0.3	60.7 ± 0.4	60.6 ± 0.4
Day 23	59.2 ± 0.4	59.4 ± 0.3	59.5 ± 0.3	59.3 ± 0.4	59.3 ± 0.5	59.4 ± 0.4
Week 14	55.6 ± 0.2	55.4 ± 0.2	55.7 ± 0.2	55.4 ± 0.2	55.7 ± 0.2	55.5 ± 0.2
Mean cell hemoglobin (pg)						
Day 4	18.4 ± 0.1	18.5 ± 0.2	18.3 ± 0.1	18.6 ± 0.1	18.5 ± 0.1	18.4 ± 0.1
Day 23	19.7 ± 0.1	20.0 ± 0.1	19.8 ± 0.1	19.8 ± 0.1	19.8 ± 0.2	19.8 ± 0.1
Week 14	16.9 ± 0.1	16.8 ± 0.1	16.7 ± 0.1	16.7 ± 0.1	16.6 ± 0.1	16.6 ± 0.1
Mean cell hemoglobin concentration (g/dL)						
Day 4	30.2 ± 0.2	30.6 ± 0.2	30.4 ± 0.2	30.4 ± 0.2	30.4 ± 0.2	30.4 ± 0.2
Day 23	33.2 ± 0.2	33.7 ± 0.2	33.2 ± 0.2	33.4 ± 0.3	33.4 ± 0.2	33.4 ± 0.3
Week 14	31.8 ± 0.2	31.9 ± 0.2	31.3 ± 0.2	31.8 ± 0.2	31.5 ± 0.2	31.7 ± 0.2
Platelets (10 <sup>3</sup> /μL)						
Day 4	1,070.4 ± 27.0	1,036.2 ± 27.3	1,100.6 ± 31.4	1,036.9 ± 18.3	1,057.6 ± 23.0	1,056.8 ± 28.8
Day 23	780.2 ± 41.4	838.9 ± 23.3	883.6 ± 26.5	864.3 ± 22.5	911.8 ± 18.5**	909.2 ± 19.1**
Week 14	582.8 ± 15.7	568.7 ± 28.4	632.5 ± 19.7	592.1 ± 56.8	659.2 ± 32.4*	713.1 ± 16.0**
Leukocytes (10 <sup>3</sup> /μL)						
Day 4	8.47 ± 0.38	8.36 ± 0.24	8.64 ± 0.30	8.11 ± 0.42	7.41 ± 0.26	7.79 ± 0.61
Day 23	6.36 ± 0.54	6.27 ± 0.49	6.20 ± 0.32	6.12 ± 0.50	6.03 ± 0.34	5.98 ± 0.47
Week 14	8.30 ± 0.53	7.53 ± 0.52	8.67 ± 0.57	8.43 ± 0.53	7.92 ± 0.63	8.99 ± 0.42
Segmented neutrophils (10 <sup>3</sup> /μL)						
Day 4	1.15 ± 0.03	1.18 ± 0.08	1.29 ± 0.06	1.07 ± 0.05	1.11 ± 0.07	1.03 ± 0.07
Day 23	0.92 ± 0.11	0.84 ± 0.06	0.86 ± 0.04	0.80 ± 0.05	0.76 ± 0.05	0.88 ± 0.04
Week 14	1.08 ± 0.04	1.18 ± 0.09	1.16 ± 0.06	1.17 ± 0.06	1.06 ± 0.07	1.24 ± 0.08
Lymphocytes (10 <sup>3</sup> /μL)						
Day 4	7.00 ± 0.36	6.82 ± 0.20	7.03 ± 0.27	6.72 ± 0.38	6.00 ± 0.24	6.47 ± 0.53
Day 23	5.22 ± 0.45	5.22 ± 0.45	5.14 ± 0.30	5.12 ± 0.44	5.09 ± 0.30	4.91 ± 0.43
Week 14	6.91 ± 0.49	6.10 ± 0.51	7.26 ± 0.51	6.98 ± 0.52	6.62 ± 0.62	7.46 ± 0.43
Monocytes (10 <sup>3</sup> /μL)						
Day 4	0.24 ± 0.01	0.28 ± 0.01	0.24 ± 0.02	0.25 ± 0.02	0.22 ± 0.02	0.23 ± 0.03
Day 23	0.11 ± 0.01	0.10 ± 0.02	0.10 ± 0.01	0.10 ± 0.02	0.10 ± 0.01	0.09 ± 0.01
Week 14	0.19 ± 0.02	0.12 ± 0.01*	0.16 ± 0.02	0.17 ± 0.01	0.14 ± 0.01	0.16 ± 0.01

**TABLE F1**  
**Hematology and Clinical Chemistry Data for Rats in the 3-Month Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Male (continued)</b>						
Hematology (continued)						
n						
Day 4	10	10	10	9	10	9
Day 23	10	9	10	10	10	9
Week 14	10	10	10	10	9	10
Basophils (10 <sup>3</sup> /μL)						
Day 4	0.043 ± 0.004	0.035 ± 0.004	0.030 ± 0.004	0.033 ± 0.004	0.034 ± 0.007	0.028 ± 0.006
Day 23	0.029 ± 0.006	0.023 ± 0.003	0.028 ± 0.004	0.022 ± 0.003	0.016 ± 0.002	0.022 ± 0.003
Week 14	0.028 ± 0.005	0.029 ± 0.004	0.028 ± 0.002	0.028 ± 0.005	0.024 ± 0.002	0.035 ± 0.004
Eosinophils (10 <sup>3</sup> /μL)						
Day 4	0.04 ± 0.00	0.05 ± 0.01	0.05 ± 0.00	0.03 ± 0.00	0.04 ± 0.01	0.04 ± 0.00
Day 23	0.08 ± 0.02	0.09 ± 0.01	0.07 ± 0.01	0.08 ± 0.01	0.07 ± 0.01	0.08 ± 0.02
Week 14	0.08 ± 0.01	0.10 ± 0.02	0.08 ± 0.01	0.09 ± 0.02	0.07 ± 0.01	0.10 ± 0.02
Clinical Chemistry						
n						
Day 4	10	10	10	10	10	10
Day 23	10	10	10	10	10	9
Week 14	10	10	10	10	10	10
Urea nitrogen (mg/dL)						
Day 4	10.2 ± 0.5	11.1 ± 0.4	10.4 ± 0.4	9.9 ± 0.4	10.8 ± 0.6	9.9 ± 0.5
Day 23	13.2 ± 0.4	14.9 ± 0.4	14.9 ± 0.6	13.4 ± 0.8	14.0 ± 0.4	14.8 ± 0.7
Week 14	13.0 ± 0.6	13.0 ± 0.4	12.3 ± 0.4	11.9 ± 0.4	12.5 ± 0.5	11.8 ± 0.4
Creatinine (mg/dL)						
Day 4	0.40 ± 0.00	0.40 ± 0.00	0.41 ± 0.01	0.40 ± 0.00	0.40 ± 0.00	0.40 ± 0.00
Day 23	0.47 ± 0.02	0.49 ± 0.01	0.49 ± 0.01	0.49 ± 0.01	0.47 ± 0.02	0.44 ± 0.02
Week 14	0.54 ± 0.02	0.54 ± 0.02	0.51 ± 0.01	0.53 ± 0.02	0.53 ± 0.02	0.52 ± 0.01
Glucose (mg/dL)						
Day 4	139 ± 2	130 ± 2*	133 ± 2	133 ± 2	136 ± 3	136 ± 3
Day 23	147 ± 4	140 ± 4	141 ± 3	144 ± 5	148 ± 4	136 ± 3
Week 14	132 ± 3	138 ± 4	131 ± 4	132 ± 2	142 ± 5	127 ± 2
Total protein (g/dL)						
Day 4	5.8 ± 0.1	5.8 ± 0.1	5.8 ± 0.1	5.8 ± 0.1	5.8 ± 0.1	5.9 ± 0.1
Day 23	6.5 ± 0.0	6.7 ± 0.1**	6.8 ± 0.1**	6.7 ± 0.1**	6.8 ± 0.1**	7.0 ± 0.1**
Week 14	6.6 ± 0.0	6.8 ± 0.1	6.9 ± 0.1**	7.0 ± 0.1**	7.2 ± 0.1**	7.2 ± 0.1**
Albumin (g/dL)						
Day 4	4.0 ± 0.0	4.0 ± 0.1	4.1 ± 0.1	4.0 ± 0.0	4.0 ± 0.1	4.0 ± 0.1
Day 23	4.4 ± 0.0	4.5 ± 0.0*	4.5 ± 0.0*	4.4 ± 0.0*	4.5 ± 0.1*	4.6 ± 0.0**
Week 14	4.6 ± 0.0	4.7 ± 0.0	4.8 ± 0.0*	4.8 ± 0.0**	4.9 ± 0.0**	4.9 ± 0.0**
Alanine aminotransferase (IU/L)						
Day 4	64 ± 2	66 ± 3	65 ± 2	64 ± 2	64 ± 2	65 ± 2
Day 23	57 ± 1	62 ± 2	64 ± 4	56 ± 1	58 ± 2	58 ± 3
Week 14	74 ± 6	41 ± 1**	45 ± 2**	42 ± 1**	45 ± 1**	42 ± 1**
Alkaline phosphatase (IU/L)						
Day 4	707 ± 11	699 ± 14	678 ± 17	701 ± 14	699 ± 22	697 ± 13
Day 23	482 ± 6	468 ± 12	464 ± 10	451 ± 13*	450 ± 11*	446 ± 7**
Week 14	224 ± 6	210 ± 5	200 ± 3**	188 ± 3**	194 ± 5**	181 ± 3**
Creatine kinase (IU/L)						
Day 4	341 ± 38	462 ± 48	507 ± 44	401 ± 55	427 ± 58	410 ± 54 <sup>b</sup>
Day 23	253 ± 19	260 ± 48	268 ± 28	342 ± 37	237 ± 32	334 ± 77
Week 14	149 ± 32	209 ± 26	145 ± 24	321 ± 65	191 ± 82	294 ± 54

**TABLE F1**  
**Hematology and Clinical Chemistry Data for Rats in the 3-Month Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Male (continued)</b>						
Clinical Chemistry (continued)						
n						
Day 4	10	10	10	10	10	10
Day 23	10	10	10	10	10	9
Week 14	10	10	10	10	10	10
Sorbitol dehydrogenase (IU/L)						
Day 4	15 ± 0	14 ± 1	13 ± 1	16 ± 1	14 ± 1	14 ± 1
Day 23	15 ± 1	16 ± 0	14 ± 1	14 ± 1	13 ± 1	12 ± 0*
Week 14	13 ± 1	10 ± 0*	10 ± 1	11 ± 0	11 ± 1	10 ± 1*
Bile salts (μmol/L)						
Day 4	9.6 ± 1.0	7.3 ± 0.8	5.9 ± 0.8*	7.0 ± 0.8*	5.5 ± 1.2**	5.3 ± 0.5**
Day 23	4.5 ± 0.9	2.7 ± 0.4	3.9 ± 0.6	4.4 ± 0.7	2.7 ± 0.2	2.9 ± 0.4
Week 14	5.5 ± 0.8	3.8 ± 0.4	3.9 ± 0.5	3.3 ± 0.4**	3.8 ± 0.7*	2.8 ± 0.4**
<b>Female</b>						
Hematology						
n						
Day 4	10	10	10	10	10	9
Day 23	10	10	10	10	9	10
Week 14	10	10	10	10	10	10
Hematocrit (%)						
Day 4	45.9 ± 0.6	44.9 ± 0.7	45.3 ± 0.6	45.7 ± 0.9	44.9 ± 0.7	43.7 ± 0.5
Day 23	46.0 ± 0.6	46.1 ± 0.6	46.1 ± 0.7	45.6 ± 0.7	45.1 ± 0.6	45.3 ± 0.4
Week 14	47.5 ± 0.4	47.4 ± 0.4	46.7 ± 0.4	46.6 ± 0.6	45.9 ± 0.5*	46.3 ± 0.5*
Hemoglobin (g/dL)						
Day 4	14.2 ± 0.1	13.9 ± 0.2	14.0 ± 0.1	14.1 ± 0.3	13.8 ± 0.2	13.6 ± 0.2
Day 23	15.4 ± 0.2	15.2 ± 0.1	15.4 ± 0.2	15.1 ± 0.1	14.9 ± 0.1	15.1 ± 0.1
Week 14	15.1 ± 0.1	15.2 ± 0.1	15.0 ± 0.1	14.8 ± 0.1	14.8 ± 0.1	14.9 ± 0.2
Erythrocytes (10 <sup>6</sup> /μL)						
Day 4	7.68 ± 0.09	7.54 ± 0.11	7.61 ± 0.08	7.65 ± 0.15	7.55 ± 0.13	7.37 ± 0.10
Day 23	7.86 ± 0.08	7.86 ± 0.09	7.90 ± 0.10	7.77 ± 0.11	7.74 ± 0.10	7.75 ± 0.07
Week 14	8.49 ± 0.10	8.50 ± 0.06	8.43 ± 0.06	8.27 ± 0.09	8.37 ± 0.06	8.37 ± 0.06
Reticulocytes (10 <sup>6</sup> /μL)						
Day 4	0.48 ± 0.02	0.49 ± 0.03	0.48 ± 0.02	0.48 ± 0.03	0.46 ± 0.03	0.46 ± 0.03
Day 23	0.19 ± 0.01	0.17 ± 0.01	0.17 ± 0.01	0.17 ± 0.01	0.17 ± 0.01	0.18 ± 0.00
Week 14	0.17 ± 0.01	0.16 ± 0.01	0.16 ± 0.00	0.18 ± 0.01	0.18 ± 0.01	0.17 ± 0.01
Mean cell volume (fL)						
Day 4	59.7 ± 0.3	59.5 ± 0.3	59.5 ± 0.3	59.8 ± 0.3	59.5 ± 0.3	59.2 ± 0.3
Day 23	58.5 ± 0.3	58.7 ± 0.2	58.3 ± 0.3	58.7 ± 0.3	58.3 ± 0.3	58.4 ± 0.3
Week 14	57.2 ± 0.2	57.5 ± 0.2	57.4 ± 0.2	57.5 ± 0.2	57.2 ± 0.2	57.1 ± 0.2
Mean cell hemoglobin (pg)						
Day 4	18.5 ± 0.1	18.4 ± 0.1	18.4 ± 0.1	18.4 ± 0.1	18.3 ± 0.1	18.5 ± 0.1
Day 23	19.5 ± 0.2	19.4 ± 0.2	19.5 ± 0.2	19.4 ± 0.2	19.3 ± 0.1	19.6 ± 0.1
Week 14	17.8 ± 0.1	17.9 ± 0.1	17.8 ± 0.1	17.8 ± 0.1	17.7 ± 0.1	17.8 ± 0.1
Mean cell hemoglobin concentration (g/dL)						
Day 4	30.9 ± 0.2	31.0 ± 0.1	31.0 ± 0.2	30.8 ± 0.2	30.8 ± 0.2	31.2 ± 0.2
Day 23	33.4 ± 0.4	33.1 ± 0.2	33.4 ± 0.4	33.1 ± 0.4	33.2 ± 0.3	33.5 ± 0.2
Week 14	31.9 ± 0.2	32.0 ± 0.1	32.1 ± 0.3	31.7 ± 0.2	32.3 ± 0.2	32.2 ± 0.2

**TABLE F1**  
**Hematology and Clinical Chemistry Data for Rats in the 3-Month Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Female (continued)</b>						
Hematology (continued)						
n						
Day 4	10	10	10	10	10	9
Day 24	10	10	10	10	9	10
Week 14	10	10	10	10	10	10
Platelets (10 <sup>3</sup> /μL)						
Day 4	969.7 ± 28.2	972.7 ± 23.0	1,014.8 ± 29.0	989.7 ± 27.4	989.0 ± 34.6	1,020.9 ± 26.7
Day 23	805.6 ± 13.5	811.1 ± 12.0	749.6 ± 21.1	803.8 ± 19.8	778.7 ± 22.0	803.5 ± 24.4
Week 14	663.1 ± 17.0	614.4 ± 26.4	615.3 ± 29.6	677.3 ± 15.3	662.4 ± 36.9	659.8 ± 30.8
Leukocytes (10 <sup>3</sup> /μL)						
Day 4	8.22 ± 0.49	8.49 ± 0.29	8.43 ± 0.47	7.29 ± 0.58	7.68 ± 0.28	7.88 ± 0.25
Day 23	7.80 ± 0.55	6.63 ± 0.27	7.03 ± 0.36	6.31 ± 0.46	6.67 ± 0.35	6.42 ± 0.55
Week 14	6.24 ± 0.40	6.31 ± 0.33	5.21 ± 0.51	5.52 ± 0.45	5.62 ± 0.44	6.39 ± 0.38
Segmented neutrophils (10 <sup>3</sup> /μL)						
Day 4	0.99 ± 0.09	1.07 ± 0.07	1.06 ± 0.05	0.87 ± 0.07	1.11 ± 0.06	0.93 ± 0.05
Day 23	0.79 ± 0.06	0.75 ± 0.05	1.04 ± 0.13	0.76 ± 0.09	0.80 ± 0.07	0.79 ± 0.06
Week 14	0.94 ± 0.07	0.93 ± 0.08	0.88 ± 0.11	1.14 ± 0.09	0.97 ± 0.12	1.09 ± 0.13
Lymphocytes (10 <sup>3</sup> /μL)						
Day 4	6.94 ± 0.42	7.09 ± 0.26	7.04 ± 0.41	6.15 ± 0.50	6.26 ± 0.24	6.63 ± 0.22
Day 23	6.80 ± 0.49	5.69 ± 0.23	5.78 ± 0.27	5.37 ± 0.39*	5.68 ± 0.27	5.44 ± 0.49
Week 14	5.10 ± 0.32	5.13 ± 0.30	4.13 ± 0.49	4.15 ± 0.38	4.49 ± 0.36	5.09 ± 0.32
Monocytes (10 <sup>3</sup> /μL)						
Day 4	0.20 ± 0.02	0.23 ± 0.01	0.23 ± 0.02	0.19 ± 0.02	0.22 ± 0.01	0.22 ± 0.01
Day 23	0.13 ± 0.01	0.12 ± 0.01	0.11 ± 0.01	0.10 ± 0.01	0.13 ± 0.02	0.11 ± 0.02
Week 14	0.11 ± 0.01	0.14 ± 0.01	0.10 ± 0.01	0.11 ± 0.01	0.09 ± 0.01	0.12 ± 0.02
Basophils (10 <sup>3</sup> /μL)						
Day 4	0.032 ± 0.003	0.036 ± 0.006	0.039 ± 0.007	0.029 ± 0.005	0.037 ± 0.007	0.037 ± 0.004
Day 23	0.039 ± 0.010	0.022 ± 0.004	0.027 ± 0.006	0.014 ± 0.002	0.016 ± 0.002	0.022 ± 0.005
Week 14	0.018 ± 0.002	0.015 ± 0.003	0.019 ± 0.004	0.017 ± 0.002	0.014 ± 0.003	0.018 ± 0.002
Eosinophils (10 <sup>3</sup> /μL)						
Day 4	0.06 ± 0.01	0.07 ± 0.01	0.06 ± 0.00	0.05 ± 0.01	0.06 ± 0.01	0.06 ± 0.00
Day 23	0.05 ± 0.00	0.04 ± 0.00	0.06 ± 0.00	0.05 ± 0.01	0.05 ± 0.01	0.07 ± 0.01
Week 14	0.08 ± 0.01	0.09 ± 0.02	0.09 ± 0.02	0.10 ± 0.02	0.06 ± 0.01	0.08 ± 0.02
Clinical Chemistry						
n	10	10	10	10	10	10
Urea nitrogen (mg/dL)						
Day 4	10.9 ± 0.5	10.2 ± 0.5	11.9 ± 0.4	11.5 ± 0.8	10.5 ± 0.6	10.8 ± 0.6
Day 23	12.3 ± 0.3	13.6 ± 0.6	12.4 ± 0.7	12.5 ± 0.5	12.8 ± 0.7	12.6 ± 0.4
Week 14	12.7 ± 0.5	13.5 ± 0.4	13.3 ± 0.8	12.1 ± 0.4	11.6 ± 0.5	12.6 ± 0.4
Creatinine (mg/dL)						
Day 4	0.41 ± 0.01	0.39 ± 0.01	0.41 ± 0.01	0.40 ± 0.00	0.40 ± 0.00	0.40 ± 0.00
Day 23	0.46 ± 0.02	0.50 ± 0.00	0.48 ± 0.01	0.50 ± 0.00	0.48 ± 0.01	0.48 ± 0.01
Week 14	0.56 ± 0.02	0.58 ± 0.03	0.57 ± 0.02	0.54 ± 0.02	0.52 ± 0.01	0.57 ± 0.02
Glucose (mg/dL)						
Day 4	144 ± 5	137 ± 4	138 ± 6	146 ± 5	135 ± 3	135 ± 3
Day 23	140 ± 4	145 ± 6	133 ± 3	145 ± 6	143 ± 4	137 ± 5
Week 14	117 ± 3	123 ± 4	125 ± 2	129 ± 6	130 ± 6	121 ± 4
Total protein (g/dL)						
Day 4	6.0 ± 0.1	5.9 ± 0.1	6.1 ± 0.1	6.1 ± 0.1	6.0 ± 0.1	5.9 ± 0.1
Day 23	6.2 ± 0.1	6.2 ± 0.1	6.2 ± 0.1	6.3 ± 0.1	6.2 ± 0.1	6.4 ± 0.1
Week 14	7.0 ± 0.1	7.2 ± 0.1	7.2 ± 0.1	7.2 ± 0.1	7.2 ± 0.1	7.4 ± 0.1



**TABLE F1**  
**Hematology and Clinical Chemistry Data for Rats in the 3-Month Gavage Study of Ginkgo biloba Extract**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
<b>Female</b> (continued)						
Clinical chemistry (continued)						
n	10	10	10	10	10	10
Albumin (g/dL)						
Day 4	4.3 ± 0.0	4.2 ± 0.0	4.3 ± 0.0	4.4 ± 0.0	4.2 ± 0.1	4.2 ± 0.0
Day 23	4.4 ± 0.1	4.4 ± 0.0	4.4 ± 0.1	4.4 ± 0.0	4.3 ± 0.0	4.4 ± 0.0
Week 14	5.1 ± 0.1	5.2 ± 0.1	5.2 ± 0.1	5.1 ± 0.1	5.1 ± 0.1	5.1 ± 0.1
Alanine aminotransferase (IU/L)						
Day 4	54 ± 2	54 ± 2	53 ± 2	57 ± 2	53 ± 2	52 ± 2
Day 23	40 ± 1	44 ± 1*	41 ± 1	43 ± 1	40 ± 1	41 ± 2
Week 14	49 ± 3	45 ± 1	40 ± 1**	39 ± 1**	39 ± 1**	35 ± 1**
Alkaline phosphatase (IU/L)						
Day 4	563 ± 10	536 ± 19	518 ± 10	546 ± 14	517 ± 18	519 ± 20
Day 23	365 ± 5	348 ± 11*	340 ± 9*	339 ± 8*	320 ± 8**	311 ± 9**
Week 14	183 ± 7	160 ± 7*	159 ± 4*	138 ± 4**	146 ± 4**	135 ± 3**
Creatine kinase (IU/L)						
Day 4	380 ± 43	331 ± 47	321 ± 41	309 ± 42	307 ± 33	368 ± 60
Day 23	246 ± 28	241 ± 25	237 ± 57	257 ± 50	207 ± 29	336 ± 85
Week 14	258 ± 54	211 ± 30	165 ± 31	201 ± 27	160 ± 29	181 ± 21
Sorbitol dehydrogenase (IU/L)						
Day 4	13 ± 1	13 ± 1	14 ± 0	15 ± 0*	13 ± 1	14 ± 1
Day 23	12 ± 1	12 ± 1	11 ± 1	12 ± 1	13 ± 1	13 ± 1
Week 14	13 ± 1	13 ± 1	12 ± 1	11 ± 1	10 ± 1	11 ± 1
Bile salts (µmol/L)						
Day 4	6.1 ± 1.1	5.8 ± 0.8	3.7 ± 0.4	5.0 ± 0.7	3.6 ± 0.4	3.5 ± 0.4
Day 23	5.6 ± 0.9	6.4 ± 0.9	4.9 ± 1.3	5.0 ± 0.8	5.3 ± 1.0	3.3 ± 0.5
Week 14	10.0 ± 1.2	8.7 ± 0.9	6.0 ± 0.9*	4.3 ± 0.5**	3.4 ± 0.5**	3.1 ± 0.4**

\* Significantly different ( $P \leq 0.05$ ) from the vehicle control group by Dunn's or Shirley's test

\*\*  $P \leq 0.01$

<sup>a</sup> Data are presented as mean ± standard error. Statistical tests were performed on unrounded data.

<sup>b</sup> n=9

**TABLE F2**  
**Thyroid Hormone Data for Special Study Rats in the 2-Year Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
n	9	10	10	10
Thyroid stimulating hormone (ng/mL)				
Day 22	8.33 ± 0.47	8.38 ± 0.89 <sup>b</sup>	10.78 ± 1.49 <sup>c</sup>	11.20 ± 0.96
Week 14	6.89 ± 0.56	9.10 ± 0.50 <sup>**</sup>	9.60 ± 0.75 <sup>**</sup>	10.90 ± 0.81 <sup>**</sup>
Triiodothyronine (ng/dL)				
Day 22	154.6 ± 5.6	167.9 ± 8.2	149.8 ± 6.9	142.5 ± 10.2
Week 14	128.7 ± 6.8	145.4 ± 7.6	132.2 ± 5.2	143.9 ± 6.0
Total thyroxine (ng/dL)				
Day 22	5.78 ± 0.23	6.51 ± 0.28	6.39 ± 0.15	5.63 ± 0.33
Week 14	5.23 ± 0.29	5.60 ± 0.22	5.31 ± 0.30	5.88 ± 0.14
<b>Female</b>				
n	10	10	10	10
Thyroid stimulating hormone (ng/mL)				
Day 22	9.43 ± 0.48 <sup>d</sup>	10.00 ± 0.82 <sup>c</sup>	9.56 ± 0.53 <sup>c</sup>	10.44 ± 0.56 <sup>c</sup>
Week 14	5.56 ± 0.34 <sup>c</sup>	5.70 ± 0.33	6.40 ± 0.54	7.30 ± 0.40 <sup>**</sup>
Triiodothyronine (ng/dL)				
Day 22	124.7 ± 5.4	130.7 ± 8.0	127.7 ± 5.9	136.7 ± 6.5
Week 14	134.0 ± 6.0	148.9 ± 8.0	155.9 ± 6.1	151.3 ± 8.6
Total thyroxine (ng/dL)				
Day 22	4.19 ± 0.30	4.53 ± 0.28	4.86 ± 0.31	4.64 ± 0.32
Week 14	3.88 ± 0.29	3.31 ± 0.25	4.07 ± 0.28	3.48 ± 0.21

<sup>\*\*</sup> Significantly different ( $P \leq 0.01$ ) from the vehicle control group by Shirley's test

<sup>a</sup> Data are presented as mean ± standard error. Statistical tests were performed on unrounded data.

<sup>b</sup> n=8

<sup>c</sup> n=9

<sup>d</sup> n=7

**TABLE F3**  
**Hematology Data for Mice in the 3-Month Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg	2,000 mg/kg
<b>Male</b>						
n	10	10	10	10	10	10
Hematocrit (%)	45.9±0.4	47.0±0.5	47.1±0.4	47.0±0.4	46.5±0.4	46.9±0.5
Hemoglobin (g/dL)	14.7±0.1	15.0±0.2	15.1±0.1	15.2±0.1	15.0±0.1	15.3±0.2*
Erythrocytes (10 <sup>6</sup> /μL)	9.90±0.11	10.04±0.11	10.05±0.08	10.03±0.09	9.97±0.11	10.08±0.14
Reticulocytes (10 <sup>6</sup> /μL)	0.27±0.01	0.25±0.01	0.26±0.01	0.23±0.01**	0.21±0.00**	0.16±0.01**
Mean cell volume (fL)	46.3±0.2	46.8±0.2	46.9±0.3	46.9±0.2	46.7±0.2	46.5±0.2
Mean cell hemoglobin (pg)	14.9±0.1	14.9±0.0	15.0±0.1	15.2±0.1	15.0±0.1	15.2±0.1**
Mean cell hemoglobin concentration (g/dL)	32.1±0.1	31.9±0.1	32.1±0.2	32.3±0.1	32.2±0.1	32.6±0.2
Platelets (10 <sup>3</sup> /μL)	1,142.9±40.1	1,168.3±41.1	1,231.0±32.8	1,274.1±49.6*	1,305.3±48.5**	1,375.8±72.4**
Leukocytes (10 <sup>3</sup> /μL)	4.23±0.73	3.50±0.57	5.12±0.39	5.07±0.30	3.70±0.35	3.98±0.38
Segmented neutrophils (10 <sup>3</sup> /μL)	0.77±0.12	0.67±0.20	0.89±0.10	0.88±0.10	0.60±0.07	0.62±0.08
Lymphocytes (10 <sup>3</sup> /μL)	3.28±0.58	2.70±0.40	4.01±0.31	4.02±0.29	2.94±0.29	3.20±0.30
Monocytes (10 <sup>3</sup> /μL)	0.09±0.02	0.05±0.01	0.11±0.02	0.07±0.01	0.05±0.01	0.07±0.01
Basophils (10 <sup>3</sup> /μL)	0.006±0.002	0.009±0.002	0.009±0.002	0.009±0.002	0.005±0.002	0.008±0.001
Eosinophils (10 <sup>3</sup> /μL)	0.09±0.02	0.08±0.01	0.11±0.01	0.10±0.01	0.11±0.01	0.09±0.01
<b>Female</b>						
n	10	10	10	10	9	10
Hematocrit (%)	46.7±0.4	46.0±1.3	46.3±0.6	46.4±0.6	46.1±0.3	47.3±0.4
Hemoglobin (g/dL)	15.4±0.1	15.1±0.4	15.4±0.2	15.5±0.2	15.4±0.1	15.6±0.1
Erythrocytes (10 <sup>6</sup> /μL)	10.19±0.09	9.90±0.29	10.02±0.12	10.05±0.12	10.11±0.09	10.29±0.07
Reticulocytes (10 <sup>6</sup> /μL)	0.29±0.01	0.32±0.03	0.29±0.02	0.23±0.01*	0.21±0.01**	0.22±0.01**
Mean cell volume (fL)	45.8±0.2	46.5±0.2	46.2±0.1	46.2±0.2	45.7±0.2	45.9±0.1
Mean cell hemoglobin (pg)	15.1±0.1	15.3±0.1	15.4±0.1	15.4±0.1	15.2±0.1	15.2±0.1
Mean cell hemoglobin concentration (g/dL)	33.0±0.1	32.9±0.1	33.3±0.1	33.3±0.1	33.3±0.2	33.0±0.2
Platelets (10 <sup>3</sup> /μL)	951.5±48.5	974.0±68.7	977.9±71.2	1,010.6±82.2	1,082.8±46.8	1,133.6±52.5
Leukocytes (10 <sup>3</sup> /μL)	4.85±0.31	4.66±0.30	4.40±0.34	3.43±0.40*	2.58±0.26**	3.77±0.32**
Segmented neutrophils (10 <sup>3</sup> /μL)	0.49±0.05	0.40±0.06	0.46±0.05	0.29±0.03*	0.26±0.02**	0.41±0.06
Lymphocytes (10 <sup>3</sup> /μL)	4.14±0.26	4.05±0.26	3.75±0.29	2.99±0.36*	2.24±0.23**	3.26±0.27**
Monocytes (10 <sup>3</sup> /μL)	0.08±0.01	0.08±0.01	0.08±0.01	0.06±0.01	0.03±0.01**	0.05±0.01**
Basophils (10 <sup>3</sup> /μL)	0.010±0.001	0.007±0.002	0.006±0.002	0.003±0.002*	0.003±0.002	0.006±0.002
Eosinophils (10 <sup>3</sup> /μL)	0.13±0.02	0.12±0.02	0.10±0.01	0.08±0.01	0.05±0.01**	0.05±0.01**

\* Significantly different (P≤0.05) from the vehicle control group by Dunn's or Shirley's test

\*\* P≤0.01

<sup>a</sup> Data are presented as mean ± standard error. Statistical tests were performed on unrounded data.

## **APPENDIX G ORGAN WEIGHTS AND ORGAN-WEIGHT-TO-BODY-WEIGHT RATIOS**

<b>TABLE G1</b>	<b>Organ Weights and Organ-Weight-to-Body-Weight Ratios for Rats in the 3-Month Gavage Study of <i>Ginkgo biloba</i> Extract .....</b>	<b>158</b>
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**TABLE G1**  
**Organ Weights and Organ-Weight-to-Body-Weight Ratios for Rats in the 3-Month Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	62.5 mg/kg	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg
n	10	10	10	10	10	10
<b>Male</b>						
Necropsy body wt	322 ± 5	329 ± 5	322 ± 3	326 ± 4	324 ± 2	314 ± 5
Heart						
Absolute	0.912 ± 0.016	0.911 ± 0.018	0.903 ± 0.016	0.930 ± 0.013	0.939 ± 0.020	0.915 ± 0.023
Relative	2.835 ± 0.022	2.770 ± 0.033	2.805 ± 0.030	2.849 ± 0.028	2.901 ± 0.057	2.908 ± 0.034
R. Kidney						
Absolute	0.987 ± 0.025	0.977 ± 0.022	0.973 ± 0.014	0.999 ± 0.020	1.015 ± 0.012	1.031 ± 0.024
Relative	3.067 ± 0.053	2.973 ± 0.061	3.025 ± 0.043	3.061 ± 0.037	3.137 ± 0.044	3.279 ± 0.046**
Liver						
Absolute	11.296 ± 0.257	13.654 ± 0.300**	13.856 ± 0.357**	14.317 ± 0.244**	15.151 ± 0.219**	15.341 ± 0.511**
Relative	35.106 ± 0.524	41.503 ± 0.634**	43.012 ± 0.710**	43.906 ± 0.828**	46.815 ± 0.565**	48.700 ± 0.982**
Lung						
Absolute	1.974 ± 0.057	1.969 ± 0.086	1.730 ± 0.049	1.884 ± 0.085	1.833 ± 0.081	1.927 ± 0.070
Relative	6.148 ± 0.193	5.995 ± 0.275	5.374 ± 0.133	5.761 ± 0.220	5.667 ± 0.255	6.149 ± 0.260
R. Testis						
Absolute	1.384 ± 0.015	1.402 ± 0.025	1.406 ± 0.017	1.408 ± 0.015	1.408 ± 0.012	1.410 ± 0.016
Relative	4.306 ± 0.041	4.265 ± 0.067	4.375 ± 0.065	4.319 ± 0.055	4.353 ± 0.040	4.494 ± 0.081
Thymus						
Absolute	0.306 ± 0.010	0.287 ± 0.007	0.295 ± 0.014	0.290 ± 0.012	0.288 ± 0.017	0.291 ± 0.015
Relative	0.956 ± 0.042	0.873 ± 0.025	0.920 ± 0.048	0.889 ± 0.041	0.891 ± 0.053	0.927 ± 0.050
<b>Female</b>						
Necropsy body wt	192 ± 2	191 ± 2	194 ± 3	194 ± 4	193 ± 1	193 ± 2
Heart						
Absolute	0.605 ± 0.008	0.604 ± 0.009	0.622 ± 0.013	0.606 ± 0.011	0.618 ± 0.011	0.645 ± 0.020
Relative	3.146 ± 0.037	3.166 ± 0.042	3.218 ± 0.066	3.137 ± 0.072	3.211 ± 0.057	3.334 ± 0.086
R. Kidney						
Absolute	0.664 ± 0.010	0.655 ± 0.008	0.649 ± 0.014	0.663 ± 0.015	0.679 ± 0.015	0.680 ± 0.016
Relative	3.454 ± 0.059	3.437 ± 0.046	3.356 ± 0.063	3.426 ± 0.058	3.528 ± 0.075	3.521 ± 0.077
Liver						
Absolute	5.952 ± 0.110	6.590 ± 0.134**	6.548 ± 0.132**	7.286 ± 0.208**	7.485 ± 0.098**	8.026 ± 0.128**
Relative	30.949 ± 0.497	34.521 ± 0.375**	33.841 ± 0.552**	37.576 ± 0.595**	38.905 ± 0.614**	41.547 ± 0.631**
Lung						
Absolute	1.173 ± 0.039	1.309 ± 0.114	1.240 ± 0.032	1.164 ± 0.037	1.267 ± 0.077	1.254 ± 0.059
Relative	6.104 ± 0.212	6.844 ± 0.549	6.422 ± 0.198	6.014 ± 0.184	6.586 ± 0.412	6.479 ± 0.273
Thymus						
Absolute	0.242 ± 0.012	0.244 ± 0.008	0.246 ± 0.007	0.249 ± 0.011	0.254 ± 0.015	0.247 ± 0.005
Relative	1.260 ± 0.060	1.281 ± 0.038	1.269 ± 0.019	1.282 ± 0.047	1.317 ± 0.075	1.279 ± 0.027

\*\* Significantly different (P<0.01) from the vehicle control group by Williams' test

<sup>a</sup> Organ weights (absolute weights) and body weights are given in grams; organ-weight-to-body-weight ratios (relative weights) are given as mg organ weight/g body weight (mean ± standard error).

**TABLE G2**  
**Organ Weights and Organ-Weight-to-Body-Weight Ratios for Rats at 14 Weeks in the 2-Year Gavage Study**  
**of *Ginkgo biloba* Extract<sup>a</sup>**

	Vehicle Control	100 mg/kg	300 mg/kg	1,000 mg/kg
<b>Male</b>				
n	9	10	10	10
Necropsy body weight	335 ± 9	329 ± 5	330 ± 4	328 ± 3
Liver				
Absolute	12.24 ± 0.38	14.22 ± 0.29**	15.07 ± 0.23**	16.09 ± 0.25**
Relative	36.589 ± 0.634	43.178 ± 0.746**	45.650 ± 0.647**	49.087 ± 0.591**
Thyroid gland				
Absolute	0.026 ± 0.001	0.029 ± 0.001	0.027 ± 0.001	0.028 ± 0.002
Relative	0.076 ± 0.004	0.089 ± 0.002*	0.083 ± 0.003	0.087 ± 0.005
<b>Female</b>				
n	10	10	10	10
Necropsy body weight	194 ± 4	200 ± 3	193 ± 3	198 ± 3
Liver				
Absolute	6.37 ± 0.20	7.03 ± 0.14**	7.28 ± 0.15**	8.60 ± 0.16**
Relative	32.812 ± 0.643	35.092 ± 0.585**	37.703 ± 0.481**	43.345 ± 0.427**
Thyroid gland				
Absolute	0.023 ± 0.001	0.026 ± 0.001	0.023 ± 0.001	0.025 ± 0.001
Relative	0.119 ± 0.004	0.128 ± 0.006	0.120 ± 0.007	0.127 ± 0.006

\* Significantly different ( $P \leq 0.05$ ) from the vehicle control group by Dunnett's test

\*\* Significantly different ( $P \leq 0.01$ ) from the vehicle control group by Williams' test

<sup>a</sup> Organ weights (absolute weights) and body weights are given in grams; organ-weight-to-body-weight ratios (relative weights) are given as mg organ weight/g body weight (mean ± standard error).

**TABLE G3**  
**Organ Weights and Organ-Weight-to-Body-Weight Ratios for Mice in the 3-Month Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	125 mg/kg	250 mg/kg	500 mg/kg	1,000 mg/kg	2,000 mg/kg
<b>Male</b>						
n	10	10	10	10	10	10
Necropsy body wt	33.6 ± 0.9	34.4 ± 0.6	34.3 ± 0.8	34.0 ± 1.0	33.2 ± 0.3	32.4 ± 0.6
Heart						
Absolute	0.185 ± 0.011	0.183 ± 0.007	0.179 ± 0.005	0.171 ± 0.007	0.169 ± 0.007	0.175 ± 0.009
Relative	5.516 ± 0.308	5.323 ± 0.193	5.262 ± 0.230	5.063 ± 0.231	5.082 ± 0.211	5.404 ± 0.314
R. Kidney						
Absolute	0.275 ± 0.006	0.270 ± 0.004	0.271 ± 0.003	0.268 ± 0.008	0.258 ± 0.006	0.244 ± 0.008**
Relative	8.233 ± 0.187	7.864 ± 0.168	7.957 ± 0.209	7.888 ± 0.219	7.772 ± 0.190	7.524 ± 0.161*
Liver						
Absolute	1.595 ± 0.045	1.747 ± 0.025	1.902 ± 0.043**	1.996 ± 0.086**	2.169 ± 0.049**	2.453 ± 0.066**
Relative	47.583 ± 0.758	50.796 ± 0.647*	55.519 ± 0.670**	58.511 ± 0.952**	65.340 ± 0.150**	75.593 ± 1.111**
Lung						
Absolute	0.230 ± 0.011	0.248 ± 0.015	0.228 ± 0.007	0.234 ± 0.012	0.209 ± 0.010	0.231 ± 0.011
Relative	6.878 ± 0.312	7.217 ± 0.436	6.711 ± 0.299	6.941 ± 0.401	6.303 ± 0.281	7.116 ± 0.316
R. Testis						
Absolute	0.117 ± 0.003 <sup>b</sup>	0.116 ± 0.002	0.119 ± 0.002	0.119 ± 0.003	0.119 ± 0.002	0.119 ± 0.003
Relative	3.528 ± 0.089 <sup>b</sup>	3.368 ± 0.084	3.487 ± 0.088	3.501 ± 0.113	3.586 ± 0.077	3.658 ± 0.051
Thymus						
Absolute	0.043 ± 0.003	0.042 ± 0.003	0.041 ± 0.002	0.042 ± 0.001	0.045 ± 0.002	0.040 ± 0.003
Relative	1.272 ± 0.098	1.228 ± 0.088	1.207 ± 0.059	1.239 ± 0.056	1.347 ± 0.068	1.245 ± 0.079
<b>Female</b>						
n	10	10	10	10	9	10
Necropsy body wt	27.8 ± 0.3	27.9 ± 1.1	27.4 ± 0.5	27.3 ± 0.6	26.1 ± 0.5	25.4 ± 0.2*
Heart						
Absolute	0.147 ± 0.008	0.149 ± 0.010	0.139 ± 0.005	0.144 ± 0.007	0.147 ± 0.007	0.139 ± 0.007
Relative	5.311 ± 0.279	5.374 ± 0.337	5.093 ± 0.186	5.301 ± 0.311	5.649 ± 0.276	5.464 ± 0.250
R. Kidney						
Absolute	0.160 ± 0.004	0.158 ± 0.004	0.162 ± 0.004	0.155 ± 0.006	0.153 ± 0.004	0.151 ± 0.003
Relative	5.752 ± 0.162	5.688 ± 0.152	5.907 ± 0.152	5.697 ± 0.210	5.879 ± 0.171	5.940 ± 0.105
Liver						
Absolute	1.108 ± 0.025	1.236 ± 0.045**	1.275 ± 0.027**	1.322 ± 0.039**	1.390 ± 0.026**	1.663 ± 0.030**
Relative	39.965 ± 1.048	44.429 ± 0.980**	46.533 ± 0.762**	48.409 ± 0.799**	53.252 ± 1.103**	65.362 ± 0.906**
Lung						
Absolute	0.261 ± 0.013	0.259 ± 0.023	0.252 ± 0.016	0.258 ± 0.019	0.237 ± 0.014	0.228 ± 0.014
Relative	9.424 ± 0.458	9.276 ± 0.693	9.199 ± 0.536	9.418 ± 0.599	9.104 ± 0.589	8.960 ± 0.510
Thymus						
Absolute	0.052 ± 0.003	0.055 ± 0.003	0.056 ± 0.002	0.052 ± 0.003	0.051 ± 0.002	0.047 ± 0.002
Relative	1.860 ± 0.131	1.964 ± 0.102	2.019 ± 0.068	1.889 ± 0.097	1.967 ± 0.081	1.836 ± 0.083

\* Significantly different (P≤0.05) from the vehicle control group by Williams' or Dunnett's test

\*\* P≤0.01

<sup>a</sup> Organ weights (absolute weights) and body weights are given in grams; organ-weight-to-body-weight ratios (relative weights) are given as mg organ weight/g body weight (mean ± standard error).

<sup>b</sup> n=9

## APPENDIX H

### REPRODUCTIVE TISSUE EVALUATIONS AND ESTROUS CYCLE CHARACTERIZATION

<b>TABLE H1</b>	<b>Summary of Reproductive Tissue Evaluations for Male Rats in the 3-Month Gavage Study of <i>Ginkgo biloba</i> Extract .....</b>	<b>162</b>
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**TABLE H1**  
**Summary of Reproductive Tissue Evaluations for Male Rats in the 3-Month Gavage Study**  
**of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	250 mg/kg	500 mg/kg	1,000 mg/kg
n	10	10	10	10
Weights (g)				
Necropsy body wt	322 ± 5	326 ± 4	324 ± 2	314 ± 5
L. Cauda epididymis	0.1360 ± 0.0029	0.1283 ± 0.0042	0.1297 ± 0.0071	0.1326 ± 0.0028
L. Epididymis	0.4008 ± 0.0050	0.3997 ± 0.0065	0.4034 ± 0.0078	0.4055 ± 0.0068
L. Testis	1.4167 ± 0.0218	1.4656 ± 0.0166	1.4777 ± 0.0116	1.4635 ± 0.0211
Spermatid measurements				
Spermatid heads (10 <sup>6</sup> /testis)	170.3 ± 5.7	162.9 ± 2.5	174.5 ± 3.1	176.1 ± 4.9
Spermatid heads (10 <sup>6</sup> /g testis)	136.6 ± 4.7	121.1 ± 1.8*	133.1 ± 2.8	128.0 ± 3.5
Epididymal spermatozoal measurements				
Sperm motility (%)	85.60 ± 0.81	85.90 ± 0.85	77.60 ± 7.55	85.00 ± 0.88
Sperm (10 <sup>6</sup> /cauda epididymis)	92.4 ± 5.9	91.3 ± 3.8	74.5 ± 7.9	89.9 ± 5.9
Sperm (10 <sup>6</sup> /g cauda epididymis)	680 ± 42	713 ± 24	562 ± 49	679 ± 43

\* Significantly different (P≤0.05) from the vehicle control group by Dunn's test

<sup>a</sup> Data are presented as mean ± standard error. Differences from the vehicle control group are not significant by Dunnett's test (body and tissue weights) or Dunn's test (spermatid heads per testis and epididymal spermatozoal measurements).

**TABLE H2**  
**Estrous Cycle Characterization for Female Rats in the 3-Month Gavage Study of Ginkgo biloba Extract<sup>a</sup>**

	Vehicle Control	250 mg/kg	500 mg/kg	1,000 mg/kg
Number weighed at necropsy	10	10	10	10
Necropsy body wt (g)	192 ± 2	194 ± 4	193 ± 1	193 ± 2
Proportion of regular cycling females <sup>b</sup>	10/10	10/10	10/10	10/10
Estrous cycle length (days)	5.00 ± 0.15	5.20 ± 0.13	5.05 ± 0.05	4.95 ± 0.05
Estrous stages (% of cycle)				
Diestrus	60.0	64.2	65.8	60.8
Proestrus	15.0	14.2	12.5	15.0
Estrus	20.8	20.0	19.2	20.8
Metestrus	4.2	0.8	0.8	1.7
Uncertain diagnosis	0.0	0.8	1.7	1.7

<sup>a</sup> Necropsy body weights and estrous cycle length data are presented as mean ± standard error. Differences from the vehicle control group are not significant by Dunnett's test (body weight) or Dunn's test (estrous cycle length). By multivariate analysis of variance, dosed females do not differ significantly from the vehicle control females in the relative length of time spent in the estrous stages. The tests for equality of transition probability matrices indicated no significant differences in the probability of an altered cycle for any dosed group compared to the vehicle controls.

<sup>b</sup> Number of females with a regular cycle/number of females cycling

**TABLE H3**  
**Summary of Reproductive Tissue Evaluations for Male Mice in the 3-Month Gavage Study**  
**of *Ginkgo biloba* Extract<sup>a</sup>**

	Vehicle Control	500 mg/kg	1,000 mg/kg	2,000 mg/kg
n	9	10	10	10
Weights (g)				
Necropsy body wt	33.4 ± 1.0	34.0 ± 1.0	33.2 ± 0.3	32.4 ± 0.6
L. Cauda epididymis	0.0153 ± 0.0014	0.0141 ± 0.0006	0.0154 ± 0.0008	0.0144 ± 0.0006
L. Epididymis	0.0423 ± 0.0020	0.0438 ± 0.0008	0.0437 ± 0.0010	0.0408 ± 0.0014
L. Testis	0.1121 ± 0.0019	0.1161 ± 0.0024	0.1116 ± 0.0019	0.1128 ± 0.0023
Spermatid measurements				
Spermatid heads (10 <sup>6</sup> /testis)	17.89 ± 0.72	17.52 ± 0.87	18.63 ± 1.00	18.74 ± 0.91
Spermatid heads (10 <sup>6</sup> /g testis)	205.5 ± 8.9	194.7 ± 9.8	215.9 ± 9.4	218.6 ± 8.0
Epididymal spermatozoal measurements				
Sperm motility (%)	87.22 ± 0.36	87.70 ± 0.73	87.30 ± 0.56	87.10 ± 0.48
Sperm (10 <sup>6</sup> /cauda epididymis)	14.0 ± 1.5	15.5 ± 1.7	16.1 ± 1.4	16.0 ± 1.7
Sperm (10 <sup>6</sup> /g cauda epididymis)	931 ± 85	1,121 ± 129	1,029 ± 52	1,106 ± 108

<sup>a</sup> Data are presented as mean ± standard error. Differences from the vehicle control group are not significant by Dunnett's test (body and tissue weights) or Dunn's test (spermatid and epididymal spermatozoal measurements).

**TABLE H4**  
**Estrous Cycle Characterization for Female Mice in the 3-Month Gavage Study of *Ginkgo biloba* Extract<sup>a</sup>**

	Vehicle Control	500 mg/kg	1,000 mg/kg	2,000 mg/kg
Number weighed at necropsy	10	10	9	10
Necropsy body wt (g)	27.8 ± 0.3	27.3 ± 0.6	26.1 ± 0.5*	25.4 ± 0.2**
Proportion of regular cycling females <sup>b</sup>	6/8	8/10	7/9	5/10
Estrous cycle length (days)	4.04 ± 0.13 <sup>c</sup>	4.97 ± 0.47	4.83 ± 0.31	4.67 ± 0.40 <sup>d</sup>
Estrous stages (% of cycle)				
Diestrus	41.7	40.8	31.5	40.8
Proestrus	0.0	0.0	0.0	0.0
Estrus	40.8	36.7	43.5	40.0
Metestrus	16.7	22.5	24.1	19.2
Uncertain diagnosis	0.8	0.0	0.9	0.0

\* Significantly different (P≤0.05) from the vehicle control group by William's test

\*\* P≤0.01

<sup>a</sup> Necropsy body weights and estrous cycle length data are presented as mean ± standard error. Differences from the vehicle control group are not significant by Dunn's test (estrous cycle length). By multivariate analysis of variance, dosed females do not differ significantly from the vehicle control females in the relative length of time spent in the estrous stages. The tests for equality of transition probability matrices indicated a significantly higher probability of extended estrus for female mice in the 2,000 mg/kg group compared to the vehicle controls.

<sup>b</sup> Number of females with a regular cycle/number of females cycling

<sup>c</sup> Estrous cycle was longer than 12 days or unclear in 2 of 10 animals.

<sup>d</sup> Estrous cycle was longer than 12 days or unclear in 1 of 10 animals.



# APPENDIX I

## CHEMICAL CHARACTERIZATION AND DOSE FORMULATION STUDIES

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# CHEMICAL CHARACTERIZATION AND DOSE FORMULATION STUDIES

## PROCUREMENT AND CHARACTERIZATION

### *Ginkgo biloba* Extract

Although the original study planned to use standardized extract EGB 761<sup>®</sup>, manufactured by Wilhelm Schwabe, this material was not available to the NTP because at the time of procurement for the NTP studies, this standardized extract was sold unformulated only to pharmaceutical companies. Through industry contacts, the NTP learned that Shanghai Xing Ling Science and Technology Pharmaceutical Company, Ltd. (Shanghai, China), produced an extract comparable to the Schwabe extract and that was widely distributed in commerce. *Ginkgo biloba* extract from leaves was obtained from this company in two lots (020703 and GBE-50-001003). Lot 020703 was used during the 3-month and 2-year studies. Identity, purity, stability, and moisture analyses were conducted by the analytical chemistry laboratory at Midwest Research Institute (Kansas City, MO); in addition, the study laboratory at Battelle Columbus Operations (Columbus, OH) confirmed the identity of the test article versus a frozen reference of the same lot, shipped separately, by infrared spectroscopy. Reports on analyses performed in support of the *Ginkgo biloba* extract studies are on file at the National Institute of Environmental Health Sciences.

The identity and purity of the test article were determined by using a combination of techniques and authentic standards specific for ginkgo. Estimation of the distribution of particle sizes in lot GBE-50-001003 was determined using a sieve method, and the results indicated that 84.3% of the test article passed through a No. 140 (106  $\mu\text{m}$ ) sieve (Table II). The bulk density of lot 020703 was determined to be 0.521 g/mL. To evaluate organic constituents of the test article, extracts were prepared, and a combination of chromatographic and spectrometric techniques was used to characterize this lot. High-performance thin layer chromatography (HPTLC) fingerprint analyses were conducted for ginkgolides and flavonoids in methanol extracts of the test article using two systems specified in Application Notes F-16A and F-16B, respectively, obtained from CAMAG Scientific, Inc. (Wilmington, NC). Many components of the test article were tentatively identified using various chromatography/mass spectrometry techniques, including liquid chromatography/mass spectrometry, gas chromatography/mass spectrometry, and matrix-assisted laser-desorption ionization time-of-flight mass spectrometry. High-performance liquid chromatography (HPLC) was used to profile ethanol:water:12N hydrochloric acid (64:26:10) extracts of the bulk material and to quantitate (using caffeine as an internal standard)  $\alpha$ -glycosides and terpenoids in these extracts. Analyses were conducted on nonhydrolyzed extracts and also on extracts hydrolyzed at 90 $^{\circ}$  C for approximately 1 hour, utilizing commercially obtained standards with matching retention times published in the literature (Hasler *et al.*, 1992). The HPLC system used a Spectra SYSTEM<sup>™</sup> liquid chromatograph (Thermo Fisher Scientific, Inc., Pittsburgh, PA), ultraviolet (UV) and evaporative light scattering (ELS) detectors (Applied Biosystems, Foster City, CA, and SEDERE, Inc., Cranbury, NJ, respectively) and a Prodigy<sup>®</sup> ODS3 5  $\mu\text{m}$  column (250 mm  $\times$  4.6 mm; Phenomenex, Torrance, CA) maintained at ambient temperature. For these assays, a mobile phase of A: water:methanol (90:10) containing 0.25% formic acid and B: methanol containing 0.25% formic acid was linearly ramped; from 15% B to 38% B in 23 minutes, then to 45% B in 2 minutes with a 30-minute hold, and then to 15% B in 5 minutes with a 5 minute hold. In addition, UV absorbance was recorded at 270 nm, and the flow rate of the mobile phase was 1.0 mL/minute. For the ginkgolic acids and colchicines analyses, the HPLC system consisted of a Hewlett-Packard 1090 Series II chromatograph (Palo Alto, CA), UV detector [Thermo Separation Products Spectromonitor 3200 (Waltham, MA)], and Fisons Instruments Quattro I Mass Spectrometer (St. Louis, MO). For these assays, methanol:water (50:50) extracts of the *Ginkgo biloba* powder were partitioned with dichloromethane and dried over anhydrous sodium sulfate. The residue was reconstituted with methanol and analyzed using total ion current and single ion response mode following the methodology of Ndjoko *et al.* (2000) and Li *et al.* (2002). Further information on these methods can be found in Gray *et al.* (2005, 2007).

One aliquot each of lot GBE-50-001003 and lot 020703 were submitted to Covance Laboratories, Inc., for nutritional and contaminant testing using standard methods. For lot 020703, heavy metals present in the extract included antimony (57.2 ppb), arsenic (32.4 ppb), cadmium (13.2 ppb), lead (249 ppb), mercury (10.7 ppb), and molybdenum (14.6 ppb). Levels for aflatoxins B1, B2, G1, and G2 were all less than 0.500 ppb and pesticide levels were below the detection limit, with the exception of carbendazim (0.24 ppm) and 2-phenylphenol (0.11 ppm). For

lot GBE-50-001003, organochlorine, organophosphorus pesticide, nitrosamine, and aflatoxin levels were below the limit of detection for the analysis method.

As determined by weight loss on drying, moisture content for lot 020703 was 0.90%. Developed, dried HPTLC plates were viewed under UV light, and multiple bands were obtained for the test article by both systems; bands consistent with those for standards obtained from Sigma-Aldrich (St. Louis, MO) of the ginkgolides bilobalide, ginkgolide A, and ginkgolide B, and of the flavonoid rutin hydrate were observed. In HPLC/UV profiles of the test article extracts, 37 components were observed to have peak areas greater than or equal to 0.05% of the total peak area, and three components were identified: quercetin, kaempferol, and isorhamnetin, which had peak areas equal to 34.08%, 27.77%, and 5.43%, respectively, of the total peak area. In HPLC/ELS profiles of the test article extracts, 18 components were observed to have peak areas greater than or equal to 0.05% of the total peak area, and seven components were identified: bilobalide, ginkgolide C, ginkgolide A, ginkgolide B, quercetin, kaempferol, and isorhamnetin, which had peak areas equal to 17.30%, 3.25%, 9.06%, 2.05%, 28.74%, 12.58%, and 2.24%, respectively, of the total peak area. Quantitation assays of  $\alpha$ -glycosides in the hydrolyzed extracts using HPLC/UV indicated that the test material contained 16.71% quercetin, 12.20% kaempferol, and 2.37% isorhamnetin when reported as glycosides. HPLC/ELS quantitation assays of terpenoids in the hydrolyzed extracts determined that the test material contained 6.94% bilobalide, 3.06% ginkgolide C, 3.74% ginkgolide A, and 1.62% ginkgolide B. Representative HPLC chromatograms for the  $\alpha$ -glycosides and terpenoids quantitated in these assays are presented in Figures I1 and I2, respectively. HPLC/MS analysis for the presence of colchicine using the colchicine standard from Sigma-Aldrich resulted in no observable peak of colchicine in the test material. HPLC analyses for the presence of ginkgolic acids I and II using standards from ChromaDex, Inc. (Irvine, CA), revealed concentrations of 9.17 and 1.28 ppm, respectively, in the test material.

Stability studies of lot 020703 of the bulk chemical were performed using HPLC analyses by the same UV and ELS detection techniques used to characterize this lot of the bulk product. Results of these assays were inconclusive due to high amounts of variability in the measurements, but the seven  $\alpha$ -glycosides and terpenoid components in lot 020703 appeared to be stable, within experimental error, at temperatures up to approximately 60° C when the bulk material was stored protected from light. To ensure stability, the bulk chemical was stored at room temperature in amber glass bottles. Periodic reanalyses of the bulk chemical were performed during the 3-month and 2-year studies by the study laboratory using the same HPLC/UV system used to characterize the test material except that the isocratic mobile phase consisted of 0.5% aqueous formic acid:methanol (1:1) and the analytical column was heated to 35° C; no degradation of the bulk material was observed over the course of the studies.

### Corn Oil

NF-grade corn oil was obtained in multiple lots from Spectrum Chemicals and Laboratory Products (Gardena, CA) and was used as the vehicle in the 3-month and 2-year studies. Periodic analyses of the corn oil vehicle performed by the study laboratory using potentiometric titration demonstrated peroxide concentrations less than the rejection level of 3 mEq/kg.

## PREPARATION AND ANALYSIS OF DOSE FORMULATIONS

The dose formulations were prepared by mixing *Ginkgo biloba* extract with corn oil to give the required concentrations (Table I2). The dose formulations were stored at room temperature in sealed plastic bottles enclosed in amber plastic bags for up to 35 days (3-month studies) or 41 days (2-year studies).

Homogeneity studies of the 25 and 400 mg/mL dose formulations were performed by the study laboratory with the isocratic HPLC/UV system previously described for the periodic bulk chemical reanalyses; this system was also used by Battelle Chemistry Support Services (Columbus, OH) to perform stability studies of a 1 mg/mL formulation made with lot GBE-50-001003 of *Ginkgo biloba* extract. Homogeneity was confirmed, and stability was confirmed for at least 42 days for formulations stored in sealed plastic bottles protected from light at room temperature or at approximately 5° C, and for at least 3 hours under simulated animal room conditions.

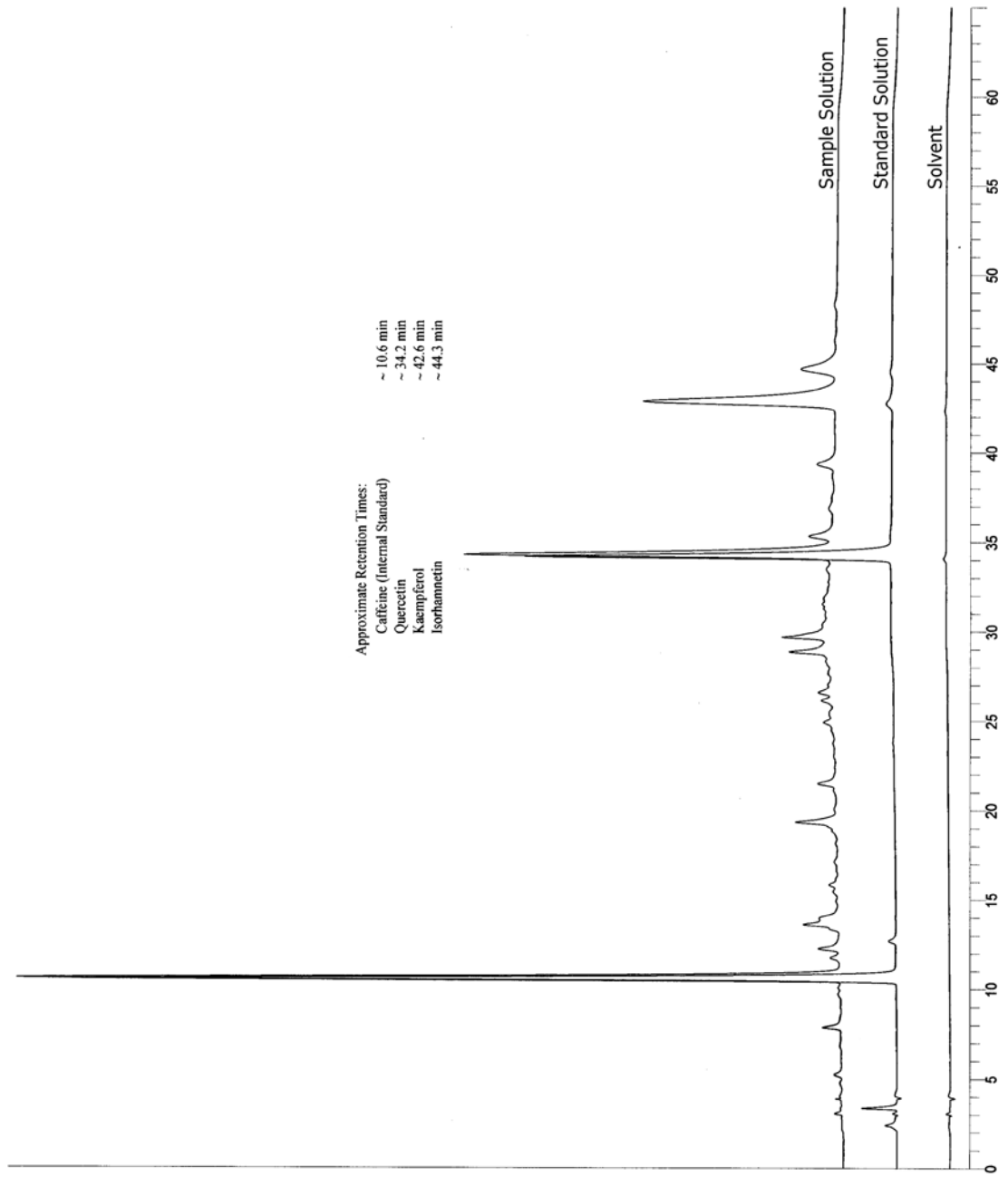
The study laboratory determined that the 400 mg/mL dose formulation of *Ginkgo biloba* extract in corn oil was gavagable using a 20-gauge gavage needle.

Periodic analyses of the dose formulations of *Ginkgo biloba* extract were conducted by the study laboratory using the isocratic HPLC/UV system previously described and an authentic standard of quercetin dihydrate. During the 3-month studies, the dose formulations were analyzed three times; all 15 dose formulations for rats and mice were within 10% of the target concentrations (Table I3). Animal room samples of these dose formulations were also analyzed; all 15 animal room samples for rats and all 15 for mice were within 10% of the target concentrations. During the 2-year studies, the dose formulations were analyzed approximately every 12 weeks; animal room samples were also analyzed (Table I4). All 30 dose formulations analyzed for rats and mice were within 10% of the target concentrations; all 12 animal room samples for rats and all 12 for mice were within 10% of the target concentrations.

**TABLE II**  
**Particle Size Distribution in *Ginkgo biloba* Extract**

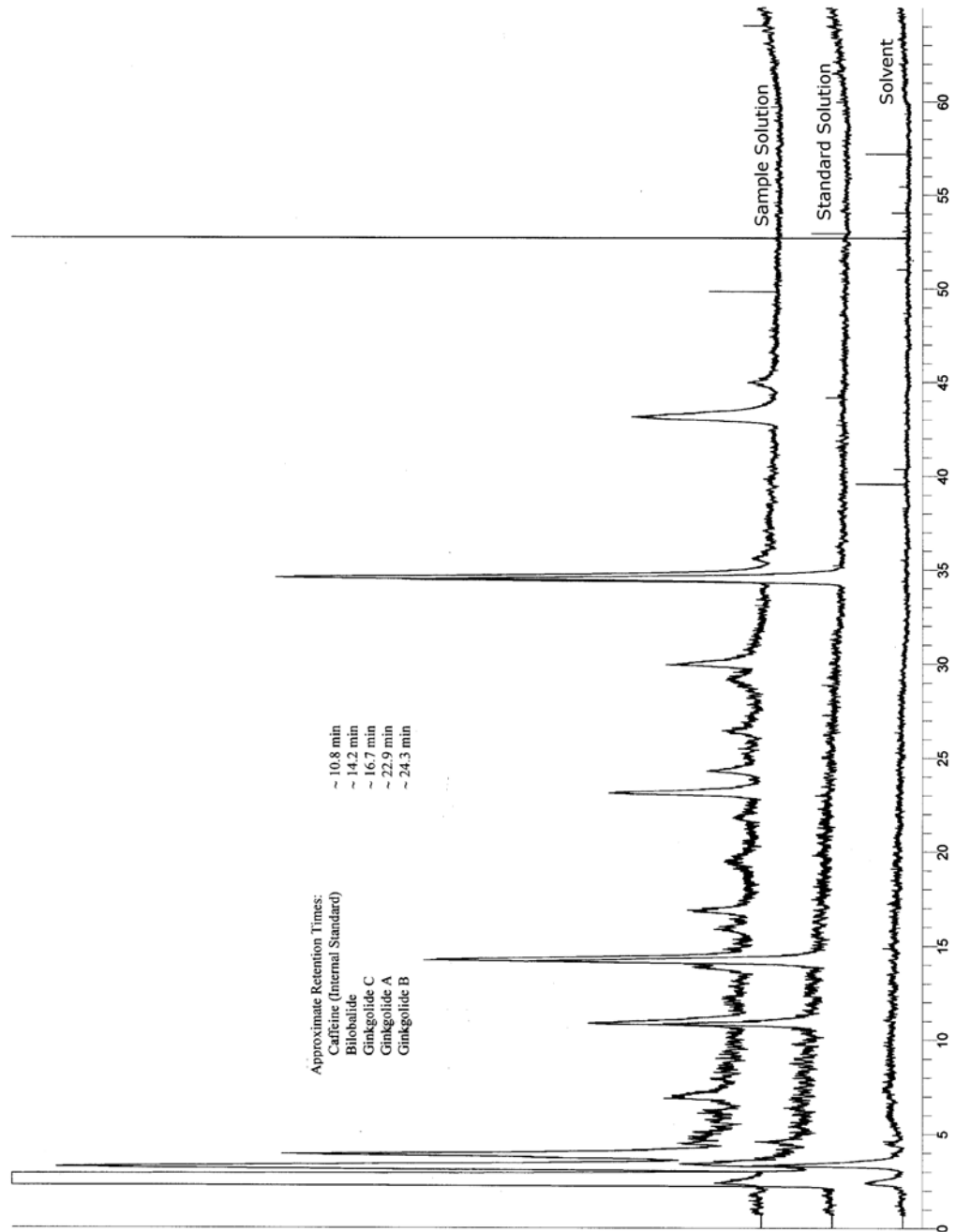
U.S. Sieve Number	Sieve Size (µm)	Weight of Powder (g)	Percent of Total	Percent Through
40	425	0.0	0.0	100.0
60	250	0.6	0.6	99.4
70	212	1.1	1.1	98.3
80	180	1.8	1.8	96.5
100	150	2.9	2.9	93.6
120	125	5.0	5.0	88.6
140	106	4.3	4.3	84.3
200	75	12.7	12.6	71.7
270	53	60.4	59.9	11.8
Bottom pan	NA	12.1	12.0	NA

NA = not applicable; the bottom pan is solid



**FIGURE II**  
**High-Performance Liquid Chromatography with Ultraviolet Detection Quantitation of  $\alpha$ -Glycosides in *Ginkgo biloba* Extract**  
Kaempferol and isorhamnetin were determined against the quercetin dihydrate standard.





**FIGURE I2**  
**High-Performance Liquid Chromatography**  
**with Evaporative Light Scattering Detection Quantitation of Terpenoids**  
**in *Ginkgo biloba* Extract**  
Ginkgolides C, A, and B were determined against the bilobalide standard.

**TABLE I2**  
**Preparation and Storage of Dose Formulations in the Gavage Studies of *Ginkgo biloba* Extract**

3-Month Studies	2-Year Studies
<p><b>Preparation</b>            The appropriate amount of test article was weighed into a plastic beaker. Enough corn oil was added to wet the test article, and a smooth slurry was formed by stirring with a spatula. The wetted test article was transferred into a carboy containing corn oil that was being stirred with an overhead stirrer. The plastic beaker, spatula, and sides of the carboy were rinsed with corn oil. The contents of the carboy were diluted to the total final volume with corn oil, and the contents were stirred at a vigorous vortex for approximately 15 minutes with an overhead stirrer. While the formulation was being stirred, approximately 500 mL of it was dispensed into a beaker and poured back into the carboy. The contents of the carboy were stirred at a vigorous vortex for approximately 5 additional minutes with an overhead stirrer.</p>	<p>For the 40 and 120 mg/mL dose formulations, the appropriate amount of test article was weighed into a stainless steel mixing bowl. Enough corn oil was added to wet the test article, and the mixture was vigorously stirred with a KitchenAid mixer for approximately 2 minutes. The wetted test article was transferred into a carboy containing corn oil that was being vigorously stirred with an overhead stirrer, and the mixing bowl was rinsed with corn oil until all of the test article was transferred into the carboy. The formulation was vigorously stirred for approximately 5 minutes, and any settled or unwetted test article was scraped with a spatula. While the formulation was being stirred, approximately 200 mL of it were dispensed into a plastic beaker and then poured back into the carboy. The beaker was rinsed with corn oil, and the formulation was diluted to the final volume with additional corn oil, and the mixture was stirred at maximum speed for approximately 5 additional minutes. For the 400 mg/mL formulation, the same procedure was used with the exception that two premixes were prepared in stainless steel mixing bowls and combined into a single carboy.</p>
<p>The dose formulations were prepared five times during the studies.</p>	<p>Dose formulations were prepared approximately every 4 weeks.</p>
<p><b>Chemical Lot Number</b> 020703</p>	<p>020703</p>
<p><b>Maximum Storage Time</b> 35 days</p>	<p>41 days</p>
<p><b>Storage Conditions</b> Stored in sealed plastic bottles enclosed in amber plastic bags at approximately 25° C</p>	<p>Stored in sealed plastic bottles enclosed in amber plastic bags at approximately 25° C</p>
<p><b>Study Laboratory</b> Battelle Columbus Operations (Columbus, OH)</p>	<p>Battelle Columbus Operations (Columbus, OH)</p>

**TABLE I3**  
**Results of Analyses of Dose Formulations Administered to Rats and Mice in the 3-Month Gavage Studies**  
**of *Ginkgo biloba* Extract**

Date Prepared	Date Analyzed	Target Concentration (mg/mL)	Determined Concentration <sup>a</sup> (mg/mL)	Difference from Target (%)
January 26, 2004	January 30-31, 2004	25	24.01 ± 0.28	-4
		50	50.73 ± 0.81	+1
		100	101.1 ± 2.9	+1
		200	219.9 ± 7.8	+10
		400	411.5 ± 15.0	+3
	March 3-4, 2004 <sup>b</sup>	25	25.43 ± 0.38	+2
		50	49.50 ± 1.67	-1
		100	100.0 ± 4.0	0
		200	184.3 ± 8.7	-8
		400	376.6 ± 10.8	-6
	March 8-9, 2004 <sup>c</sup>	25	25.07 ± 1.32	0
		50	50.65 <sup>d</sup>	+1
		100	94.29 ± 0.46	-6
		200	205.3 ± 8.4	+3
		400	384.3 ± 28.5	-4
February 18, 2004	February 26-27, 2004	25	24.33 ± 0.48	-3
		50	50.64 ± 2.48	+1
		100	105.5 ± 2.5	+6
		200	202.2 ± 12.2	+1
		400	416.6 ± 24.4	+4
	March 29-31, 2004 <sup>b</sup>	25	26.01 ± 0.27	+4
		50	49.38 ± 0.83	-1
	April 7-8, 2004 <sup>b</sup>	100	104.7 ± 1.8	+5
		200	209.2 ± 11.1	+5
		400	434.3 ± 28.1	+9
	March 29-31, 2004 <sup>c</sup>	25	26.23 ± 0.81	+5
		50	50.62 ± 2.85	+1
	April 7-8, 2004 <sup>c</sup>	100	103.7 ± 2.5	+4
		200	206.5 ± 4.3	+3
		400	423.8 ± 4.3	+6

**TABLE I3**  
**Results of Analyses of Dose Formulations Administered to Rats and Mice in the 3-Month Gavage Studies**  
**of *Ginkgo biloba* Extract**

Date Prepared	Date Analyzed	Target Concentration (mg/mL)	Determined Concentration (mg/mL)	Difference from Target (%)
April 12, 2004	April 13-14, 2004	25	26.86 ± 1.33	+7
		50	51.63 ± 3.38	+3
		100	98.62 ± 2.15	-1
		200	201.8 ± 4.0	+1
	April 15-16, 2004	400	417.4 ± 2.7	+4
	May 18-19, 2004 <sup>b</sup>	25	27.10 ± 0.61	+8
		50	51.65 ± 1.45	+3
		100	103.2 ± 3.9	+3
		200	202.7 ± 4.2	+1
		400	420.1 ± 24.8	+5
	May 18-19, 2004 <sup>c</sup>	25	26.92 ± 0.21	+8
		50	52.25 <sup>d</sup>	+5
		100	103.5 ± 4.8	+4
		200	212.4 ± 8.91	+6
		400	417.1 ± 15.8	+4

<sup>a</sup> Results of triplicate analyses (mean ± standard deviation). For rats, dosing volume=2.5 mL/kg; 25 mg/mL=62.5 mg/kg, 50 mg/mL=125 mg/kg, 100 mg/mL=250 mg/kg, 200 mg/mL=500 mg/kg, 400 mg/mL=1,000 mg/kg. For mice, dosing volume=5 mL/kg; 25 mg/mL=125 mg/kg, 50 mg/mL=250 mg/kg, 100 mg/mL=500 mg/kg, 200 mg/mL=1,000 mg/kg, 400 mg/mL=2,000 mg/kg.

<sup>b</sup> Animal room samples for rats

<sup>c</sup> Animal room samples for mice

<sup>d</sup> The result from one of the triplicates was a statistical outlier and was excluded.

**TABLE I4**  
**Results of Analyses of Dose Formulations Administered to Rats and Mice in the 2-Year Gavage Studies**  
**of Ginkgo biloba Extract**

Date Prepared	Date Analyzed	Target Concentration (mg/mL)	Determined Concentration <sup>a</sup> (mg/mL)	Difference from Target (%)
<b>Rats</b>				
February 28, 2005	March 4-5, 2005	40	39.7 ± 0.9	-1
		120	114 ± 1	-5
		400	399 ± 14	0
	April 14-15, 2005 <sup>b</sup>	40	40.1 ± 0.6	0
		120	118 ± 5	-2
		400	397 ± 5	-1
May 2, 2005	May 3-4, 2005	40	41.1 ± 0.3	+3
		120	122 ± 0	+2
		400	437 ± 26	+9
July 25-26, 2005	July 28-29, 2005	40	42.0 ± 1.1	+5
		120	125 ± 2	+4
		400	417 ± 4	+4
October 13, 2005	October 24-25, 2005	40	42.9 ± 1.5	+7
		120	130 ± 2	+8
		400	429 ± 7	+7
	November 29-December 1, 2005 <sup>b</sup>	40	41.4 ± 1.5	+4
		120	118 ± 7	-2
		400	386 ± 13	-4
January 3, 2006	January 6-7, 2006	40	42.6 ± 0.6	+7
		120	131 ± 2	+9
		400	421 ± 15	+5
March 27, 2006	March 29-30, 2006	40	41.5 ± 0.9	+4
		120	120 ± 3	0
		400	404 ± 12	+1
June 14, 2006	June 16-17, 19-20, 2006	40	43.7 ± 0.6	+9
		120	124 ± 3	+3
		400	423 ± 4	+6
	July 21-25, 2006 <sup>b</sup>	40	38.9 ± 1.1	-3
		120	119 ± 8	-1
		400	388 <sup>c</sup>	-3
September 1, 2006	September 6-8, 11, 2006	40	41.2 ± 3.1	+3
		120	127 ± 2	+6
		400	417 ± 18	+4
November 20, 2006	November 22-23, 2006	40	41.7 ± 0.3	+4
		120	124 ± 3	+3
		400	397 ± 7	-1

**TABLE I4**  
**Results of Analyses of Dose Formulations Administered to Rats and Mice in the 2-Year Gavage Studies**  
**of Ginkgo biloba Extract**

Date Prepared	Date Analyzed	Target Concentration (mg/mL)	Determined Concentration (mg/mL)	Difference from Target (%)
<b>Rats (continued)</b>				
February 7, 2007	February 8-9, 2007	40	42.7 ± 1.3	+7
		120	129 ± 0	+8
		400	433 ± 1	+8
	March 16-17, 2006 <sup>b</sup>	40	41.1 ± 0.8	+3
		120	128 ± 2	+7
		400	414 ± 6	+4
<b>Mice</b>				
February 28, 2005	March 4-5, 2005	40	39.7 ± 0.9	-1
		120	114 ± 1	-5
		400	399 ± 14	0
	April 14-15, 2005 <sup>b</sup>	40	40.9 ± 0.9	+2
		120	119 ± 4	-1
		400	415 ± 7	+4
May 2, 2005	May 3-4, 2005	40	41.1 ± 0.3	+3
		120	122 ± 0	+2
		400	437 ± 26	+9
July 25-26, 2005	July 28-29, 2005	40	42.0 ± 1.1	+5
		120	125 ± 2	+4
		400	417 ± 4	+4
October 13, 2005	October 24-25, 2005	40	42.9 ± 1.5	+7
		120	130 ± 2	+8
		400	429 ± 7	+7
	November 29-December 1, 2005 <sup>b</sup>	40	40.5 ± 2.3	+1
		120	128 ± 2	+7
		400	420 ± 31	+5
January 3, 2006	January 6-7, 2006	40	42.6 ± 0.6	+7
		120	131 ± 2	+9
		400	421 ± 15	+5
March 27, 2006	March 29-30, 2006	40	41.5 ± 0.9	+4
		120	120 ± 3	0
		400	404 ± 12	+1
June 14, 2006	June 16-17, 19-20, 2006	40	43.7 ± 0.6	+9
		120	124 ± 3	+3
		400	423 ± 4	+6
	July 21-25, 2006 <sup>b</sup>	40	41.5 ± 0.6	+4
		120	118 ± 8	-2
		400	391 ± 13	-2

**TABLE I4**  
**Results of Analyses of Dose Formulations Administered to Rats and Mice in the 2-Year Gavage Studies**  
**of Ginkgo biloba Extract**

Date Prepared	Date Analyzed	Target Concentration (mg/mL)	Determined Concentration (mg/mL)	Difference from Target (%)
<b>Mice (continued)</b>				
September 1, 2006	September 6-8, 11, 2006	40	41.2 ± 3.1	+3
		120	127 ± 2	+6
		400	417 ± 18	+4
November 20, 2006	November 22-23, 2006	40	41.7 ± 0.3	+4
		120	124 ± 3	+3
		400	397 ± 7	-1
February 7, 2007	February 8-9, 2007	40	42.7 ± 1.3	+7
		120	129 ± 0	+8
		400	433 ± 1	+8
	March 16-17, 2006 <sup>b</sup>	40	41.6 ± 1.7	+4
		120	123 ± 1	+3
		400	422 ± 10	+6

<sup>a</sup> Results of triplicate analyses. For rats, dosing volume=2.5 mL/kg; 40 mg/mL=100 mg/kg, 120 mg/mL=300 mg/kg, 400 mg/mL=1,000 mg/kg. For mice, dosing volume=5 mL/kg; 40 mg/mL=200 mg/kg, 120 mg/mL=600 mg/kg, 400 mg/mL=2,000 mg/kg.

<sup>b</sup> Animal room samples

<sup>c</sup> The result from one of the triplicates was a statistical outlier and was excluded.

**APPENDIX J**  
**INGREDIENTS, NUTRIENT COMPOSITION,**  
**AND CONTAMINANT LEVELS**  
**IN NTP-2000 RAT AND MOUSE RATION**

<b>TABLE J1</b>	<b>Ingredients of NTP-2000 Rat and Mouse Ration .....</b>	<b>178</b>
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**TABLE J1**  
**Ingredients of NTP-2000 Rat and Mouse Ration**

Ingredients	Percent by Weight
Ground hard winter wheat	22.26
Ground #2 yellow shelled corn	22.18
Wheat middlings	15.0
Oat hulls	8.5
Alfalfa meal (dehydrated, 17% protein)	7.5
Purified cellulose	5.5
Soybean meal (49% protein)	5.0
Fish meal (60% protein)	4.0
Corn oil (without preservatives)	3.0
Soy oil (without preservatives)	3.0
Dried brewer's yeast	1.0
Calcium carbonate (USP)	0.9
Vitamin premix <sup>a</sup>	0.5
Mineral premix <sup>b</sup>	0.5
Calcium phosphate, dibasic (USP)	0.4
Sodium chloride	0.3
Choline chloride (70% choline)	0.26
Methionine	0.2

<sup>a</sup> Wheat middlings as carrier

<sup>b</sup> Calcium carbonate as carrier

**TABLE J2**  
**Vitamins and Minerals in NTP-2000 Rat and Mouse Ration<sup>a</sup>**

	Amount	Source
<b>Vitamins</b>		
A	4,000 IU	Stabilized vitamin A palmitate or acetate
D	1,000 IU	D-activated animal sterol
K	1.0 mg	Menadione sodium bisulfite complex
$\alpha$ -Tocopheryl acetate	100 IU	
Niacin	23 mg	
Folic acid	1.1 mg	
<i>d</i> -Pantothenic acid	10 mg	<i>d</i> -Calcium pantothenate
Riboflavin	3.3 mg	
Thiamine	4 mg	Thiamine mononitrate
B <sub>12</sub>	52 $\mu$ g	
Pyridoxine	6.3 mg	Pyridoxine hydrochloride
Biotin	0.2 mg	<i>d</i> -Biotin
<b>Minerals</b>		
Magnesium	514 mg	Magnesium oxide
Iron	35 mg	Iron sulfate
Zinc	12 mg	Zinc oxide
Manganese	10 mg	Manganese oxide
Copper	2.0 mg	Copper sulfate
Iodine	0.2 mg	Calcium iodate
Chromium	0.2 mg	Chromium acetate

<sup>a</sup> Per kg of finished product

**TABLE J3**  
**Nutrient Composition of NTP-2000 Rat and Mouse Ration**

Nutrient	Mean ± Standard Deviation	Range	Number of Samples
Protein (% by weight)	14.6 ± 0.68	13.5 – 16.3	25
Crude fat (% by weight)	8.2 ± 0.33	7.6 – 9.3	25
Crude fiber (% by weight)	9.2 ± 0.49	8.4 – 10.0	25
Ash (% by weight)	4.9 ± 0.24	4.6 – 5.4	25
<b>Amino Acids (% of total diet)</b>			
Arginine	0.778 ± 0.068	0.670 – 0.970	21
Cystine	0.220 ± 0.025	0.150 – 0.250	21
Glycine	0.701 ± 0.042	0.620 – 0.800	21
Histidine	0.354 ± 0.079	0.270 – 0.680	21
Isoleucine	0.544 ± 0.045	0.430 – 0.660	21
Leucine	1.092 ± 0.068	0.960 – 1.240	21
Lysine	0.704 ± 0.112	0.310 – 0.840	21
Methionine	0.409 ± 0.047	0.260 – 0.490	21
Phenylalanine	0.626 ± 0.040	0.540 – 0.720	21
Threonine	0.503 ± 0.043	0.430 – 0.610	21
Tryptophan	0.148 ± 0.027	0.110 – 0.200	21
Tyrosine	0.397 ± 0.058	0.280 – 0.540	21
Valine	0.666 ± 0.044	0.550 – 0.730	21
<b>Essential Fatty Acids (% of total diet)</b>			
Linoleic	3.92 ± 0.227	3.49 – 4.54	21
Linolenic	0.30 ± 0.030	0.21 – 0.35	21
<b>Vitamins</b>			
Vitamin A (IU/kg)	3,737 ± 605	2,340 – 5,080	25
Vitamin D (IU/kg)	1,000 <sup>a</sup>		
α-Tocopherol (ppm)	80.1 ± 22.48	27.0 – 124.0	21
Thiamine (ppm) <sup>b</sup>	7.6 ± 0.98	6.3 – 10.5	25
Riboflavin (ppm)	7.1 ± 1.91	4.20 – 11.20	21
Niacin (ppm)	78.6 ± 9.16	66.4 – 98.2	21
Pantothenic acid (ppm)	27.1 ± 12.89	17.4 – 81.0	21
Pyridoxine (ppm) <sup>b</sup>	9.47 ± 2.01	6.4 – 13.7	21
Folic acid (ppm)	1.63 ± 0.49	1.15 – 3.27	21
Biotin (ppm)	0.319 ± 0.10	0.200 – 0.704	21
Vitamin B <sub>12</sub> (ppb)	53.8 ± 40.6	18.3 – 174.0	21
Choline (ppm) <sup>b</sup>	2,885 ± 459	1,820 – 3,790	21
<b>Minerals</b>			
Calcium (%)	0.960 ± 0.053	0.865 – 1.080	25
Phosphorus (%)	0.554 ± 0.028	0.499 – 0.607	25
Potassium (%)	0.663 ± 0.027	0.626 – 0.732	21
Chloride (%)	0.387 ± 0.039	0.300 – 0.474	21
Sodium (%)	0.190 ± 0.016	0.160 – 0.222	21
Magnesium (%)	0.216 ± 0.063	0.185 – 0.490	21
Sulfur (%)	0.170 ± 0.029	0.116 – 0.209	14
Iron (ppm)	185 ± 40.1	135 – 311	21
Manganese (ppm)	51.6 ± 10.49	21.0 – 73.1	21
Zinc (ppm)	53.6 ± 8.62	43.3 – 78.5	21
Copper (ppm)	7.07 ± 2.611	3.21 – 16.30	21
Iodine (ppm)	0.497 ± 0.209	0.158 – 0.972	21
Chromium (ppm)	0.684 ± 0.279	0.330 – 1.380	20
Cobalt (ppm)	0.26 ± 0.164	0.11 – 0.86	19

<sup>a</sup> From formulation

<sup>b</sup> As hydrochloride (thiamine and pyridoxine) or chloride (choline)

**TABLE J4**  
**Contaminant Levels in NTP-2000 Rat and Mouse Ration<sup>a</sup>**

	Mean ± Standard Deviation <sup>b</sup>	Range	Number of Samples
<b>Contaminants</b>			
Arsenic (ppm)	0.24 ± 0.067	0.16 – 0.40	25
Cadmium (ppm)	0.05 ± 0.007	0.04 – 0.07	25
Lead (ppm)	0.09 ± 0.012	0.07 – 0.12	25
Mercury (ppm)	<0.02		25
Selenium (ppm)	0.28 ± 0.094	0.18 – 0.49	25
Aflatoxins (ppb)	<5.00		25
Nitrate nitrogen (ppm) <sup>c</sup>	13.44 ± 7.29	4.76 – 36.8	25
Nitrite nitrogen (ppm) <sup>c</sup>	<0.61		25
BHA (ppm) <sup>d</sup>	<1.0		25
BHT (ppm) <sup>d</sup>	<1.0		25
Aerobic plate count (CFU/g)	10 ± 0.0	10.0 – 10.0	25
Coliform (MPN/g)	3.0 ± 0.0	3.0 – 3.0	25
<i>Escherichia coli</i> (MPN/g)	<10		25
<i>Salmonella</i> (MPN/g)	Negative		25
Total nitrosoamines (ppb) <sup>e</sup>	4.85 ± 1.85	2.0 – 9.9	25
<i>N</i> -Nitrosodimethylamine (ppb) <sup>e</sup>	2.7 ± 1.22	1.0 – 6.3	25
<i>N</i> -Nitrosopyrrolidine (ppb) <sup>e</sup>	2.2 ± 1.14	1.1 – 6.1	25
<b>Pesticides (ppm)</b>			
α-BHC	<0.01		25
β-BHC	<0.02		25
γ-BHC	<0.01		25
δ-BHC	<0.01		25
Heptachlor	<0.01		25
Aldrin	<0.01		25
Heptachlor epoxide	<0.01		25
DDE	<0.01		25
DDD	<0.01		25
DDT	<0.01		25
HCB	<0.01		25
Mirex	<0.01		25
Methoxychlor	<0.05		25
Dieldrin	<0.01		25
Endrin	<0.01		25
Telodrin	<0.01		25
Chlordane	<0.05		25
Toxaphene	<0.10		25
Estimated PCBs	<0.20		25
Ronnel	<0.01		25
Ethion	<0.02		25
Trithion	<0.05		25
Diazinon	<0.10		25
Methyl chlorpyrifos	0.109 ± 0.098	0.020 – 0.356	25
Methyl parathion	<0.02		25
Ethyl parathion	<0.02		25
Malathion	0.245 ± 0.240	0.020 – 0.997	25
Endosulfan I	<0.01		25
Endosulfan II	<0.01		25
Endosulfan sulfate	<0.03		25

<sup>a</sup> All samples were irradiated. CFU=colony-forming units; MPN=most probable number; BHC=hexachlorocyclohexane or benzene hexachloride

<sup>b</sup> For values less than the limit of detection, the detection limit is given as the mean.

<sup>c</sup> Sources of contamination: alfalfa, grains, and fish meal

<sup>d</sup> Sources of contamination: soy oil and fish meal

<sup>e</sup> All values were corrected for percent recovery.

## **APPENDIX K SENTINEL ANIMAL PROGRAM**

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## SENTINEL ANIMAL PROGRAM

### METHODS

Rodents used in the Carcinogenesis Program of the National Toxicology Program are produced in optimally clean facilities to eliminate potential pathogens that may affect study results. The Sentinel Animal Program is part of the periodic monitoring of animal health that occurs during the toxicologic evaluation of chemical compounds. Under this program, the disease state of the rodents is monitored via sera or feces from extra (sentinel) animals in the study rooms. These animals and the study animals are subject to identical environmental conditions. The sentinel animals come from the same production source and weanling groups as the animals used for the studies of chemical compounds.

In the 3-month studies, serum samples were collected from five male and five female sentinel rats and mice at 1 month and end of the study. In the 2-year studies, serum samples were collected from male and female sentinel rats and mice at 6, 12, and 18 months and from the 1,000 mg/kg (rats) and 2,000 mg/kg (mice) groups at the end of the study. Serum samples were collected from extra animals at the beginning of all studies. Fecal samples were collected from five male and five female mice at 18 months in the 2-year study for *Helicobacter* analyses. Blood from each animal was collected and allowed to clot, and the serum was separated. The samples were processed appropriately and sent to BioReliance Corporation (Rockville, MD) for determination of antibody titers. The laboratory methods and agents for which testing was performed are tabulated below; the times at which samples were collected during the studies are also listed.

#### Method and Test

#### Time of Collection

### RATS

#### 3-Month Study

##### ELISA

PVM (pneumonia virus of mice)

Study start, 1 month, study termination

RCV/SDA

(rat coronavirus/sialodacryoadenitis virus)

Study start, 1 month, study termination

Sendai

Study start, 1 month, study termination

##### Immunofluorescence Assay

Parvovirus

Study start, 1 month, study termination

PVM

1 month

#### 2-Year Study

##### ELISA

*Mycoplasma arthritidis*

Study termination

*Mycoplasma pulmonis*

Study termination

PVM

Study start, 1, 6, 12, and 18 months, study termination

RCV/SDA

Study start, 1, 6, 12, and 18 months, study termination

Sendai

Study start, 1, 6, 12, and 18 months, study termination

##### Immunofluorescence Assay

Parvovirus

Study start, 1, 6, 12, and 18 months, study termination

PVM

Study start

**Method and Test****Time of Collection****MICE****3-Month Study**

## ELISA

Ectromelia virus  
 EDIM (epizootic diarrhea of infant mice)  
 GDVII (mouse encephalomyelitis virus)  
 LCM (lymphocytic choriomeningitis virus)  
 Mouse adenoma virus-FL  
 MHV (mouse hepatitis virus)  
 PVM  
 Reovirus 3  
 Sendai

Study start, 1 month, and study termination  
 Study start, 1 month, and study termination  
 Study start, 1 month, and study termination  
 Study start, 1 month, and study termination  
 Study start, 1 month, and study termination  
 Study start, 1 month, and study termination  
 Study start, 1 month, and study termination  
 Study start, 1 month, and study termination

## Immunofluorescence Assay

Parvovirus

Study start, 1 month, and study termination

**2-Year Study**

## ELISA

Ectromelia virus  
 EDIM  
 GDVII  
 LCM  
 Mouse adenoma virus-FL  
 Mouse adenoma virus-1  
 MHV  
 MMV (mouse minute virus, viral protein 2)  
 MPV (mouse parvovirus, viral protein 2)  
*M. arthritidis*  
*M. pulmonis*  
 PVM  
 Reovirus 3  
 Sendai

Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1 month  
 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study termination  
 Study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination  
 Study start, 1, 6, 12, and 18 months, study termination

## Immunofluorescence Assay

MPV, VP2  
 EDIM  
 MCMV (mouse cytomegalovirus)

18 months  
 18 months  
 Study termination

## Polymerase Chain Reaction (PCR)

*Helicobacter* species

18 months

**RESULTS**

All test results were negative.





## National Toxicology Program

National Institute of Environmental Health Sciences

National Institutes of Health

P.O. Box 12233, MD K2-05

Durham, NC 27709

Tel: 984-287-3211

[ntpwebrequest@niehs.nih.gov](mailto:ntpwebrequest@niehs.nih.gov)

<https://ntp.niehs.nih.gov>

ISSN 2378-8925